HAVASUPAI TRIBAL COUNCIL
P.O. Box 10 • Supai, Arizona 86435
(928) 433-8130 • Fax (928) 433-8119

HAVASUPAI TRIBE
HAVASUPAI TRIBAL COUNCIL
SUPAI, ARIZONA

Resolution No. 12-19

Resolution to Support HR1373 to Permanently Ban Mining near Grand Canyon

WHEREAS, The Havasupai Tribe is a federally recognized sovereign Indian Tribe organized on June 8, 1880 by Presidential Executive Order and subsequently by Section 16 of the Indian Reorganization Act (the "Tribe"); and

WHEREAS, The Amended Constitution of the Havasupai Tribe of the Havasupai Reservation (the "Constitution") provides, at Article V, Section 2 "The Havasupai Tribal Council may take any and all actions necessary and proper for the exercise of the foregoing powers and duties, including those powers and duties not enumerated above, and all other powers and duties now or hereafter delegated to the Tribal Council, or vested in the Tribal Council through its inherent sovereignty"; and

WHEREAS, The Constitution further provides at Article XI, "Mining, exploration, or surveying for uranium on the reservation shall be prohibited";

WHEREAS, the Havasupai, the Havasu 'Bajaa, are the People of the blue-green water that emits from the Redwall-Muav aquifer at the springs on our reservation and that flows through Havasu Creek cascading over the magnificent waterfalls on its way to the Colorado River;

WHEREAS, the Redwall-Muav aquifer underlies the Coconino Plateau including the underneath the Canyon uranium mine and other proposed mines and discharges 96% of its water directly to springs and into Havasu Creek on the Havasupai Reservation;

WHEREAS, there is contaminated groundwater at the Canyon uranium mine site and it may contaminate the Redwall aquifer resulting in direct contamination to the sole source of our water which will harm our being as Havasu 'Bajaa;

WHEREAS, the water from the Redwall-Muav aquifer is the sole source for all water in the Village of Supai for drinking, domestic use, tourism, livestock, and wildlife;

WHEREAS, the Tribal Council finds that the Secretarial Withdrawal of the federal lands around Grand Canyon was intended to provide scientific information about the effects of uranium mining on the land, the water, the wildlife and the people but the studies have not been adequately funded and there is much to still be studied about the harms from uranium mining;

WHEREAS, we, the Havasu 'Baaja, will be the ones who suffer the consequences of not knowing the science and not knowing the effects of uranium mining around the Grand Canyon;

WHEREAS, our aboriginal lands include the sacred site on which Canyon Mine is located, we are the Indians who lived and grew crops with water from the springs at Indian Gardens in Grand Canyon National Park, we have always lived in our canyon home and will always remain here, we cannot be relocated and remain Havasu 'Baaja;

WHEREAS, we have opposed uranium mining in this area for over 40 years and will continue to do so for all time;

WHEREAS, the United States has a trust obligation to protect us and an obligation to protect and preserve the Grand Canyon region that cannot be met if mining is permitted to continue and to increase on the Coconino Plateau.

NOW, THEREFORE BE IT RESOLVED by the Havasupai Tribal Council that we support HR1373 and any similar federal legislation that will permanently ban uranium mining and the establishment of new mining claims near the Grand Canyon.

BE IT FURTHER RESOLVED, that the Tribal Chairwoman, or in her absence the Vice Chairman or designee, is hereby authorized and directed to take actions necessary to carry out the purposes of this Resolution.

CERTIFICATION

The foregoing Resolution is adopted pursuant to the authority of Article V, Section 1 of the Amended Constitution of the Havasupai Tribe, a federally recognized sovereign Indian Tribe and Article II of the Bylaws of the Havasupai Tribe at the Special Council meeting of the Tribal Council on the 15th day of March, 2019 by a vote of 4 for; 0 opposed and 3 abstained.

HAVASUPAI TRIBAL COUNCIL:

By: Muriel Coochwytewa

Muriel Coochwytewa, Chairwoman

ATTEST:

Hope Manakaja

Hope Manakaja, Tribal Secretary

NATIONAL CONGRESS OF AMERICAN INDIANS

The National Congress of American Indians
Resolution #MKE-17-058

TITLE: Opposing the Reversal of Mineral Withdrawals that Would Adversely Impact Tribal Lands, Waters, Resources, or Native People

WHEREAS, we, the members of the National Congress of American Indians of the United States, invoking the divine blessing of the Creator upon our efforts and purposes, in order to preserve for ourselves and our descendants the inherent sovereign rights of our Indian nations, rights secured under Indian treaties and agreements with the United States, and all other rights and benefits to which we are entitled under the laws and Constitution of the United States and the United Nations Declaration on the Rights of Indigenous Peoples, to enlighten the public toward a better understanding of the Indian people, to preserve Indian cultural values, and otherwise promote the health, safety and welfare of the Indian people, do hereby establish and submit the following resolution; and

WHEREAS, the National Congress of American Indians (NCAI) was established in 1944 and is the oldest and largest national organization of American Indian and Alaska Native tribal governments; and

WHEREAS, because the link of Native peoples to their lands is fundamental to their identities, cultures, and populations, the NCAI has historically prioritized lands and resources issues; and

WHEREAS, in 2012, largely at the request of Tribes and other stakeholders, the prior Administration withdrew 1,006,545 acres of public lands near the Grand Canyon from new uranium and other hard rock mining claims, to protect the region and the Colorado River from environmental degradation; and

WHEREAS, Congressional members have urged the Departments of the Interior and Agriculture to review mineral withdrawals made during the previous Administration and lift those that they feel are without merit; and

WHEREAS, the mining industry has been advocating for the Administration to lift mining moratoriums and allow mineral exploration on federal lands; and

WHEREAS, expanded uranium mining near the Grand Canyon poses a threat to the health, safety and environmental integrity of the Grand Canyon region and all 40 million people who depend on Colorado River water; and

WHEREAS, uranium mining at the Grand Canyon and in other areas would pose significant risks to the waters on which nearby tribes rely, and threaten their very existence as a people.

NCAI HEADQUARTERS
1516 P Street, N.W.
Washington, DC 20005
202.466.7767
202.466.7797 fax
www.ncai.org

NOW THEREFORE BE IT RESOLVED, that the National Congress of American Indians (NCAI) hereby opposes any efforts by the Administration or Congress to reverse mineral withdrawals that would negatively impact tribal lands, natural resources, cultural resources, tribal water rights, or Native people; and

BE IT FURTHER RESOLVED, that this resolution shall be the policy of NCAI until it is withdrawn or modified by subsequent resolution.

CERTIFICATION

The foregoing resolution was adopted by the General Assembly at the 2017 Annual Session of the National Congress of American Indians, held at the Wisconsin Center in Milwaukee, WI, Oct 15, 2017 - Oct 20, 2017, with a quorum present.

Jefferson Keel

Jefferson Keel, President

ATTEST:

Juana Majel

Juana Majel Dixon, Recording Secretary

THE HOPI TRIBE

Timothy L. Nuvangyaoma
CHAIRMAN

Clark W. Tenakhongva
VICE-CHAIRMAN

MEMORANDUM

TO: **Stewart Koyiyumptewa, Program Manager**
Hopi Cultural Preservation Office

FROM: **Theresa A. Lomakema, Tribal Secretary**
Hopi Tribal Council

DATE: **April 12, 2019**

SUBJECT: **THE HOPI TRIBE TO SUPPORT THE GRAND CANYON CENTENNIAL PROTECTION ACT OF 2019 – A.I. #023-2019 / H-025-2019**

On April 9, 2019, the Hopi Tribal Council by motion and majority vote approved the Action Item and Resolution mentioned above.

By passage of this Resolution, the Hopi Tribal Council hereby supports other governmental and non-governmental institutions and organizations that join Hopi in opposing continuing efforts to undermine the Northern Arizona Mineral Withdrawal.

Furthermore, the Hopi Tribe supports the Grand Canyon Centennial Protection Act of 2019 to permanently withdraw approximately one million acres surrounding the Grand Canyon from mineral entry under the General Mining Law of 1872.

C: Office of the Chairman
Office of the Vice Chairman
Office of the Treasurer
Office of Financial Management
Office of Executive Director
Department of Natural Resources
Office of General Counsel

HOPI TRIBAL COUNCIL
RESOLUTION
H-025-2019

WHEREAS, the Constitution and By-Laws of the Hopi Tribe, ARTICLE VI - POWERS OF THE TRIBAL COUNCIL, SECTION 1 (a), (k) and (l) authorizes the Hopi Tribal Council "To represent and speak for the Hopi Tribe in all matters for the welfare of the Tribe, . . ."; "To protect the arts, crafts, traditions, and ceremonies of the Hopi Indians."; and "To delegate any of the powers of the Council to committee's or officers, keeping the right to review any action taken."; and

WHEREAS, the Hopi Tribe has repeatedly stated that past contamination from uranium mining should be cleaned up before any additional uranium mining is approved, and we oppose the continued use of the archaic 1872 Mining Law to justify uranium mining; and

WHEREAS, the Hopi Tribe has stated that we believe the Federal, State and local governments should focus on and address the existing threat to human life and that Congress replace the 1872 Mining Law with a Sacred Sites Act and mining law fit for life in the 21st Century and into the future; and

WHEREAS, Hopi people emerged into this World at the Grand Canyon, known to us as *Öngtupqa* or Salt Canyon. *Öngtupqa* is our birthplace as a People and these lands contain the testimony of our ancestors' occupation and use for thousands of years, manifest in the prehistoric ruins, the rock "art" and artifacts, and the human remains of our ancestors, *Hisatsinom*, People of Long ago, who continue to inhabit them; and

WHEREAS, the Grand Canyon is a Traditional Cultural Property of the Hopi Tribe and these "public lands" are part of our ancestral lands, and *Hopisinom* have returned to *Öngtupqa* on salt gathering pilgrimages since time immemorial and continue to do so today; and

WHEREAS, for over a thousand years, the springs and waters of the Hopi Mesas have provided life to *Hopisinom* and the legacy of past uranium mining has left wounds on our land, our water, and our people. These wounds are not scars, for they have not healed. Two of our Villages, Upper and Lower *Munqapi* (Moenkopi) are now threatened by a uranium contaminated plume of ground water from the former Rare Metals uranium mill near Tuba City; and

WHEREAS, *Hopisinom* and many other Native American people suffer an ongoing legacy of death by cancer, chronic health problems, and radioactive contamination including water contamination on tribal lands. We know firsthand from our experience at *Munqapi*, that the contamination will travel, that it does not stay in one place, and that it spreads contamination as it moves; and

WHEREAS, the 1872 mining law is a 19th Century tool of archaic law used to "discover," "claim," and "take" Native Americans' lands and continues today as a policy of disregard and disrespect toward the beliefs and sacred ties that Hopi and Native American people have with the Earth. The legacy of uranium mining has devastated the people and the land, and the 1872 mining law continues to destroy the land and lives of *Hopisinom*, Native Americans and Americans alike; and

WHEREAS, over two thousand mining claims have been filed around the Grand Canyon on

United States Forest Service and Bureau of Land Management lands. Therefore, we support the Proposed Action that would protect one million acres around the Grand Canyon from uranium mining and exploration by withdrawing the Tusayan Ranger District and Federal land managed by the Bureau of Land Management in the vicinity of Kanab Creek and in Rock House Valley from location, entry, and patent under the mining laws; and

WHEREAS, *Koyanisqatsi*, told in Hopi history and prophecy, is life out of balance, or a state of life that calls for another way of living. This state of life characterizes the risks we face together in modern times. If Americans are to live together in America in the 21st Century, we must call together for another way of living. The laws of the past that are now being used against all American people must be consigned to the past and replaced with laws that support life and not destruction and death.

NOW THEREFORE BE IT RESOLVED that the Hopi Tribe supports other governmental and non-governmental institutions and organizations that join us in opposing continuing legislative efforts to undermine the Northern Arizona Mineral Withdrawal.

BE IT FURTHER RESOLVED that the Hopi Tribe agrees that a qualifying threat to the Grand Canyon continues to exist and we continue to offer our complete support for the Grand Canyon Centennial Protection Act of 2019 to withdraw these lands pursuant to the Federal Land Policy Management Act.

BE IT FINALLY RESOLVED that the Hopi Tribe enthusiastically supports the Grand Canyon

Centennial Act of 2019 to permanently withdraw approximately one million acres surrounding the Grand Canyon from mineral entry under the General Mining Law of 1872.

CERTIFICATION

The Hopi Tribal Council duly adopted the foregoing Resolution on April 9, 2019 at a meeting at which a quorum was present with a vote of 18 in favor, 0 opposed, 1 abstaining (Chairman presiding and not voting) pursuant to the authority vested in the Hopi Tribal Council by ARTICLE VI-POWERS OF THE TRIBAL COUNCIL, SECTION 1 (a), (k), and (l) of the Hopi Tribal Constitution and By-Laws of the Hopi Tribe of Arizona, as ratified by the Tribe on October 24, 1936, and approved by the Secretary of Interior on December 19, 1936, pursuant to Section 16 of the Act of June 18, 1934. Said Resolution is effective as of the date of adoption and does not require Secretarial approval.

Timothy L. Nuvangyaoma, Chairman
Hopi Tribal Council

ATTEST:

Theresa A. Lomakema, Tribal Secretary
Hopi Tribal Council

THE HOPI TRIBE

Leroy Shingoitewa
CHAIRMAN

Herman G. Honanie
VICE-CHAIRMAN

Testimony of Benjamin H. Nuvamsa
Chairman, The Hopi Tribe
to the Subcommittee on National Parks and Public Lands
of the Committee on Natural Resources
Community Impacts of Proposed Uranium Mining Near Grand Canyon National Park
March 28, 2008, Flagstaff, Arizona

Loloma. Good morning. On behalf of the Hopi people, it is my responsibility as Chairman of the Hopi Tribe to be here today to express the Hopi Tribal government and *Hopisenom,* or Hopi people's opposition to uranium exploration and mining around the Grand Canyon. We understand that thousands of new mining claims have been filed around the Grand Canyon on United States Forest Service and Bureau of Land Management lands. These "public lands" are part of our ancestral lands.

Therefore, it is my pleasure as Chairman of the Hopi Tribe to be here today to express the Hopi Tribe and *Hopisenom* support for The Grand Canyon Watersheds Protection Act of 2008. H.R. 5583 would protect one million acres around the Grand Canyon from uranium mining and exploration by withdrawing "the Tusayan Ranger District and Federal land managed by the Bureau of Land Management in the vicinity of Kanab Creek and in Rock House Valley from location, entry, and patent under the mining laws, and for other purposes."

The Grand Canyon is a Traditional Cultural Property of the Hopi Tribe. Hopi people emerged into this World at the Grand Canyon, known to us as *Ongtupqa*, or Salt Canyon. *Ongtupqa* is our birthplace as a People.

With our emergence from *Ongtupqa*, Hopi people entered into a sacred Covenant with *Maasaw*, the Earth Guardian, in which it is our responsibility to be preservers and protectors, or Stewards of the Earth. In accordance with that Covenant, our ancestors migrated to and settled in these lands, and then migrated from them to Hopi, *Tuuwanasavi*, the Center of the Universe.

These lands contain the testimony of our ancestors' "discovery" thousands of years ago, manifest in the prehistoric ruins, the rock "art" and artifacts, and the human remains of our ancestors, *Motisenom*, First People, and *Hisatsenom*, People of Long Ago, who continue to inhabit them. *Hopisenom* have returned to *Ongtupqa* on salt pilgrimages since time immemorial, and continue to do so today.

Patuwaquatsi. Water is life. The legacy of past uranium mining has left wounds on our land, our water, and our people. These wounds are not scars, for the have not healed. Two of our Villages, Upper and Lower *Munqapi* (Moencopi), were established by residents of *Orayvi* (Oraibi), recognized as the oldest continuously occupied community in the United States. These Villages are now threatened by a uranium contaminated plume of ground water from the former Rare Metals mine near Tuba City.

For over a thousand years, the springs and waters of *Munqapi* have provided life to *Hopisenom*. These springs and waters, farms and people are threatened now from the legacy of past uranium mining. The federal government is proposing new studies of these wounds, apparently because action to heal them is beyond current technological capabilities. Although the Rare Metals mine is now closed, the wounds it left are continuing to infect the lives of our Villages and people.

The hard rock mining law of 1872 offers very little protection for lands. Rather, it essentially prioritizes the interests of mining companies over those of the public. According to the Environmental Protection Agency (EPA) Toxics Release Inventory, mining metals is the country's leading source of toxic pollution, and as a result the EPA estimates that more than 40%of Western watersheds have contamination in their headwaters. According to the Arizona Game and Fish Department, in the mining of uranium, "all the methods have the potential for radioactive pollution."

Hopisenom and many other Native American people suffer an ongoing legacy of death by cancer, chronic health problems, and radioactive contamination including water contamination on tribal lands. We appreciate the efforts of the Navajo Nation and President Shirley in opposing uranium mining on and around the Navajo Nation. We know first hand from our experience at *Munqapi,* that the contamination will travel, that it does not stay in one place, and that it spreads contamination as it moves. We are facing just this situation in *Munqapi* today. We share President Shirley's position that "The federal government should clean up existing contaminated sites before it promotes renewed uranium mining."

The 1872 mining law is a 19th Century tool of Manifest Destiny used to "discover," "claim," and "take" Native Americans' lands, continues today as a policy of disregard and disrespect toward the beliefs and sacred ties that Hopi and Native American people have with the Earth. The legacy of uranium mining has devastated the people and the land, and the 1872 mining law continues to destroy the land and lives of *Hopisenom*, Native Americans, and Americans alike.

Hopi Cultural Preservation Office consultations with the United States Forest Service, Kaibab National Forest and Bureau of Land Management, Arizona Strip confirm that these agencies proclaim that "The 1872 Mining Law specifically authorizes the taking of valuable mineral commodities from Public Domain Lands. A 'No Action" alternative is not an option that can be considered."

Koyaanisqatsi, told in Hopi history and prophesy, is life out of balance, or a state of life that calls for another way of living. This state of life characterizes the risks we face together in modern times. If Americans are to live together in America in the 21st Century, we must call together for another way of living. The laws of the past that are now being used against all American people must be consigned to the past, and replaced with laws that support life, and not destruction and death.

We would like to gratefully thank Representative Grijalva for his leadership in the United States House of Representatives' recent passage of a bill reforming the 1872 Mining Law, which includes a provision for Native American sacred sites preservation and protection. We hope the Senate acts positively on that House bill and the President signs it into law.

We would also like to thank Representative Grijalva for introducing The Grand Canyon Watersheds Protection Act of 2008. We look forward to working with the Grand Canyon Trust and the Tribes in the Grand Canyon area, including the Navajo, Hualapai, Havasupai, and Kaibab Paiute Tribes, to develop a collective Tribal policy opposing uranium development around the Grand Canyon. We also look forward to working with Representative Grijalva, Governor Napolitano, the Coconino County Board of Supervisors, and others to ensure that *Ongtupqa* is protected and preserved for future generations of Hopisenom, Americans, and all the people and living things of the Earth. As *Lomasumi'nangwtukwsiwmani*, the Hopi Foundation, says, "Our destiny together is a matter of choice, since we are the community we make."

Hopisenom say, "We're not just farming, we're growing children. This is why it is my responsibility as well as my pleasure to be here today: to express the Hopi Tribe and *Hopisenom* opposition to the 1872 mining law and uranium development around *Ongtupqa,* and our support for the reform of that law and the Grand Canyon Watersheds Protection Act of 2008, H.R. 5583. We join others calling Arizona's delegation in the House and Senate to act and act quickly to protect the Grand Canyon. *Kwa'kwai.* Thank you.

THE HOPI TRIBE

LeRoy N. Shingoitewa
CHAIRMAN

Herman G. Honanie
VICE-CHAIRMAN

February 28, 2011

Scott Florence, District Manager
Bureau of Land Management, Arizona Strip District Office
345 East Riverside Dr.
St George, Utah 84790

Re: Northern Arizona Proposed Withdrawal Project

Dear Mr. Florence,

This letter is in preliminary response to your correspondence dated February, 2011, and your administrative meeting with the Hopi Cultural Preservation Office on February 23, 2001, regarding the Northern Arizona Proposed Withdrawal Draft Environmental Impact Statement (DEIS). As we have stated throughout the review process for this DEIS, the Hopi Tribe enthusiastically supports the Proposed Action, Alternative B, to withdraw approximately one million acres surrounding the Grand Canyon from mineral entry under the General Mining Law of 1872.

The Grand Canyon is a Traditional Cultural Property of the Hopi Tribe. These "public lands" are part of our ancestral lands. Hopi people emerged into this World at the Grand Canyon, known to us as *Ongtuqa*, or Salt Canyon. *Ongtuqa* is our birthplace as a People. These lands contain the testimony of our ancestors' occupation and use for thousands of years, manifest in the prehistoric ruins, the rock "art" and artifacts, and the human remains of our ancestors *Hisatsinom*, People of Long Ago, who continue to inhabit them. *Hopisinom* have returned to *Ongtuqa* on salt gathering pilgrimages since time immemorial, and continue to do so today.

The Hopi Tribe provided testimony to the Subcommittee on National Parks and Public Lands of the Committee on Natural Resources at a hearing entitled *Community Impacts of Proposed Uranium Mining Near Grand Canyon National Park* on March 28, 2008, in Flagstaff, Arizona. In that testimony, Chairman Nuvamsa expressed the Hopi Tribal government and *Hopisinom*, or Hopi people's, opposition to uranium exploration and mining around the Grand Canyon.

We understand that thousands of new mining claims have been filed around the Grand Canyon on United States Forest Service and Bureau of Land Management lands. Therefore, we support the Proposed Action that would protect one million acres around the Grand Canyon from uranium mining and exploration by withdrawing the Tusayan Ranger District and Federal land managed by the Bureau of Land Management in the vicinity of Kanab Creek and in Rock House Valley from location, entry, and patent under the mining laws.

P.O. BOX 123 KYKOTSMOVI, AZ 86039 (928) 734-3000

Patuwaqatsi. Means "ocean" and is used literally by some as "water is life." For over a thousand years, the springs and waters of the Hopi Mesas have provided life to *Hopisinom*. The legacy of past uranium mining has left wounds on our land, our water, and our people. These wounds are not scars, for they have not healed. Two of our Villages, Upper and Lower *Munqapi* (Moenkopi), were established by residents of *Orayvi* (Oraibi), recognized as the oldest continuously occupied community in the United States. These Villages are now threatened by a uranium contaminated plume of ground water from the former Rare Metals mine near Tuba City.

Hopisinom and many other Native American people suffer an ongoing legacy of death by cancer, chronic health problems, and radioactive contamination including water contamination on tribal lands. We know first hand from our experience at *Munqapi*, that the contamination will travel, that it does not stay in one place, and that it spreads contamination as it moves. We hold the position that the federal government should clean up and reclaim existing contaminated sites before it promotes renewed uranium mining.

The 1872 mining law is a 19th Century tool of archaic law used to "discover," "claim," and "take" Native Americans' lands, and continues today as a policy of disregard and disrespect toward the beliefs and sacred ties that Hopi and Native American people have with the Earth. The legacy of uranium mining has devastated the people and the land, and the 1872 mining law continues to destroy the land and lives of *Hopisinom*, Native Americans, and Americans alike.

Koyaanisqatsi, told in Hopi history and prophesy, is life out of balance, or a state of life that calls for another way of living. This state of life characterizes the risks we face together in modern times. If Americans are to live together in America in the 21st Century, we must call together for another way of living. The laws of the past that are now being used against all American people must be consigned to the past, and replaced with laws that support life, and not destruction and death.

We agree that a qualifying threat to the Grand Canyon currently exists. Although we are disappointed that the Bureau of Land Management did not consider our recommendation that an area larger than the Proposed Action be included as an alternative in this DEIS, we nevertheless offer our complete support for the Proposed Action to require the Secretary of the Interior to withdraw these lands pursuant to the Federal Land Policy Management Act.

As discussed at your administrative meeting with the Hopi Cultural Preservation Office, the Hopi Tribe is interested in pursuing further consultations on the DEIS, additional protection of cultural resources within the withdrawal area, and the potential application of this DEIS to lands outside the withdrawal area. I look forward to that meeting. Please continue to communicate with the Hopi Cultural Preservation Office on confirming a time and date. Subsequent to that meeting, the Hopi Tribe may offer additional comments on the DEIS. *Kwa'kway.* Thank you.

Respectfully,

LeRoy N. Shingoitewa
Chairman
THE HOPI TRIBE

Enclosures: April 11, 2006 letter; March 28, 2008 testimony; September 4, 2009 and January 29, 2010 letters

THE HOPI TRIBE

Leroy Shingoitewa
CHAIRMAN

Herman G. Honanie
VICE-CHAIRMAN

January 29, 2010

Scott Florence, District Manager
Bureau of Land Management, Arizona Strip District Office
345 East Riverside Drive
St. George, Utah 84790

Dear Mr. Florence,

This letter is in response to your correspondence dated January 20, 2010, regarding the Bureau of Land Management (BLM), Arizona Strip District, U.S. Forest Service, Kaibab National Forest, National Park Service (NPS), Grand Canyon National Park, and United States Geological Survey collaborating on an Environmental Impact Statement for a proposed mining withdrawal in the vicinity of the Grand Canyon.

The Hopi Tribe claims cultural affiliation to the prehistoric cultural groups in the 993,549-acre proposed mining withdrawal area, and the Hopi Cultural Preservation Office supports identification and avoidance of prehistoric archaeological sites and Traditional Cultural Properties. The Grand Canyon and Red Butte are Traditional Cultural Properties of the Hopi Tribe. The Hopi Cultural Preservation Office also considers the archaeological sites of our ancestors to be Traditional Cultural Properties. Therefore, we appreciate your continuing solicitation of our input and your efforts to address our concerns.

Enclosed are the Hopi Tribe's September 4, 2009, letter and our testimony to the Subcommittee on National Parks and Public Lands regarding community impacts of proposed uranium mining near Grand Canyon National Park. We reiterate that we share the position that the federal government should clean up existing contaminated sites before it promotes renewed uranium mining, and we welcome and support the proposed action in this Environmental Impact Statement for the mining withdrawal in the vicinity of the Grand Canyon.

Your correspondence included a *Study Summary-Northern Arizona Proposed Withdrawal (AZA 35138).* We have been contacted by the NPS regarding the Traditional Cultural Properties study, and we are interested in receiving copies of all of the draft studies for review and comment. Your correspondence did not include a copy of the draft consultation plan. Please provide us with a copy of the draft consultation plan for review and comment.

P.O. BOX 123 KYKOTSMOVI, AZ 86039 (928) 734-3000

We were disappointed to hear that the BLM approved the opening of a uranium mine while simultaneously developing this Environmental Impact Statement.

Should you have any questions or need additional information, please contact Terry Morgart at the Hopi Cultural Preservation Office at 928-734-3619 or tmorgart@hopi.nsn.us. Thank you for your consideration.

Respectfully,

Leigh J. Kuwanwisiwma, Director
Hopi Cultural Preservation Office

Enclosures: September 4, 2009, letter; March 28, 2008, Hopi Testimony

xc: Mike Williams, Mike Lyndon, Kaibab National Forest, 800 South 6th Street, Williams, Arizona 86046
Angela Parker, Tusayan Ranger District; Congressman Grijalva; Sierra Club; Grand Canyon Trust;
Steve Martin, Grand Canyon; Havasupai, Zuni and Hualapai Tribes; Arizona State Historic Preservation Office

THE HOPI TRIBE

CHAIRMAN

VICE-CHAIRMAN

September 4, 2009

Lorraine M. Christian, Field Manager
Bureau of Land Management, Arizona Strip Field Office
345 East Riverside Drive
St. George, Utah 84790

Dear Ms. Christian,

This letter is in response to your correspondence dated August 19, 2009, regarding the Bureau of Land Management, Arizona Strip District, U.S. Forest Service, Kaibab National Forest, National Park Service, Grand Canyon National Park, and United States Geological Survey collaborating on an Environmental Impact Statement for a proposed mining withdrawal in the vicinity of the Grand Canyon.

The Hopi Tribe claims cultural affiliation to the prehistoric cultural groups in the 993,549-acre proposed mining withdrawal area, and the Hopi Cultural Preservation Office supports identification and avoidance of prehistoric archaeological sites and Traditional Cultural Properties. The Grand Canyon and Red Butte are Traditional Cultural Properties of the Hopi Tribe. The Hopi Cultural Preservation Office also considers the archaeological sites of our ancestors to be Traditional Cultural Properties. Therefore, we appreciate your continuing solicitation of our input and your efforts to address our concerns.

Enclosed is the Hopi Tribe's testimony to the Subcommittee on National Parks and Public Lands regarding community impacts of proposed uranium mining near Grand Canyon National Park, which states:

> The legacy of past uranium mining has left wounds on our land, our water, and our people... These wounds are not scars, for the have not healed...These springs and waters, farms and people are threatened now from the legacy of past uranium mining...*Hopisinom* and many other Native American people suffer an ongoing legacy of death by cancer, chronic health problems, and radioactive contamination including water contamination on tribal lands.... The legacy of uranium mining has devastated the people and the land, and the 1872 mining law continues to destroy the land and lives of *Hopisinom*, Native Americans, and Americans alike...The laws of the past that are now being used against all American people must be consigned to the past, and replaced with laws that support life, and not destruction and death...

Also enclosed are our recent letters to the Forest Service regarding uranium exploration projects proposed on the Kaibab National Forest within this proposed mining withdrawal area. The Forest Service and Bureau of Land Management had assured us that they had no choice but to approve categorical exclusions, and that no long-term adverse environmental impacts were expected from drilling exploration projects.

We share the position that the federal government should clean up existing contaminated sites before it promotes renewed uranium mining. Therefore, we welcome this Environmental Impact Statement and look forward to being informed of its status and the status of any associated studies.

Should you have any questions or need additional information, please contact Terry Morgart at the Hopi Cultural Preservation Office at 928-734-3619 or tmorgart@hopi.nsn.us. Thank you for your consideration.

Respectfully,

Leigh J. Kuwanwisiwma, Director
Hopi Cultural Preservation Office

Enclosures: March 28, 2008, Hopi Testimony
August, 2009, letters to KNF

xc: Mike Williams, Mike Lyndon, Kaibab National Forest, 800 South 6th Street, Williams, Arizona 86046
Angela Parker, Tusayan Ranger District
Congressman Grijalva; Sierra Club; Grand Canyon Trust
Steve Martin, Superintendent, Grand Ganyon National Park
Havasupai and Hualapai Tribes
Arizona State Historic Preservation Office

....

(Original Signature of Member)

116TH CONGRESS
1ST SESSION

H. R. ______

To protect, for current and future generations, the watershed, ecosystem, and cultural heritage of the Grand Canyon region in the State of Arizona, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

Mr. GRIJALVA introduced the following bill; which was referred to the Committee on ______________________

A BILL

To protect, for current and future generations, the watershed, ecosystem, and cultural heritage of the Grand Canyon region in the State of Arizona, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Grand Canyon Centennial Protection Act".

SEC. 2. WITHDRAWAL OF FEDERAL LAND FROM MINING LAWS.

(a) DEFINITION OF MAP.—In this Act, the term "Map" means the Bureau of Land Management map entitled "Grand Canyon Centennial Protection Act" and dated February 8, 2019.

(b) WITHDRAWAL.—Subject to valid existing rights, the approximately 1,070,613 acres of Federal lands in the State of Arizona within the area depicted on the Map, including any land or interest in land that is acquired by the United States after the date of enactment of this Act, are hereby withdrawn from—

(1) all forms of entry, appropriation, and disposal under the public land laws;

(2) location, entry, and patent under the mining laws; and

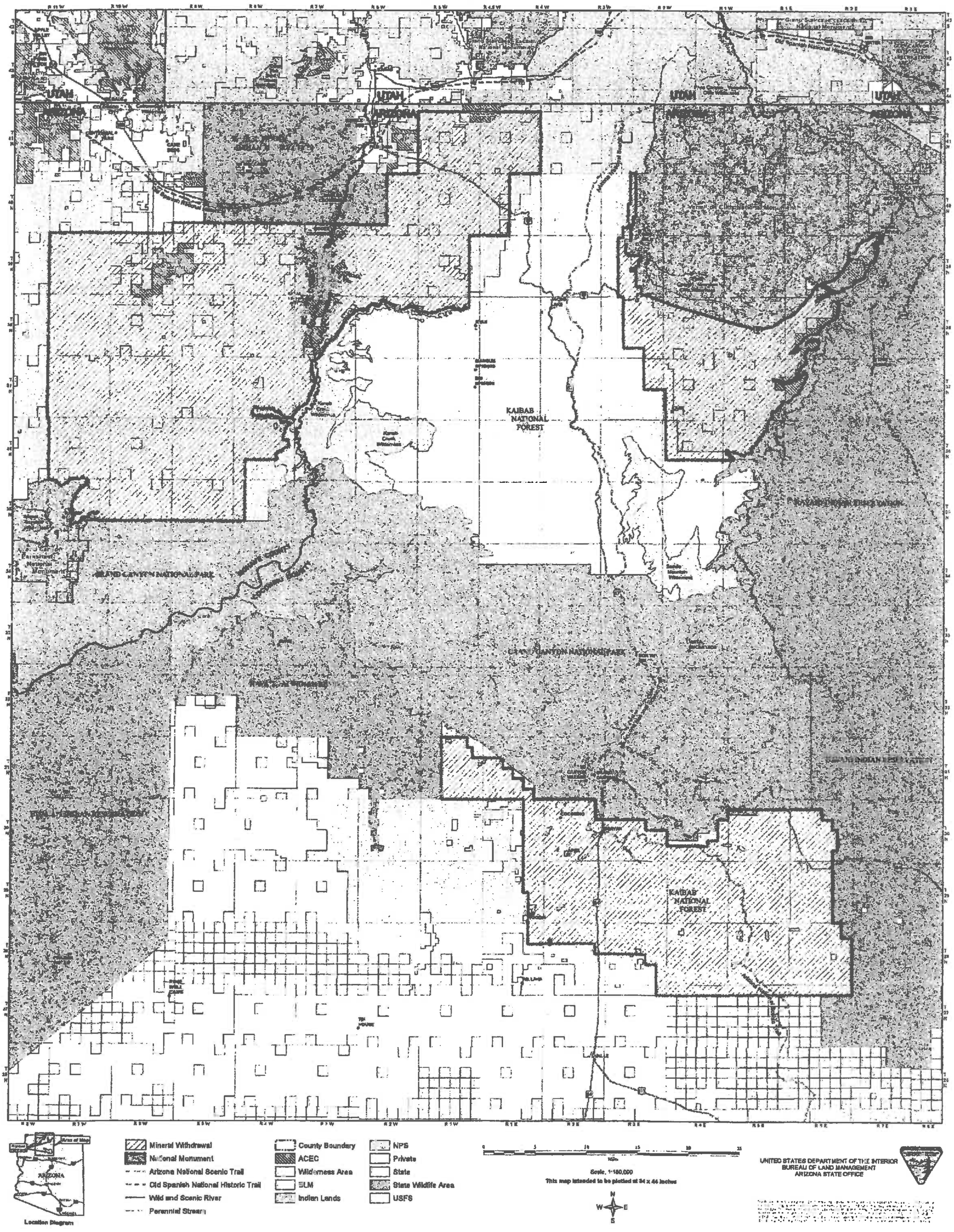
(3) operation of the mineral leasing and geothermal leasing laws and mineral materials laws.

(c) AVAILABILITY OF MAP.—The Map shall be kept on file and made available for public inspection in the appropriate offices of the Forest Service and the Bureau of Land Management.

Grand Canyon Centennial Protection Act

February 8, 2019

This map prepared at the request of Representative Raul Grijalva



Scale, 1:180,000

This map intended to be plotted at 34 x 44 inches

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
ARIZONA STATE OFFICE

THE HOPI TRIBE

LeRoy N. Shingoitewa
CHAIRMAN

Herman G. Honanie
VICE-CHAIRMAN

October 13, 2011

Ken Salazar, Secretary
Department of the Interior
1849 C St., NW
Washington DC 20240

Re: Northern Arizona Mineral Withdrawal

Dear Secretary Salazar,

As Chairman of the Hopi Tribe, it is my responsibility to provide this letter in support of the Proposed and Preferred Alternative in the Northern Arizona Proposed MineralWithdrawal Environmental Impact Statement (EIS). As we have stated throughout the review process for this EIS, the Hopi Tribe enthusiastically supports the Proposed and Preferred Action to withdraw approximately one million acres surrounding the Grand Canyon from mineral entry under the General Mining Law of 1872.

The Hopi Tribes has repeatedly stated that past contamination from uranium mining should be cleaned up before any additional uranium mining is approved, and we oppose the continued use of the archaic 1872 Mining Law to justify uranium mining. We have stated that we believe the Federal, State and local governments should focus on and address the existing threat to human life, and that Congress should replace the 1872 Mining Law with a Sacred Sites Act and mining law fit for life in the 21st Century and into the future. Therefore, we oppose continuing legislative efforts to undermine the Northern Arizona Mineral Withdrawal.

The Grand Canyon is a Traditional Cultural Property of the Hopi Tribe. These "public lands" are part of our ancestral lands. Hopi people emerged into this World at the Grand Canyon, known to us as *Ongtuqa*, or Salt Canyon. *Ongtuqa* is our birthplace as a People. These lands contain the testimony of our ancestors' occupation and use for thousands of years, manifest in the prehistoric ruins, the rock "art" and artifacts, and the human remains of our ancestors *Hisatsinom*, People of Long Ago, who continue to inhabit them. *Hopisinom* have returned to *Ongtuqa* on salt gathering pilgrimages since time immemorial, and continue to do so today.

Enclosed are the Hopi Tribe's letters in support of the Proposed and Preferred Action in the EIS and testimony to the Subcommittee on National Parks and Public Lands of the Committee on Natural Resources at a hearing on March 28, 2008, in Flagstaff, Arizona.

P.O. BOX 123 KYKOTSMOVI, AZ 86039 (928) 734-3000

We understand that thousands of new mining claims have been filed around the Grand Canyon on United States Forest Service and Bureau of Land Management lands. Therefore, we support the Proposed Action that would protect one million acres around the Grand Canyon from uranium mining and exploration by withdrawing the Tusayan Ranger District and Federal land managed by the Bureau of Land Management in the vicinity of Kanab Creek and in Rock House Valley from location, entry, and patent under the mining laws.

Patuwaquatsi. Means "ocean" and is used literally by some as "water is life." For over a thousand years, the springs and waters of the Hopi Mesas have provided life to *Hopisinom*. The legacy of past uranium mining has left wounds on our land, our water, and our people. These wounds are not scars, for they have not healed. Two of our Villages, Upper and Lower *Munqapi* (Moenkopi), were established by residents of *Orayvi* (Oraibi), recognized as the oldest continuously occupied community in the United States. These Villages are now threatened by a uranium contaminated plume of ground water from the former Rare Metals mine near Tuba City.

Hopisinom and many other Native American people suffer an ongoing legacy of death by cancer, chronic health problems, and radioactive contamination including water contamination on tribal lands. We know first hand from our experience at *Munqapi*, that the contamination will travel, that it does not stay in one place, and that it spreads contamination as it moves. We hold the position that the federal government should clean up and reclaim existing contaminated sites before it promotes renewed uranium mining.

The 1872 mining law is a 19th Century tool of archaic law used to "discover," "claim," and "take" Native Americans' lands, and continues today as a policy of disregard and disrespect toward the beliefs and sacred ties that Hopi and Native American people have with the Earth. The legacy of uranium mining has devastated the people and the land, and the 1872 mining law continues to destroy the land and lives of *Hopisinom*, Native Americans, and Americans alike.

Koyaanisqatsi, told in Hopi history and prophesy, is life out of balance, or a state of life that calls for another way of living. This state of life characterizes the risks we face together in modern times. If Americans are to live together in America in the 21st Century, we must call together for another way of living. The laws of the past that are now being used against all American people must be consigned to the past, and replaced with laws that support life, and not destruction and death.

We agree that a qualifying threat to the Grand Canyon currently exists and we continue to offer our complete support for the Proposed and Preferred Action to to withdraw these lands pursuant to the Federal Land Policy Management Act.

Respectfully,

LeRoy N. Shingoitewa
Chairman
THE HOPI TRIBE

Enclosures: March 28, 2008 testimony; September 4, 2009, January 29, 2010, and February 28, 2011, letters
xc: Scott Florence, BLM, Arizona Strip District Office, 345 East Riverside Dr., St George, Utah 84790

HUALAPAI TRIBAL COUNCIL
RESOLUTION NO. 67-2009
OF THE GOVERNING BODY OF THE
HUALAPAI TRIBE OF THE HUALAPAI RESERVATION

{Position of the Hualapai Tribe's Opposition to Uranium Exploration and Mining}

WHEREAS, the Hualapai Reservation encompasses approximately one-seventh of the aboriginal territory of the Hualapai Tribe, and many places outside our Reservation boundary hold religious, cultural, and historic significance for the Hualapai people; and

WHEREAS, many places that hold religious, cultural, and historic significance for the Hualapai people are located on lands that are currently managed by various federal agencies of the federal government, including but not limited to the areas within the Kaibab National Forest, Bureau of Land Management and National Park Service; and

WHEREAS, the Hualapai Tribe considers the entire Grand Canyon from rim to rim to be a culturally significant landscape which includes hundreds of particular places that hold religious and cultural significance; and

WHEREAS, the Federal Government has responsibilities, both legal and moral, to manage public lands in a way that shows proper respect for places that hold religious and cultural and historical importance to Indian tribes; and

WHEREAS, uranium exploration and mining cause many adverse humanitarian and environmental impacts that are inconsistent with the management of public lands for the preservation of the integrity of places that hold tribal religious, historical and cultural significance; and

WHEREAS, the federal law known as the 1872 Mining Law is an anachronism; under this law the federal government gives away valuable natural resources to private companies, with the mining claims of those private companies taking precedence over other public interests, including the public interest in preserving places that hold religious and cultural importance for Indian tribes; and

WHEREAS, the 1872 Mining Law was enacted during the "robber baron" era of American history; in the historical context of the relations between the Hualapai Tribe and the United States, the 1872 law was enacted at about the same time as two traumatic events in Hualapai history: the war that the U.S. Army fought against the Hualapai people from 1866 to 1868 and the forced removal of many of the Hualapai people to La Paz in 1874; and

WHEREAS, during the Administration of President Clinton, the Solicitor for the Department of the Interior issued a legal opinion that federal land managing agencies do have discretion to deny permission to develop mining claims, in effect, if the costs associated with mitigating damage to the environment, cultural resources and ethereal belief of a tribe would render the extraction of the minerals not economically viable (Solicitor, "Regulation of Hardrock Mining," M-36999 (Dec.

27, 1999)), the Bush Administration issued a Solicitor's opinion that reached a contrary conclusion (Solicitor, "Surface Management Provisions for Hardrock Mining," M-37007 (Oct. 23, 2001)); and

WHEREAS, the Department of the Interior has proposed the withdrawal of nearly one million acres of federal lands in the Grand Canyon watershed from new mining claims under the 1872 Ming Law, an action that would put these lands off limits for mineral exploration and extraction for twenty years, and which has the immediate effect of putting these lands off limits for two years while the Secretary of the Interior considers whether to make the proposed withdrawal final; and

WHEREAS, various federal agencies have invited public comment on proposed uranium explorations and uranium mining within areas apparently not covered by the Secretary's proposed withdrawal;

NOW THEREFORE BE IT RESOLVED THAT the Hualapai Tribe formally declares strong opposition on proposed exploratory drilling and uranium mining;

1. Commends the Secretary of the Interior for the proposed withdrawal of federal lands from claims under the 1872 Mining Law and calls for the Secretary to make a final decision to proceed with the withdrawal;
2. Opposes proposals by uranium mining companies to conduct exploratory drilling for uranium within the jurisdiction of various federal land managing agencies;
3. Calls upon the Secretary of the Interior to conduct a review of Solicitor's opinions on the regulation of hardrock mining;
4. Supports efforts in Congress to repeal or substantially amend the 1872 Mining Law;
5. Opposes exploration for uranium and uranium mining without tribal approval on all Hualapai ancestral lands including lands under the sovereign authority of the Hualapai Tribe.

CERTIFICATION

I, the undersigned as Chairman of the Hualapai Tribal Council hereby certify that the Hualapai Tribal Council of the Hualapai Tribe is composed of nine (9) members of whom **9** constituting a quorum were present at a **Regular Council Meeting** thereof held on this **3rd day of September 2009**; and that the foregoing resolution was duly adopted by a vote of **9 - for, 0 - oppose**, pursuant to authority of Article V, Section (a) of the Constitution of the Hualapai Tribe approved March 13, 1991.

Wilfred W Whatoname Sr
Wilfred Whatoname, Sr., Chairman
Hualapai Tribal Council

ATTEST
Adeline Crozier
Adeline Crozier, Assist. Secretary
Hualapai Tribal Council

Inter Tribal Association of Arizona
21 TRIBAL NATIONS

Ak-Chin Indian Community
Cocopah Indian Tribe
Colorado River Indian Tribes
Fort McDowell Yavapai Nation
Fort Mojave Indian Tribe
Gila River Indian Community
Havasupai Tribe
Hopi Tribe
Hualapai Tribe
Band of Paiute Indians
Pascua Yaqui Tribe
Pueblo of Zuni
Quechan Tribe
Salt River Pima-Maricopa Indian Community
San Carlos Apache Tribe
San Juan Southern Paiute Tribe
Tohono O'odham Nation
Tonto Apache Tribe
White Mountain Apache Tribe
Yavapai-Apache Nation
Yavapai-Prescott Indian Tribe

Resolution No. 0316

Support for Designation of Grand Canyon Heritage National Monument

WHEREAS, the Inter Tribal Association of Arizona, an association of 21 tribal governments in Arizona, provides a forum for tribal governments to advocate for national, regional and specific tribal concerns and to join in united action to address these issues; and

WHEREAS, the Member Tribes of the Inter Tribal Association of Arizona have the authority to act to further their collective interests as sovereign tribal governments; and

WHEREAS, the Inter Tribal Association of Arizona has the charge to support and represent particular member Tribes on matters directly affecting them upon their request; and

WHEREAS, the Grand Canyon is a location of significance to the Native People of the Southwest with numerous locations of religious and cultural importance within the area designated as Grand Canyon National Park and on the Federal lands surrounding the Park; and

WHEREAS, the springs and seeps that provide the water for life in the Canyon for us and for the plants and animals on which we depend must be protected from depletion and from contamination and are at risk; and

WHEREAS, the ancient trails that we travel to reach each other travel through the Canyons, between the springs and across the Plateau are at risk; and

WHEREAS, the proposed legislation HR 3882 recognizes the importance of these lands to the Native People affiliated with the Grand Canyon Region and provides an advisory role for our Tribes and Nations regarding management of the National Monument so that we may inform the land management agencies about impacts from proposed actions; and

20 TRIBES

INTER TRIBAL COUNCIL of ARIZONA

MEMBER TRIBES
AK-CHIN INDIAN COMMUNITY
COCOPAH TRIBE
COLORADO RIVER INDIAN TRIBES
FORT McDOWELL YAVAPAI NATION
FORT MOJAVE TRIBE
GILA RIVER INDIAN COMMUNITY
HAVASUPAI TRIBE
HOPI TRIBE
HUALAPAI TRIBE
KAIBAB-PAIUTE TRIBE
PASCUA YAQUI TRIBE
PUEBLO OF ZUNI
QUECHAN TRIBE
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
SAN CARLOS APACHE TRIBE
TOHONO O'ODHAM NATION
TONTO APACHE TRIBE
WHITE MOUNTAIN APACHE TRIBE
YAVAPAI APACHE NATION
YAVAPAI PRESCOTT INDIAN TRIBE

RESOLUTION 0609

In Support of H.R. 644, The Grand Canyon Watersheds Protection Act of 2009

WHEREAS, the Inter Tribal Council of Arizona (ITCA), an organization of twenty tribal governments in Arizona, provides a forum for tribal governments to advocate for national, regional and specific tribal concerns and to join in united action to address those concerns; and,

WHEREAS, the member Tribes of the Inter Tribal Council of Arizona have the authority to act to further their collective interests as sovereign tribal governments; and,

WHEREAS, Congressman Raul Grijalva introduced H.R. 644, The Grand Canyon Watersheds Protection Act of 2009, and the House Natural Resources Committee chaired by Congressman Grijalva held a hearing on this bill on July 21, 2009; and,

WHEREAS, H.R. 644 aims to protect land and water resources from mining operations, specifically uranium mining by withdrawing approximately 1,068,908 acres of land surrounding the Grand Canyon; and,

WHEREAS, there are already 10,000 existing mining claims in the proposed protected area; and

WHEREAS, companies wishing to mine uranium claim that the current process of mining uranium is safer and cleaner then in the past; and,

WHEREAS, these claims are inconclusive and radioactive containments could poise a devastating threat to groundwater and other natural resources; and,

WHEREAS, the Colorado River and the major drainages which feed into the river are connected to ground water sources that would be affected by these mining operations; and,

WHEREAS, the experience of Tribes where uranium mining took place in the past on or near their reservations continues to haunt them with radioactive contamination sites yet to be recovered and cleaned up, and with devastating diseases affecting members of Tribal populations caused by exposure to uranium; and,

When recorded please return to:
BOARD OF SUPERVISORS
Clerk of the Board
219 East Cherry Ave
Flagstaff AZ 86001

Official Records of Coconino County
Patty Hansen - Recorder 04/10/2019 01:59 PM
COCONINO COUNTY BOARD OF SUPERVISOR GA
3839110
Pgs: 2
$8.00

RESOLUTION 2019-08

A RESOLUTION OF THE BOARD OF SUPERVISORS OF COCONINO COUNTY, ARIZONA, IN SUPPORT OF THE PERMANENT WITHDRAWAL OF THE GRAND CANYON AND SURROUNDING WATERSHED ACREAGE FROM MINING AND OTHER FORMS OF WITHDRAWAL AND APPROPRIATION OF PUBLIC LANDS.

WHEREAS, Coconino County previously adopted a resolution (No. 2008-09) which stated clearly that the County "opposes uranium development on lands in the proximity of the Grand Canyon National Park and its watersheds"; and

WHEREAS, U.S. Rep. Raul Grijalva, along with 27 cosponsors including Rep. Tom O'Halleran, introduced H.R. 1373, the Grand Canyon Centennial Protection Act, on February 26th, 2019 which will prohibit all mining and other extractions within the Grand Canyon National Park and its watershed, protecting over one-million acres from mining contamination; and

WHEREAS, the negative health impacts of uranium mining are evident throughout the County and within the Grand Canyon National Park and its watershed with radioactive waste from uranium mining;

NOW THEREFORE BE IT RESOLVED, that the Coconino County Board of Supervisors reaffirms Resolution 2008-09 and opposes uranium mining in the Grand Canyon National Park and its watershed;

AND BE IT FURTHER RESOLVED, that Coconino County supports and urges passage of legislation that will permanently prohibit future mining and other forms of withdrawal and appropriation of public lands in the Grand Canyon National Park and its watershed.

PASSED and ADOPTED this 2nd day of April, 2019.

AYES: 4

NO'S: 1

ABSENT: 0

COCONINO COUNTY BOARD OF SUPERVISORS

Art Babbott

Art Babbott, Chairman

(SEAL)

ATTEST:

Lindsay Daley
Clerk of the Board

APPROVED AS TO FORM:

Rose Winkeler
Deputy County Attorney

URANIUM MINING

in the Grand Canyon Region

Amber Reimondo

JANUARY 2019

GRAND CANYON TRUST

BLAKE MCCORD

Table of Contents

Executive Summary

AMY MARTIN

The Grand Canyon region is home to some of the highest-grade uranium ore in the United States, which has made it a focal point of mining interests in the past. The Grand Canyon is also an important cultural and environmental resource where substantial scientific questions regarding the scope and severity of risks posed by uranium mining remain unanswered. East of Grand Canyon National Park, hundreds of abandoned uranium mines still litter the Navajo Nation, contaminating land and water. Across the Colorado Plateau, uranium mining and milling have left a toxic and expensive legacy.

In 2012, in response to a spike in uranium prices that triggered 10,000 new mining claims around the Grand Canyon, the secretary of the interior placed a 20-year ban on all new mining claims on about 1 million acres of federal land surrounding the national park. The ban is intended to allow time for scientists to study the risks of mining uranium in this treasured landscape. Six years in, that research remains chronically underfunded and incomplete. The uranium industry has repeatedly challenged the Grand Canyon mining ban in court and lost. In October 2018, the Supreme Court laid legal challenges to the mining ban to rest by refusing to hear an appeal by mining industry groups.

However, uranium companies and politicians claim mining uranium in the U.S. is an issue of economic and national security. In 2018, two executive orders from the Trump administration renewed interest in uranium. Now, at the request of uranium companies, the Department of Commerce is considering recommending uranium import quotas and other protective measures. If the president acts to enhance access to domestic uranium reserves and to boost uranium prices, the Grand Canyon mining ban may end up in the administration's crosshairs.

But is mining uranium in the Grand Canyon region really an issue of economic security? In northern Arizona, the data suggests otherwise. Outdoor recreation and tourism are the economic engines of the Grand Canyon region. They support over 9,000 jobs, contribute over $938 million annually to gateway economies, and generate over $160 million in annual state and local tax revenues. Uranium mining threatens these economic drivers while possessing little capacity to support the regional economy.

Additionally, mining uranium in the Grand Canyon region does not appear to be key to U.S. national security. The U.S. has enough already-mined uranium to meet its defense needs, supply its electrical grid, and insulate itself from disruptions in the supply chain. The U.S. is able to obtain the majority of the uranium it needs from suppliers in the U.S., Canada, and Australia, and has enough enriched uranium stockpiled to meet military needs until 2060. Forcing the purchase of domestically mined uranium would actually harm the U.S. uranium supply by shutting out uranium from allied countries. Lastly, according to the U.S. nuclear power industry, protecting domestic uranium mining through import quotas and a "buy American" requirement would, in fact, raise costs and force nuclear power plants to close.

Uranium mining around the Grand Canyon does not make economic, cultural, or ecological sense. Uranium deposits are common throughout the world and the Grand Canyon region is home to only 0.29 percent of all known U.S. reserves. Attempts to cast domestic uranium mining as critical to U.S. economic and national security are misleading and aimed at increasing demand and boosting the bottom line of uranium companies. Given the significant environmental, cultural, and economic risks, the Grand Canyon mining ban should remain in place and uranium that lies next to the Grand Canyon should be left in the ground.

BLAKE MCCORD

Introduction

MICHAEL QUINN, NATIONAL PARK SERVICE

The Grand Canyon has been inhabited by humans for thousands of years and is culturally significant to at least 11 federally recognized Native American tribes.[1] The Grand Canyon region is incredibly biodiverse; it is home to five of the seven life zones and three of the four desert types found in North America. The region hosts over 2,000 plant and animal species, some of which are threatened, endangered, and/or not found anywhere else in the world.[2] Each year, Grand Canyon National Park draws millions of visitors who spend hundreds of millions of dollars in gateway communities in northern Arizona.[3]

The Grand Canyon region is also home to some of the highest-grade uranium ore in America. Due to uncertainties surrounding the environmental impacts of uranium mining, in 2012, the secretary of the interior placed a 20-year ban on new mining claims on about 1 million acres of federal land around Grand Canyon National Park.[4] Some want to see that ban end prematurely.

In 2018, the Interior Department officially listed uranium as a "critical mineral,"[a] and, at the request of mining companies, the Commerce Department launched an investigation into whether to impose import quotas and domestic-purchasing requirements on U.S. uranium buyers.[5] Both actions imply that mining uranium in the U.S. is vital for economic and national security. Both actions could ultimately lead to an increase in demand for domestically mined uranium. Some cite economic and national security as reasons to reopen the Grand Canyon region to mining. But is domestic uranium mining really an important economic and national security issue? Who stands to benefit if the regional ban on uranium mining is lifted? This report explores these questions and explains why the ultimate beneficiary of mining around the Grand Canyon is the uranium industry, not the American public.

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[a] Executive Order 13817. "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals." 3 C.F.R. (2017). Section 2. *whitehouse.gov.* December 20, 2017. https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/. Accessed 15 October 2018. "A 'critical mineral' is a mineral identified by the Secretary of the Interior pursuant to subsection (b) of this section to be (i) a non-fuel mineral or mineral material essential to the economic and national security of the United States, (ii) the supply chain of which is vulnerable to disruption, and (iii) that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security."

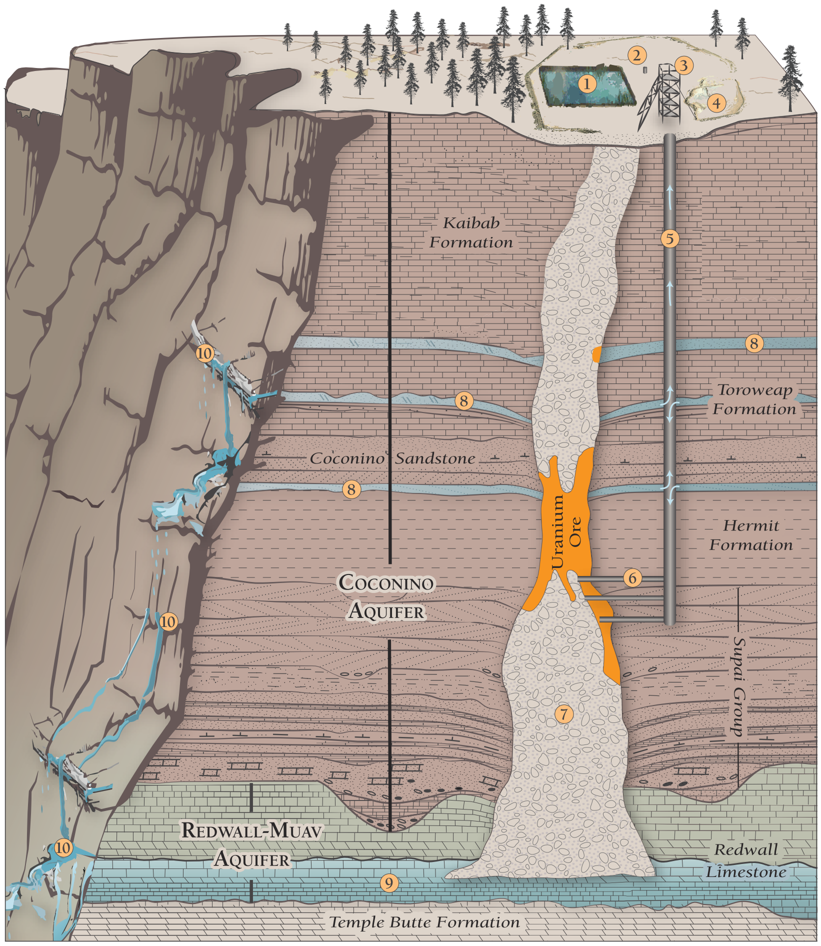
Background

URANIUM DEPOSITS AROUND THE GRAND CANYON

The Grand Canyon region holds some of the richest known reserves of uranium ore in the U.S., though these reserves are still far below ore grades found in Canada, Australia, and other countries. For comparison, the McArthur River Mine in Saskatchewan, Canada, has ore containing 9.6 percent uranium oxide,[6] while even the higher-quality ore deposits in the Grand Canyon region contain less than 1 percent uranium oxide.[7] The ore deposits in the Grand Canyon region that are most attractive for mining are found in geologic features called breccia pipes.

Below the rim of the Grand Canyon, many layers deep into the earth, sits a layer of Redwall Limestone between 120 and 215 meters thick. Hundreds of millions of years ago, underground caves formed in this layer as the limestone reacted with carbonic acid—essentially carbon-dioxide-laden water—and dissolved.[8] Over time, these caves collapsed, triggering the eventual collapse of the sedimentary rock layers that sat atop them. The results are vertical, pipe-like features thousands of feet deep and typically about 300 feet in diameter. Inside of them, breccia—a rock composed of broken fragments of rock and minerals—formed from the pieces of collapsed rock. Mineralized groundwater flowed through the breccia pipes and deposited various minerals, including uranium, in concentrated forms.[9]

Characterization of Uranium Deposits and Mining near Grand Canyon



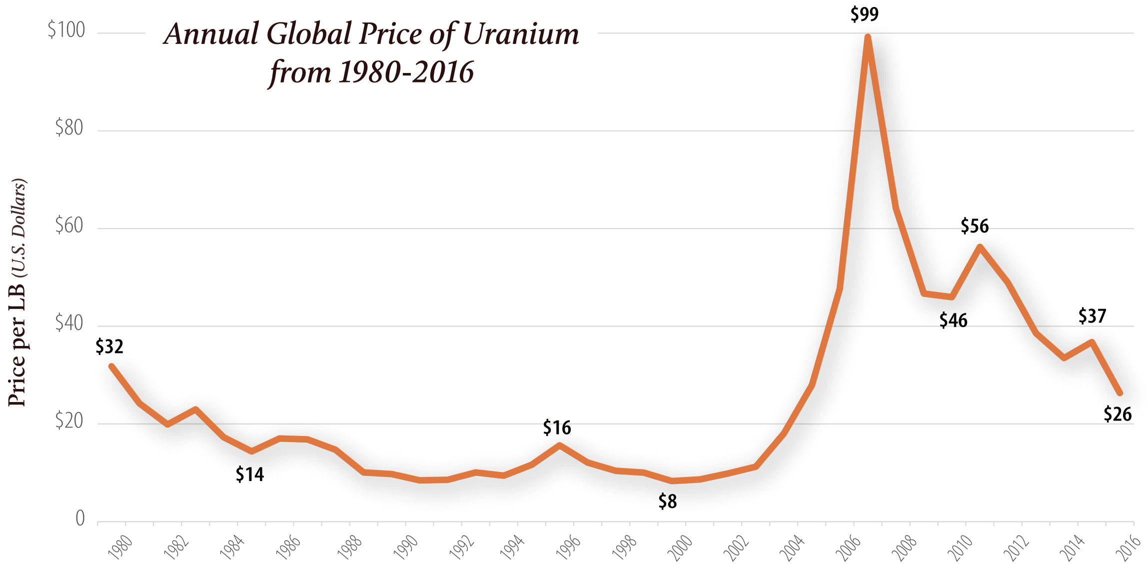
Source: Generalized and modified from the USGS Site Characterization of Breccia Pipe Uranium Deposits in Northern Arizona and Uranium Mine Conceptual Model
Graphic By Stephanie Smith

① Containment pond
② Ventilation shaft
③ Mine headframe
④ Waste rock, ore pile, & top soil storage
⑤ Mine shaft
⑥ Horizontal shaft ("drifts")
⑦ Breccia collapse feature
⑧ Perched aquifer
⑨ Regional aquifer
⑩ Seep or spring
Potential water flow in mine shaft

Unlike some uranium deposits, breccia pipe deposits are mined using underground mechanical methods, not in open pits or with chemical solutions to dissolve the uranium in place.

Uranium Market

Uranium, like many mineral resources, is a boom-and-bust commodity. Since the federal government recognized that it possessed a surplus of uranium and stopped paying bonuses to mining companies for discoveries,[10] the price of uranium has fluctuated with supply and demand within the global uranium market. Over much of the past three decades, the global uranium market has been saturated, a circumstance compounded by a drop in demand after the 2011 Fukushima nuclear disaster. Consequently, the average price of uranium has, for the most part, remained low. But there was a relatively brief period in 2007-2008 when the price of uranium spiked to an all-time high.[11] This caused renewed interest in uranium deposits in the Grand Canyon region. By 2009, over 10,000 mining claims had been staked on public lands adjacent to Grand Canyon National Park[12] even though the price of uranium had again started to decline.[13]


Annual Global Price of Uranium from 1980-2016

Data source: International Monetary Fund, Global price of Uranium, retrieved from FRED, Federal Reserve Bank of St. Louis.

THE GRAND CANYON MINING BAN

The potential for uranium mining in the Grand Canyon region caught the attention of more than just mining companies. Native American tribes, local governments, conservationists, hunters and anglers, business owners, and other stakeholders grew concerned about the effects of a drastic increase in uranium mining in the Grand Canyon region and what it could mean for such a culturally, ecologically, and economically significant landscape. In 2012, triggered by those concerns and following a multi-year public process, then Interior Secretary Ken Salazar withdrew for 20 years about 1 million acres of federal land next to Grand Canyon National Park from the location and entry of new mining claims under the 1872 Mining Law.[14]

This two-decade mining ban was meant to give scientists more time to research the region's vast hydrologic and biological unknowns before allowing new mines to begin operating, potentially putting the landscape and ecosystems of the Grand Canyon at risk.[15] As long as these unknowns exist, land managers and the public cannot understand and weigh all of the risks. Researchers don't know if or how uranium can be mined safely in this region while protecting land, water, wildlife, people, and one of the Seven Natural Wonders of the World.

Although the ban was intended to hit pause on mining to allow time for research, to date, Congress has underfunded that research, causing it to fall behind schedule, according to the U.S. Geological Survey (USGS), the Interior Department's scientific research arm. In fact, the USGS didn't receive initial funding for the planned research until 2015 and in subsequent years has received just a fraction of the amount budgeted in the original research plan. The Trump administration's 2019 budget proposal eliminates this research funding entirely.[16] The delay of the planned studies jeopardizes the goals of the research: to find definitive answers to critical scientific questions by the ban's expiration in 2032.[b]

It is important to note that the mining ban doesn't necessarily stop all mining. Miners who had established valid rights before the ban was adopted may still be allowed to mine despite the ban. To date, only Canyon Mine, located on the Kaibab National Forest near the popular south rim entrance to Grand Canyon National Park, has been allowed to operate during the ban, thanks to a green light from the U.S. Forest Service. That green light is being challenged in the courts.

Broad Support, Sharp Opposition

The public process that preceded the mining ban considered nearly 300,000 public comments[17] and revealed broad support for the ban from people across northern Arizona. Native American tribes, local governments and businesses, elected officials, sportsmen, and recreationists agreed that a mining ban was in the best interest of the Grand Canyon region and the northern Arizona economy. This sentiment was recently reaffirmed by a bipartisan poll conducted in the summer of 2018.[18] The poll, administered by Republican and Democratic polling firms, showed that the majority of Arizonans across the political spectrum support protecting the mining ban and view the protection of the state's public lands and the value of outdoor recreation and tourism as more critical to the long-term health of the state's economy than mining for uranium or other minerals.

Large majority in bipartisan poll say outdoor recreation and tourism is more important to Arizona economy than mining

Percent of Arizonans surveyed

Outdoor recreation and visitors to national parks and other pubic lands is most important to the future of the Arizona economy.

Mining of uranium and other minerals is more important to the future of the Arizona economy.

The remaining 6% didn't respond or didn't have an opinion.

---

[b] United States Geological Survey staff member. Personal Interview. March 1, 2018. Based upon a telephone conversation between Grand Canyon Trust staff and USGS research staff on March 1, 2018: While research funding was planned to begin in 2013 (see USGS 15-Year Science Plan), Congress did not approve those funds. It wasn't until 2015 that partial funding began to be approved, but even then, it was only about $1 million per year, about one quarter of the budgeted annual amounts for 2013-2016, according to the 15-year science plan (plan viewable at https://az.water.usgs.gov/projects/Uranium/docs/GrandCanyonSciencePlan.pdf). About half of the annual funding for 2013-2014 was needed for the drilling and development of key monitoring wells. Without funding to drill those wells, they were never completed. President Trump's 2019 budget proposal completely eliminates the funding for the USGS Toxic Substances Hydrology Program under which Grand Canyon research is conducted. According to USGS staff, with no monitoring wells and improper funding, definitive answers are "not possible" before 2032.

Majority support the ban to protect Grand Canyon

Bipartisan poll: continuing the existing ban on new uranium mining next to Grand Canyon National Park.

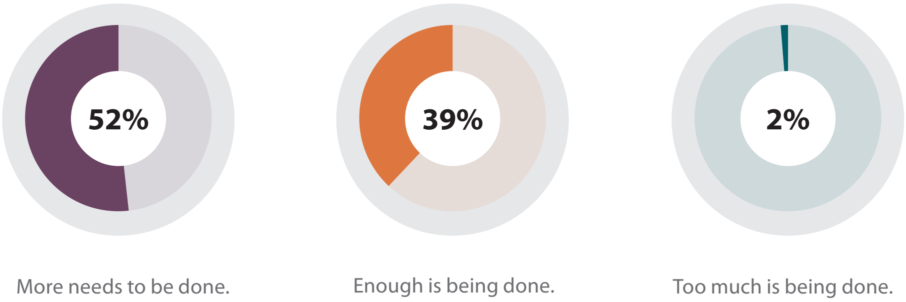
Percent of Arizonans surveyed

The remaining 6% didn't respond or didn't have an opinion.

Majority say more needs to be done to protect Grand Canyon

Bipartisan poll: protecting the air, land, and water around the Grand Canyon

Percent of Arizonans surveyed



The remaining 7% didn't respond or didn't have an opinion.

Court Case

While the mining ban has been challenged in court, it has been repeatedly upheld. The mining industry and some elected officials continue to argue that the ban constitutes federal overreach and that uranium mining around the Grand Canyon is necessary for economic and national security. In 2014, the National Mining Association and its allies lost a legal battle in U.S. District Court for the District of Arizona when the court upheld the mining ban. They appealed to the 9th Circuit Court of Appeals and lost in December 2017. In early 2018, the mining industry asked the U.S. Supreme Court to take the case; that request was denied in October 2018, ending efforts to dissolve the ban via the courts.

Executive Orders

The pressure to lift the mining ban extends beyond the judiciary. Two executive orders from President Trump have contributed to tension around the mining ban. Executive Order 13783 mandated that federal agencies “immediately review existing regulations that potentially burden the development or use of domestically produced energy resources and appropriately suspend, revise, or rescind those that unduly burden the development of domestic energy resources.”[19] In response, the Agriculture Department included the Grand Canyon mining ban on a list of recommended actions for review and revision by 2020.[20] On December 20, 2017, President Trump signed Executive Order 13817, directing Interior Secretary Ryan Zinke to develop a new list of critical minerals.[21] Curiously, the USGS had released an updated list of critical minerals just the day before; that list did not include uranium.[22] However, the new list, created in accordance with the executive order and finalized in May 2018, does include uranium.[23] Under the executive order, the Commerce Department is required, by late 2018, to develop a report that includes, among other objectives, “recommendations to streamline permitting and review processes related to developing leases; enhancing access to critical mineral resources; and increasing discovery, production, and domestic refining of critical minerals.”[24]

Uranium Industry Petition for Import Quotas

Meanwhile, in January 2018, two uranium-mining companies submitted a petition to the Commerce Department under Section 232 of the Trade Expansion Act. In the petition, both companies assert that state-sponsored producers in Russia, Kazakhstan, Uzbekistan, and China are “destroying” the U.S. uranium-mining industry and have “already seized the majority of the U.S. market.”[25] The companies insist that, in the name of national security, the Commerce Department must ask President Trump to impose import quotas and a “buy American” requirement for uranium. They contend that the requested measures would result in a higher market price for domestically mined uranium,[c] which one company executive told investors could “change our business overnight.”[d] In July 2018, the Commerce Department agreed to consider the petition and plans to send any recommendations to the president no later than mid-April 2019.[26]

If President Trump takes measures to enhance access to domestic uranium reserves and to boost uranium prices, the Grand Canyon mining ban may end up in the crosshairs. If mining uranium in the U.S. becomes an administrative priority, it is conceivable that some would look to end the Grand Canyon mining ban given that the Grand Canyon region is home to some of the country’s highest-grade known uranium reserves.[27] The current political conversation already involves such suggestions. For example, citing national security and lost economic opportunity,[28] members of the Congressional Western Caucus[29] and the Mohave County Board of Supervisors[30] have separately urged that the mining ban be eliminated.

Past Uranium Operations on the Colorado Plateau

Concerns about uranium mining near the Grand Canyon haven’t materialized from thin air. Past uranium-mining activities have exacted a serious toll across the Colorado Plateau, especially on Native American lands. Since the 1950s, the plateau has been home to at least 22 uranium mills[e] and to the

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[c] According to the Energy Fuels Resources (USA) Inc. and Ur-Energy USA Inc. Petition For Relief Under Section 232 Of The Trade Expansion Act Of 1962 From Imports Of Uranium Products That Threaten National Security: “Under the 25 percent quota, prices increase $21 per pound in 2018 and $32 per pound in 2022…which translate to a 69 and 104 percent increase in domestic prices respectively.” See page 2 of exhibit 2: http://www.energyfuels.com/wp-content/uploads/2018/01/2018.01.16-Exhibits-to-Petition_Part1.pdf.

[d] Energy Fuels’ president told an audience at an investor conference that if the requests in the Section 232 Petition were granted, “that could change our business overnight.” See timestamp 8:53 at http://noble.mediasite.com/mediasite/Play/b50773278de54313bf57df435ba81a881d.

[e] Ambrosia Lake, NM, Title I (Legacy Management (LM) Site); Bluewater, NM, Title II (LM Site); Church Rock, NM, Title I (Pending transfer to LM); Grants, NM, Title I (Pending transfer to LM); L-Bar, NM, Title II (LM Site); Lisbon Valley, UT, Title II (Pending transfer to LM); Moab, UT Title I, (Pending transfer to LM); Shootaring, UT, Title II (Pending transfer to LM); Uravan, CO, Title II (Pending transfer to LM); White Mesa, UT, Title II, (Pending transfer to LM); Monticello, UT, Title I (LM Site); Slick Rock Processing, CO, Title I (LM Site); Rifle, CO, Title I (LM Site); Naturita, CO, Title I (LM Site); Gunnison, CO, Title I (LM Site); Green River, UT, Title I (LM Site); Grand Junction, CO, Title I (LM Site); Durango Disposal/Processing, CO, Title I (LM Site); Shiprock, NM, Title I (LM Site); Mexican Hat, UT, Title I (LM SIte); Monument Valley, AZ, Title I (LM Site); Tuba City, AZ, Title I (LM Site).

The Kanab North Mine located on the north rim of the Grand Canyon. Reclamation is finally underway after decades of the mine sitting on standby, but not before USGS scientists discovered that dust with radiation levels greater than 10 times background levels had blown beyond the mine's perimeter. ECOFLIGHT

majority of all uranium mining conducted in the U.S.[31] Estimates suggest that there have been over 1,000 mines and four uranium mills on the Navajo Nation alone.[32] Today, more than 500 of those mines have been abandoned by the mining companies that operated them and remain in need of cleanup.[33] To date, the Environmental Protection Agency (EPA) has entered into more than $1.7 billion in enforcement agreements and settlements for the cleanup of fewer than half the remaining sites.[34] While the Navajo Nation and the EPA work to assess and clean up these sites, the abandoned mines continue to contaminate groundwater and land near homes. In 2008, several U.S. and tribal government agencies identified 29 water sources on the Navajo Nation with uranium and other radionuclide levels in excess of drinking water standards.[f] A 2016 study by the Centers for Disease Control and Prevention and several state and local groups surveyed 599 participants on the Navajo Nation and found that "27 percent of the participants have high levels of uranium in their urine, compared to 5 percent of the U.S. population as a whole."[35]

The uranium mining industry dismisses past contamination, points to current environmental regulations as bulwarks, and claims that recent mines prove that modern uranium mines can be operated and cleaned up without contaminating land and water.[36] However, the dearth of evidence for these claims is the primary reason that the 2012 mining ban was put in place. In fact, more recent incidents at mines near the Grand Canyon demonstrate that there is still a lot of uncertainty about potential pathways for contamination in the region.

In 2010, the USGS noted that a 1984 flash flood washed ore from the Hack Canyon mines into Kanab Creek,[37] a major tributary of the Colorado River within the Grand Canyon. On the North Rim, the Pinenut uranium mine sat idle for two decades until 2009, when the mine shaft unexpectedly filled with over 2 million gallons of radioactively contaminated water.[38] Meanwhile, radioactive dust at the

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[f] United States Environmental Protection Agency, Bureau of Indian Affairs, Nuclear Regulatory Commission, Department of Energy, Indian Health Services, Agency for Toxic Substances and Disease Registry and Navajo Nation. "Federal Actions to Address Impacts of Uranium Contamination in the Navajo Nation: 2014-2018." Page 6. https://www.epa.gov/sites/production/files/2016-06/documents/nn-five-year-plan-2014.pdf. Accessed October 15, 2018. "EPA has entered into enforcement agreements and settlements valued at over $1.7 billion to reduce the highest risks of radiation exposure to the Navajo people from AUMs [abandoned uranium mines]. As a result, funds are available to begin the assessment and cleanup process at 219 of the 523 abandoned uranium mines."

Despite claims that the mine shaft at Canyon Mine would not hit significant water, the mineshaft has taken on so much water that the company has repeatedly resorted to misting it into the air. Contact between water and exposed uranium ore risks the spread of uranium and other mining contaminants. BLAKE MCCORD

Kanab North uranium mine blew from the mine site into the surrounding ecosystem.[39] Then, in the winter of 2016-2017, after the mining company claimed it would not hit significant water, the mine shaft at Canyon Mine flooded as the mine operator was in the process of digging it.[40] At the time of this report, more than a year after a perched aquifer was pierced, water is still draining from the aquifer into the mine shaft. In addition to hauling over 1 million gallons of water to the White Mesa Mill in southeastern Utah,[g] the company has installed water sprayers to keep the mine's onsite storage pond from overflowing. The water that is sprayed into the air, and potentially beyond the mine's fence line and into the surrounding landscape, carries elevated levels of uranium.[41] Sprayers were still in use at Canyon Mine as recently as October 2018. Determining whether groundwater has been contaminated at any of these sites is impossible when, in many places, scientists don't even know the direction of groundwater flow. This determination cannot be made without multiple costly, deep monitoring wells, which are currently expected to be funded by taxpayers rather than by the mine's owner, Energy Fuels Resources, Inc.

Next, there are uranium mills. Mills convert raw uranium ore into a purified and usable form, called yellowcake. Of the 22 conventional uranium mills that once operated on the Colorado Plateau, only one—the White Mesa Mill, owned and operated by Energy Fuels Resources, Inc., in southeastern Utah—is still operational. Currently, this is the only mill in the country that could process uranium ore mined around the Grand Canyon. Groundwater flows from the mill site south toward White Mesa, a small reservation community that is home to members of the Ute Mountain Ute Tribe. There is confirmed shallow-groundwater contamination beneath the mill site, though the mill's owner, the state of Utah, and the Ute Mountain Ute Tribe disagree about whether the mill's operations are the cause.

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[g] An email obtained through a public records request from Lee Decker, an attorney at Gallagher & Kennedy to Kenneth C. Slowinski of the Arizona Department of Water Resources, dated Tuesday, May 23, 2017 at 12:51p.m. states: "To date approximately 1.3 million gallons of impacted water has been transported to the Mill..."

The 21 other uranium mills that once operated on the Colorado Plateau are in various stages of standby, cleanup, and long-term maintenance by the federal government.[h] [42] The toxic and radioactive waste at some uranium mills is buried at the site rather than hauled elsewhere; this is the plan for future waste at the White Mesa Mill. Many conventional mills have left behind legacies of contamination.[43] The cleanup of these sites has been so expensive that, by the year 2000, the U.S. Department of Energy estimated it had spent nearly $1.5 billion toward cleanup efforts since 1978—a figure that one analysis found exceeds by over 50 percent the selling price of the uranium milled at these sites.[44] Contamination cleanup and control have continued in the 18 years since that figure was released. The cleanup of the Atlas Mill near Moab, Utah, alone is expected to cost around $1 billion by 2032.[45]

The rest of this report seeks to uncover who stands to benefit and who bears the risks of additional uranium mining in the Grand Canyon region.

The White Mesa Mill, located just three miles north and up-gradient of the Ute Mountain Ute Tribe's White Mesa community. AARON PAUL

Cleanup of the Atlas Uranium Mill, on the bank of the Colorado River in Moab, Utah, is expected to cost around $1 billion by 2032. JIM HODDENBACH, MOAB URANIUM MILL TAILINGS REMEDIAL ACTION (UMTRA) PROJECT, U.S. DEPARTMENT OF ENERGY

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[h] At https://www.energy.gov/lm/sites, click links to "LM sites" or "Pending Transfer sites" then click on names of different uranium mills. This will bring you to fact sheets about each mill for background on contamination, cleanup, and other information.

The Grand Canyon Regional Economy

As the damage of past uranium operations lingers, mining companies and other opponents of the Grand Canyon mining ban pivot the conversation to jobs, economic growth, and national security. They insist that the ban on uranium mining on 1 million acres of public land stifles job creation and economic growth in northern Arizona. They also claim that domestically mined uranium is critical to national security and the stability of the U.S. electrical grid, since nuclear power plants supply about 20 percent of U.S. electricity.[46]

Are these claims accurate? Using data and public records, we look at the reality of the regional economy, explore some of the mining industry's claims about national security, and consider whether those assertions justify putting the health and future of the Grand Canyon region at risk.

Is Uranium Mining a Realistic Economic Driver?

Jobs and Revenue from Mining

An economic analysis conducted during the public process before the Grand Canyon mining ban was finalized estimated that if the ban did not exist, the uranium-mining industry could hypothetically support 636 jobs in the region,[47] 295 of those directly.[48] Before the ban, 0.6 percent of jobs in northern Arizona came from a variety of mining types, including oil, gas, coal, nickel, zinc, copper, stone, iron, and others.[49] In the 2000s, the region's entire mining industry provided an average of 545 jobs per year.[50] Notably, that time period included the last uranium price spike in 2007, which was an all-time high for the commodity.[51] In 2009, before the mining ban took effect, mining supported 345 jobs in Coconino and Mohave counties; none of them were in uranium mining.[52]

Case Study: Canyon Mine

Today, one of the region's uranium mines—Canyon Mine, near the south rim of the Grand Canyon—is poised to begin extracting ore despite the mining ban. Though Canyon Mine has been exempted from the ban, the mine's owner, Energy Fuels Resources, Inc., has postponed mining and hauling ore to the White Mesa Mill because of low uranium prices. The company's last two quarterly reports to the Mine Safety and Health Administration declared nine and then two employees at the site.[53] These numbers reflect staffing during a difficult market environment. However, even if the price of uranium rose and business were booming, breccia pipe uranium mines are relatively quick operations; even the best mining jobs would be temporary. Canyon Mine's 1986 plan of operations estimated that the mine would be depleted after 10 years of operation.[54] Energy Fuels maintains that the mine would employ 60 people during whatever period of that 10 years the mine is in peak operation.[55] Based on this information, uranium mining was never a key provider of regional jobs, let alone sustainable jobs, even before the mining ban was established. Even in the best of market environments, it is unlikely that uranium mining would ever provide a large number of stable, long-term jobs for local communities.

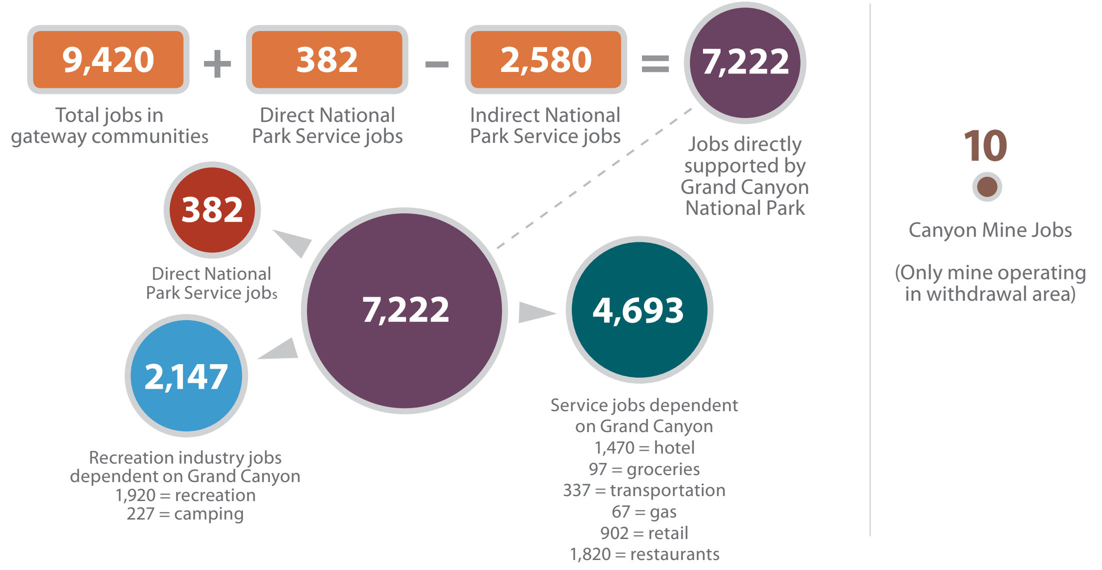
The Tourism Economy

By comparison, Grand Canyon National Park is a key driver of the regional economy. In 2017, the park employed 382 people[56] and supported an additional 9,420 jobs in gateway communities—that's 9,802 total jobs attributable to Grand Canyon National Park, 7,222 of them directly supported by the park.[57] All of these jobs depend on the health of the cultural, recreational, and ecological resources of the Grand Canyon. Yet, uranium mining—especially if it is done without completing the research the ban promised—could gravely harm the Grand Canyon, to the lasting detriment of those who live in and depend on it.

In addition to jobs, gateway economies benefit from tax revenues and increases to the gross regional product. Outdoor recreation and tourism in northern Arizona generated $160 million in local and state tax revenue in 2016.[58] Visitors to Grand Canyon National Park contributed $938 million to gateway economies in 2017.[59]

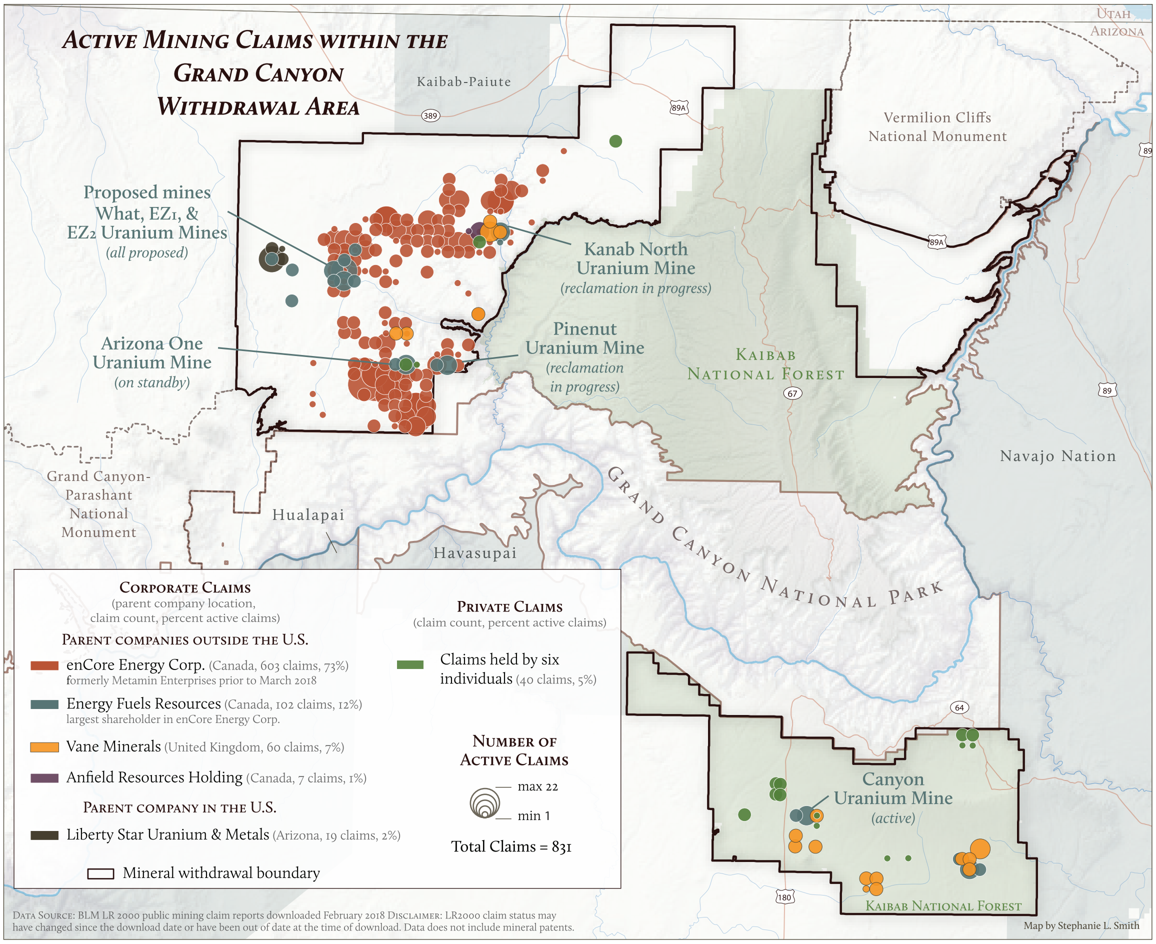
Meanwhile, uranium mining is still regulated under the 1872 Mining Law, enacted during the time of Manifest Destiny, when the federal government provided every possible incentive to encourage westward expansion. Under the law, uranium-mining companies owe no federal royalties on minerals they extract from public lands. This is in contrast to oil and gas drilling or coal mining, for which companies pay a percentage of their sales to public coffers at the local and federal levels.[60] The economic analysis conducted as part of the environmental impact statement prior to the mining ban estimated that federal, state, and local governments could see approximately $22.9 million in added annual revenue as a result of uranium mining if the ban were not implemented—$12.3 million of which would be state and local tax revenues.[61] The same study projected that the minable uranium resources in the area of the proposed ban would be "exhausted by the end of the 20 year period," at which point "uranium mining related jobs and economic benefits would cease."[62]

Jobs created by Grand Canyon National Park v. Jobs in mining (2017)



International Uranium Players

Current Bureau of Land Management data reveals that of the more than 10,000 mining claims within the mining-ban boundaries in 2009,[63] 831 remain in active status as of February 2018. Of those 831 remaining mining claims, 93 percent are held by just four mining companies, all subsidiaries of companies based in either Canada or the United Kingdom.[64] One of those companies, Energy Fuels Resources, Inc., co-authored the Section 232 Petition urging the Commerce Department to provide subsidies for businesses that mine uranium in the U.S. Another of these companies, enCore Energy Corp., acquired the vast majority (73 percent) of claims in the region in early 2018.[65] EnCore—a U.S. subsidiary of a Canadian company—also bought mining claims in the Bears Ears region in Utah from Energy Fuels. Part of the sale price was shares in enCore. That deal made Energy Fuels a primary shareholder of enCore, with about 20 percent of the company's shares, more than any other individual or entity.[66] Together, Energy Fuels and enCore now control 85 percent of claims in the current Grand Canyon mining ban area.



Data Source: BLM LR 2000 public mining claim reports downloaded February 2018 Disclaimer: LR2000 claim status may have changed since the download date or have been out of date at the time of download. Data does not include mineral patents.

Both companies are positioned to start mining if the ban is lifted, and both openly advertise their willingness to sell U.S. uranium globally. One paid internet advertisement for Energy Fuels reads "American Uranium, Clean Global Energy." In a January 2015 letter to the Energy Department (DOE), enCore wrote that it had "the capacity to license, develop and produce uranium properties in the United States and market that material throughout the world."[67] This raises doubts about whether any of their operations in the Grand Canyon region would truly be done in service to U.S. economic and national security.

Sen. Jeff Flake tries to force FBI investigation into sex allegations of Brett Kavanaugh

"American Uranium, Clean Global Energy" Advertisement by Energy Fuels taken 9/28/2018

National Security and Grand Canyon Uranium

In the petition submitted in early 2018 under Section 232 of the Trade Expansion Act, uranium-mining companies argued that enabling more domestic uranium mining is key to U.S. national security. According to the petition, a national security threat stems from state-sponsored producers in Russia, Kazakhstan, Uzbekistan, and China "destroying" the U.S. uranium-mining industry. The petition states that these producers have "already seized the majority of the U.S. market."[68] It also claims that "maintaining [the U.S. nuclear] deterrent requires a healthy U.S. uranium mining industry," and that, if U.S. mining fades, the country will "lose a highly-skilled workforce."[69] These are overstatements made by private mining companies in the pursuit of profit.

U.S. Purchases from State-Owned Mines

Contrary to a misrepresentation early on in the petition that claims U.S. uranium supplies are primarily obtained from foreign state-owned mines, U.S. Energy Information Administration (EIA) data shows that the majority of uranium purchased by U.S. nuclear utilities in 2016 originated from countries other than Russia, Kazakhstan, Uzbekistan, and China.[70] The mining companies even share EIA data later in the petition that shows the earlier alarmist claim to be a misrepresentation of the facts.[71]

The data shows that mines in these four countries actually supplied about 13.7 million pounds of uranium, only 32 percent of U.S. demand in 2017. That minority role in the U.S. market is not an anomaly. Based on government data, since 1994, imports from Russia, Kazakhstan, Uzbekistan, and China have never made up the majority of U.S. uranium supplies. U.S. purchases of uranium from these four countries have slightly decreased since 2008. That year, mines in Russia, Kazakhstan, and Uzbekistan supplied about 17.5 million pounds, or 33 percent, of U.S. uranium demand.[72] China did not sell uranium to the U.S. that year.

2010 saw the largest share of U.S. demand ever supplied by these countries, when just over 19 million pounds, or 41 percent of U.S. uranium purchases, came from mines in Russia, Kazakhstan, and Uzbekistan; China did not sell uranium to the U.S. in 2010 either.[73] These countries accounted for similar portions of U.S. uranium purchases in 2007[74] and 2011,[75] when Russian, Kazakh, and Uzbek mines collectively supplied 20 and 22 million pounds respectively; both figures represent 40 percent of U.S. demand for those years. China contributed to the U.S. supply only in 2011, but not in 2007. Since 1994, these four countries have provided an average of 29 percent of U.S. uranium demand, far below a majority.[76]

On average, the majority of uranium purchased by the U.S. has come from the U.S., Canada, and Australia. In 2017, these three countries supplied 58 percent of U.S. demand. Since 1994, an average of 59 percent of U.S. demand has come from the U.S., Canada, and Australia.[i]

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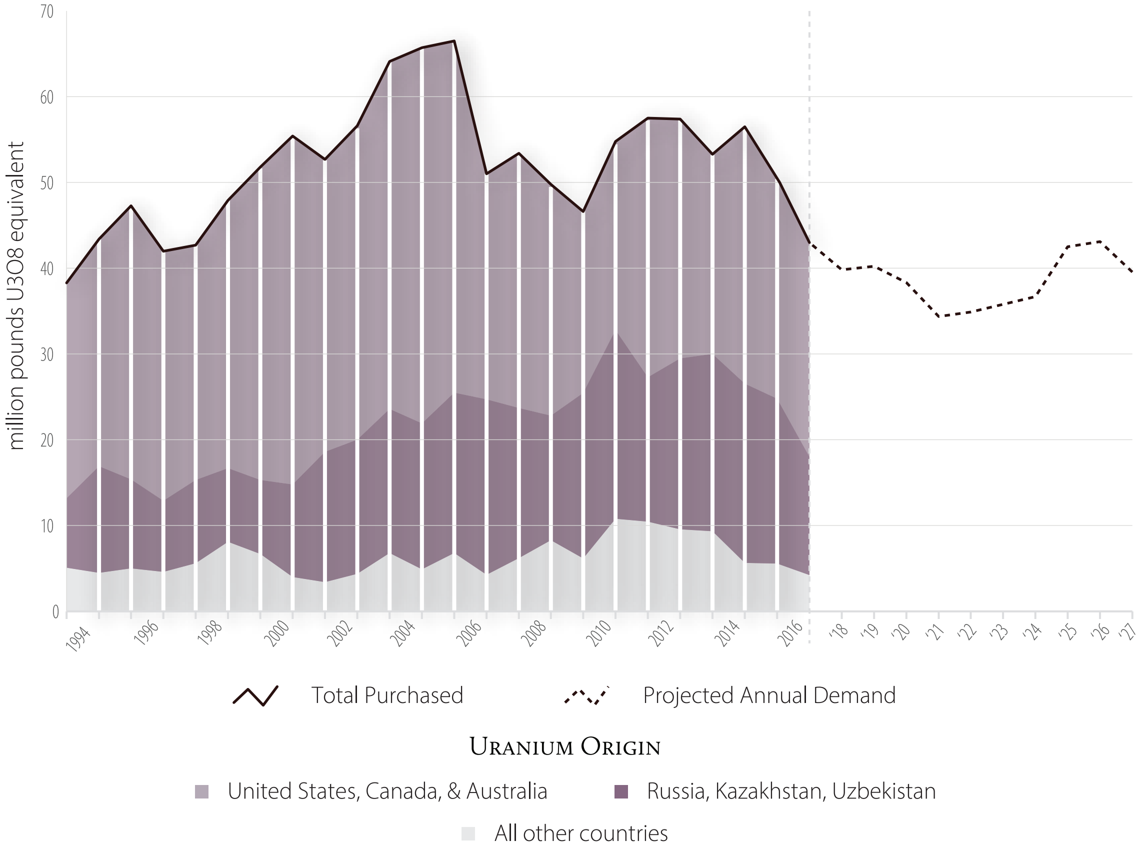
[i] Data taken from annual Uranium Marketing Reports by the Energy Information Administration from 1994 to 2017. Divided the sum of uranium supplied to U.S. nuclear reactors from the U.S., Canada, and Australia each year by the total uranium purchased by U.S. reactors each year (U.S. demand). Example: In 2017, 25 million pounds U_3O_8 came from U.S., Canada, Australia; 25 million pounds divided by 43 million pounds total U_3O_8 purchased by U.S. reactors = 58 percent of U.S. demand. EIA Annual Uranium Marketing Reports accessible at: https://www.eia.gov/uranium/marketing/.

Total Annual Uranium Purchased by Origin Country and Projected Future Demand



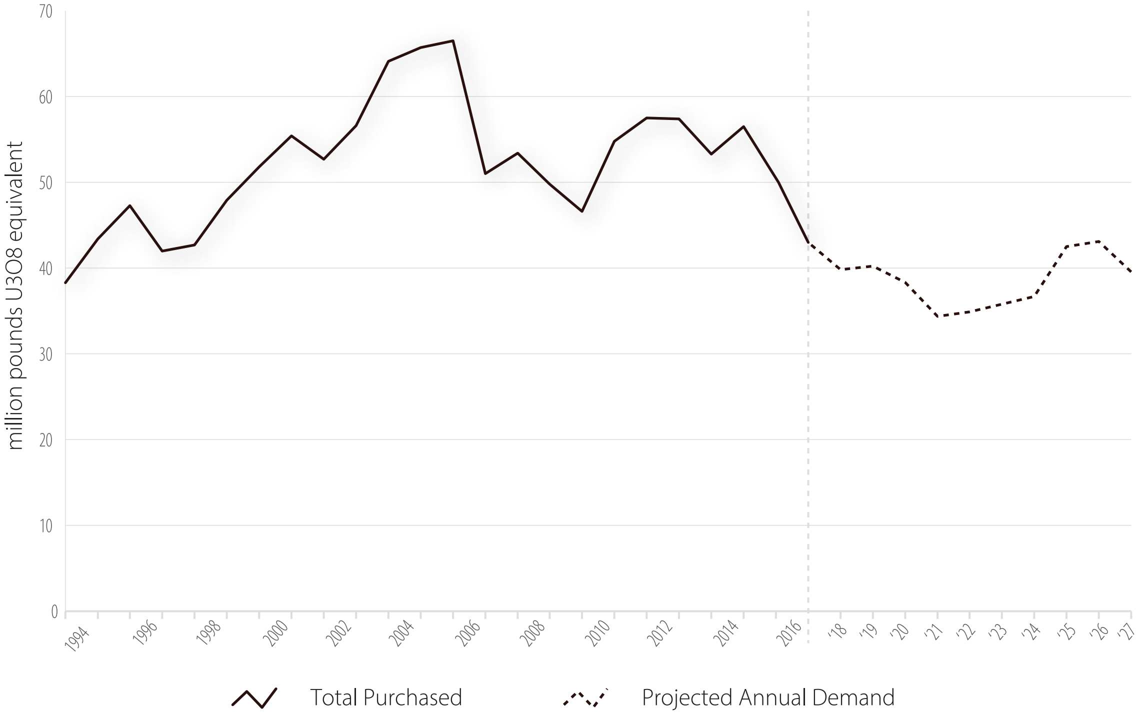
Data Source: EIA Uranium Marketing Annual Reports, Uranium purchased by owners and operators of U.S. civilian nuclear power reactors, 1994–2017 and Contracted purchases of uranium by owners and operators of U.S. civilian nuclear power reactors, signed in 2017, by delivery year, 2018–2027

Import Quotas and a "Buy American" Requirement Could Hurt Supply

The Section 232 Petition argues that uranium mines in the U.S. are put at risk by the looming expiration of an agreement that restricts Russian uranium imports, as well as by Russia's and China's plans to ramp up their roles in the U.S. uranium market.[77] To further emphasize the argument that foreign state-owned uranium suppliers jeopardize U.S. uranium supply, the petition points to Canadian mines—which meet a significant portion of U.S. uranium demand—that were placed on standby in 2018 due to poor market conditions.[78] If these threats to U.S. uranium supplies are real, there are three reasons that import quotas and a "buy American" requirement are not the answer.

First, the Commerce Department report mandated by Executive Order 13817[79] is due in late 2018. If U.S. dependence on uranium is indeed a point of national security vulnerability, more emphasis should be placed on Section 4(i) of the order, which requires "a strategy to reduce the Nation's reliance on critical minerals." Lowering domestic demand for uranium would be the most effective long-term safeguard against U.S. dependence on state-owned uranium mines in countries such as Russia. Even without explicit measures to decrease U.S. uranium demand, demand is already declining.[80] In 2017, U.S. uranium demand was 43 million pounds, down from 50.6 million pounds in 2016.[81] The average of the EIA's "maximum anticipated uranium market requirements" for the years 2018 through 2027 is just 38.5 million pounds per year.[82]

Total Annual Uranium Purchased and Projected Future Demand



Data Source: EIA Uranium Marketing Annual Reports, Uranium purchased by owners and operators of U.S. civilian nuclear power reactors, 1994–2017 and Contracted purchases of uranium by owners and operators of U.S. civilian nuclear power reactors, signed in 2017, by delivery year, 2018–2027

Second, quotas would not differentiate between uranium from allied countries such as Canada or Australia and uranium from state-owned Russian or Chinese mines. Cameco, a uranium company with significant operations in the U.S. and Canada, submitted comments regarding the 232 Petition to the Commerce Department suggesting that import quotas would harm the company's operations.[j] Cameco claims that quotas would, in fact, reduce allied supplies of uranium and serve to further necessitate purchasing uranium from countries like Russia and Kazakhstan.[k]

And finally, Cameco cautions that the petition is "unrealistic in its estimate of feasible U.S. uranium production capabilities."[83] In other words, according to Cameco, quotas and a "buy American" requirement could actually prevent the U.S. from acquiring all the uranium it needs by blocking access to the international market.

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[j] Cameco Corporation. "Comments of Cameco Corporation on the Section 232 National Security Investigation of Imports of Uranium." September 25, 2018. Page 28. https://www.regulations.gov/document?D=BIS-2018-0011-0748. Accessed 25 October 2018. "If an import quota were placed on imports of Canadian uranium despite existing NAFTA provisions and longstanding bilateral trade policy, further eroding the viability of Canadian producers, Cameco might not be able to make the investment required to sustain reliable uranium supply to U.S. customers in the long-term. Unavailability of Canadian uranium supply would necessarily increase U.S. dependence on state-owned/state controlled producers, which would pose a clearer threat to U.S. energy and national security."

[k] "Cameco does not support the specific quota proposed by the petitioners, as it is unrealistic in its estimate of feasible US uranium production capabilities; would be difficult to implement and harmful to responsible participants in the US nuclear energy industry; and could ultimately increase US dependence on state-controlled uranium supplied by the countries of concern as listed in the petition."

Is the U.S. Uranium-Mining Industry Critical to National Security?

The Section 232 Petition claims that, should the U.S. uranium mining industry fade, more than only immediate uranium supplies will take a hit. The petition argues that the U.S. would "lose a highly-skilled workforce" along with the ability to maintain its nuclear deterrent[84] and a stable electrical grid.[85] But the facts do not support these claims.

On a global scale, uranium mining is not a dying practice. The fact that the companies that submitted these petitions and many in their leadership hail from outside of the U.S.[86] [87] demonstrates that these skillsets are readily importable, if indeed the risk of losing those skills is real.

URANIUM STOCKPILES FOR DEFENSE

The Section 232 Petition does not accurately represent the truth as to whether domestic uranium mining is the linchpin in assuring that the U.S. has the uranium it needs for defense. The petition misrepresents U.S. uranium supply for defense as directly dependent upon the U.S. uranium-mining industry. In fact, the U.S. already has enough enriched uranium stockpiled to meet military needs for decades to come; improving technology only strengthens that outlook. According to an October 2015 DOE report, tritium supplies—a fuel for nuclear warheads partly derived from nuclear fission of uranium—are sufficient through at least 2040, while other defense uses may not demand new uranium until 2060.[88] Even these estimates may be conservative.

A more recent study by Frank von Hippel[89] of Princeton University's Program on Science and Global Security showed that downblending (processing highly enriched uranium into any form of uranium product that contains less than 20 percent uranium-235) of excess weapons-grade uranium could supply enough low-enriched uranium for tritium production for another 20 years—through at least 2060.[90] According to von Hippel, the DOE has twice the amount of weapons-grade uranium it needs for the country's current stockpile of 3,800 nuclear warheads. Downblending just 20 percent of this weapons-grade uranium between 2035 and 2055 would provide enough low-enriched uranium for tritium production through 2060.[91]

Indeed, for years, the DOE has been managing a stash of excess uranium that is not needed for national security purposes.[92] Commentators such as the Union of Concerned Scientists have suggested that the U.S. may never need additional uranium for military purposes if it continues to reduce its nuclear weapons stockpile and converts its naval reactors to use low-enriched uranium rather than highly enriched uranium.[93] In its petition asking the Commerce Department to protect the U.S. uranium industry, Energy Fuels extensively discusses the importance of uranium to the U.S. nuclear weapons stockpile and naval fleet, but it avoids referencing the October 2015 DOE report on this topic.[94] As the former president of the World Nuclear Association has observed, "both Russia and the United States have stockpiles of highly enriched uranium from post-Cold War arms reductions. Neither country need ever fear a shortage of uranium, for weapons or electricity."[95]

URANIUM FOR NUCLEAR POWER

Regarding nuclear power generation, the stated goal of import quotas and a "buy American" requirement is to stabilize domestic nuclear power generation. But according to the nuclear power industry, this strategy is likely to fail.

In 2018, the NorthBridge Group, an economic and strategic consulting firm serving the electricity and natural gas industries, conducted a market impact study of the proposed import quotas on the U.S.

nuclear power industry. It found the analysis of costs to the power industry in the Section 232 Petition to be "deficient." According to the study, if the Section 232 Petition had made more reasonable commonsense assumptions about how much the price of uranium would need to increase in order to jumpstart U.S. production, "the resulting range of prices is both very wide and much higher than quota proponents'[sic] estimate."[96] The study also shows that the nuclear power industry may not be able to afford to depend on domestic uranium sources. It estimates that the proposed quotas would cost the nuclear power industry "$500 to $800 million per year" and possibly more "in the early years of the policy."[97] The study goes on to state that the proposed import quotas are likely to lead to further closures of nuclear power plants, causing an employment impact likely to dwarf any increase in mining jobs. It adds that nuclear plant closures would "permanently diminish demand for uranium" and "decrease the resiliency of the electric system."[98]

Further, regarding the stated goal of maintaining a stable uranium supply for the purpose of nuclear power generation, even in the event that supplies for nuclear power generation are suddenly cut off tomorrow, the U.S. currently holds significant inventories separate from the defense stockpiles. According to the EIA, U.S. utilities currently manage an inventory of about 143 million pounds of uranium oxide. When combined with the roughly 14 million pounds[99] of excess inventory managed by the federal government, the U.S. could meet 100 percent of anticipated annual demand[100] for the next four years just on stockpiles alone.

SARANA RIGGS

Mining Uranium in the Grand Canyon Region Is Unnecessary

Despite evidence to the contrary, if the Commerce Department still determines that increased domestic uranium mining would somehow benefit economic and national security, the region surrounding the Grand Canyon should not be a source for enlarging the country’s uranium stockpile. Even if uranium mining posed no threat to the lands and waters around the Grand Canyon, it still isn’t economically practical.

First, uranium can be mined at a higher profit elsewhere in the U.S. Despite the higher grade of uranium ore in the Grand Canyon region, these deposits are in a higher forward-cost category, meaning they are more expensive to mine than other deposits.[101] The price of uranium would need to be much higher for it to be economically worthwhile to run a mine in the Grand Canyon region compared to a mine in Wyoming. At the end of 2017, the U.S. government knew of 45.4 million pounds of uranium oxide reserves in the lowest forward-cost category of $0-$30 per pound. All of these reserves were located in Colorado, Nebraska, Wyoming, and Texas.[102] Backing up that estimate, the president and CEO of Energy Fuels stated that the price of uranium would need to be at least $40-$50 per pound for the deposits at Canyon Mine to be mined at a profit.[103]

Second, uranium is a relatively common metal found in economic concentrations all around the world. The amount of known and minable resources grows as more mineral exploration is completed.[104] In the U.S., mineral exploration has uncovered 836 million pounds of economically minable uranium reserves.[105] The Grand Canyon region is home to just 0.29 percent of that total.[106] More uranium reserves could be identified in the region, but significant uranium reserves have already been identified elsewhere. Even if the price of uranium rises to make Grand Canyon deposits economically viable to mine, a greater volume, and greater efficiency, is already available elsewhere.

To put the volume of known uranium reserves into perspective, in 2017, the U.S. spent 43 million pounds of uranium in nuclear reactors. The federal government forecasts that the country will need, at most, 386 million pounds of uranium through 2027.[107] Without lifting a finger to locate additional minable reserves and without touching the Grand Canyon region, the U.S. demand for uranium could be met for decades with currently identified domestic deposits. Additionally, despite efforts by the uranium industry to see the ban lifted, mining companies have admitted on the record that the Grand Canyon region is not the most important resource. In an interview with Bloomberg News in July 2018, the chief operating officer of Energy Fuels replied to a reporter’s question about the Grand Canyon and Bears Ears regions with: “[t]here’s enough existing, permitted, licensed capacity to meet that new demand,” and “[f]rom our perspective, we don’t see a quota [on imports] creating a need to go into those areas.”[1]

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Conclusion

Without question, uranium mining damages the environment. Roads are built across landscapes and industrial truck traffic impacts wildlife and air quality. Storage ponds holding contaminated water in a semi-arid region attract birds and other wildlife. And merely exposing uranium ore to the elements by mining it mobilizes its harmful effects into air and water. We know that uranium mining comes with environmental harm, but data and research to help understand the scope and severity of that harm in the Grand Canyon region is lacking and chronically underfunded. The incomplete evidence that is available does not support claims that uranium can be safely mined in the Grand Canyon region. Without knowing how severe the impacts of mining would be for this landscape, there is no telling how mining might affect the outdoor recreation and tourism industries that depend on it.[108]

Uranium operations have left a toxic legacy across the Colorado Plateau, a legacy that still impacts land, drinking water, and public health today. The cleanup of that legacy is slow and expensive.

We know that the Grand Canyon region holds just 0.29 percent of known U.S. uranium reserves. The U.S. has enough stored uranium to meet its defense needs, supply its electrical grid, and to insulate itself from disruptions in supply. In fact, forcing the purchase of domestically mined uranium could actually harm the U.S. uranium supply by harming key suppliers in Canada and other allied countries. It would also harm the U.S. nuclear power industry by increasing costs and driving additional reactors to close. If, despite this evidence, the Trump administration still determines that mining and using more U.S. uranium is a matter of national security, the evidence—even from the mouths of industry officials themselves—says that the Grand Canyon region is not the place to get it.

The dearth of scientific information about environmental risks is a primary reason the mining ban exists. Even if the ban were lifted, outdoor recreation and tourism tied to Grand Canyon National Park and nearby public lands are a more significant and sustainable driver of the regional economy than uranium mining is, has been, or could ever be.

It is clear that enhancing access to U.S. uranium resources and instituting import quotas and a "buy American" requirement are policies suggested by some who seem to be taking advantage of fear, a protectionist agenda, and the very real economic woes of others to overcome the market reality of uranium mining. Given this market reality and the mischaracterization of data to justify these policy changes, the true goal seems to be to increase demand and industry profits rather than to protect short and long-term economic and national security. These policies could jeopardize the temporary mining ban that currently protects the Grand Canyon region from the environmental, cultural, and economic risks of uranium mining.

In the face of significant scientific uncertainty about the scope and severity of the risks uranium mining poses to critical water supplies, cultural values, and the regional economy, the benefits of mining cannot be assumed to outweigh the risks. With only history as a reference point, the precautionary principle tells us to assume that mining could harm a primary component of the regional economy while providing little economic benefit in return. With so many unknowns and so much at stake, uranium should not be mined near the Grand Canyon.

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Uranium Mining In The Grand Canyon—Biting My Tongue In Front Of Congress

As I sat before Congress in Washington d.c. last summer, I couldn't believe what the representative from the mining industry had just said. I had just testified on House Resolution (hr) 644, the Grand Canyon Watersheds Protection Act of 2009, and now the last member of the panel, the representative of the mining companies, was speaking. The mining representative had just stated to Congress, "A rock containing one percent natural uranium, ten thousand parts per million, or what is a maximum average grade of breccia pipes, can be held on a person's head for four hours, and the person will receive no more radiation than they would from a medical x-ray". I was thinking how best to respond a moment later when we would be questioned by members of Congress after the individuals on the panel finished their testimony.

I wondered if the mining representative's statement should be chided—"anyone who would make that argument has had uranium on their head too long" or "the reason I'm follicly challenged (lacking hair on top) is from balancing breccia". No, perhaps I should just explain the huge difference between putting unstable isotopes on your head, and ingesting them where internally the radionuclides accumulate, particularly in the proximal tubules of your kidneys. Build up of heavy metals in the human body can be manifest in many ways—from fatigue to central nervous system disruption—but often is a slow process that builds up over time. And it doesn't just go away quickly like when a rock is taken off your head after four hours or when the lead-protected, x-ray technician steps back in the room. Probably best to bite my tongue, stay on message, and ignore the comment from the mining representative, I thought.

I am profoundly concerned about mining in or near the Grand Canyon which I believe will damage the quantity and quality of Grand Canyon springs, and the plants and animals that depend on those springs. The lands in question include the Tusayan Ranger District and Federal land managed by the Bureau of Land Management in the vicinity of Kanab Creek and in House Rock Valley. The springs support a rich diversity of animals, birds, insects and plants, and provide water for backcountry hikers and Native Americans. My university research group was the first to study uranium concentrations in water from various springs in the Grand Canyon, including Horn Creek (which is below the site of the abandoned Orphan Uranium Mine on the Rim). In 1995, we discovered elevated uranium levels in Horn Creek (92.7 parts per billion (ppb)), which is above the epa Maximum Contaminant Level Goals (0 ppb), and in excess of the epa Maximum Contaminant Levels (zero ppb). This provided part of the impetus for the Park Service to clean up the Orphan Mine site under the Comprehensive Environmental Response, Compensation, and Liability Act (cercla), also known as Superfund. The cost for remediation of the Orphan Mine's surface area is estimated at fifteen million (Phase One), but costs to remediate contamination in the underground portion of the mine and in Horn Creek are unknown (*Washington Independent,* July 22, 2008). Elevated uranium concentrations in spring water below the Orphan Site relative to other Grand Canyon springs were later confirmed by a u.s. Geological Survey study. The Orphan Mine shut down in the late 1960's and early 1970's, yet decades later high uranium was showing up in springs below the mine site.

So this last summer, I sat and listened as Congress was addressed by representatives from the Havasupai tribe, from the Coconino County Board of Supervisors,

UNLV Graduate student Kim Zukosky filtering water samples at night (Hermit Camp).

from the Southern Nevada Water Authority, from the Grand Canyon Trust, and from the businesses in Tusayan who all voiced concerns about uranium mining near the Grand Canyon. I wasn't alone in support of HR 644 and my concern about mining operations. Two different panels testified with me before Congress that day, and each (except the two representatives of mining interests) expressed different reasons for their support of the House Resolution.

My own professional misgivings about mining operations around the Canyon, expressed in my Congressional testimony, centered on the potential degradation of both the quantity and the quality of Canyon spring flow that the mining operations would produce, and the subsequent impacts on the habitat and wildlife the springs support. It only takes a few hikes in the Grand Canyon for even the most rookie biologist to realize the importance of springs to the abundance and diversity of life in these verdant little pockets. And you don't have to be an expert to appreciate water value in arid lands. There are the hardcore scientists gathering information and statistics on springs, and then there is the backpacker or river runner, gathering his or her own data as a sundown frog symphony mixes with the sounds of their camp stove. If you've ever been thirsty in the backcountry, you know the importance of the Grand Canyon springs.


UNLV Graduate Student Kim Zukosky above Dripping Springs.

Breccia Pipes, Mining, and Groundwater Recharge

Over 10,000 mining claims have been staked in the region adjacent to the Colorado River and Grand Canyon National Park. It is important to understand geologic reasons why mining is proposed for the Canyon area, and how that might be detrimental to springs.

Uranium mines in the Grand Canyon area typically involve excavation of vertical and horizontal shafts into, or near, breccia pipes, which are geologic collapse features and zones of historical groundwater recharge. Breccia pipes are abundant in the region, and form vertical zones of angular clasts surrounded by a consolidated rock matrix originally formed by the caving-in of paleochannels in underlying rock. These pipes can also form ground surface depressions and sink holes (Huntoon, 1996). The way breccia pipes became collapse features was by dissolution cavities in the Redwall Limestone (halfway down the Canyon) falling-in, and chimneys of the rubble debris of broken up rock (breccias) propagating upward to ground surface on the Rim more than two thousand feet higher.

As mentioned, the ground surface expression of these pipes on the Rim was often a localized depression that could attract surface runoff waters. Surface runoff from rains and snowmelt eventually played connect-the-dots between many of these depressions. This made preferred pathways for surface flow on the Rim, and significant volumes of water passed in washes along the ground surface near these pipes, and were shunted underground to recharge groundwater and eventually emerge as springs in the Canyon below. Water influx into the ground could be significant as evidenced during a 100 year flood event on the South Rim in August 1984 which wiped out HWY 64—the road to Tusayan and Grand Canyon Village. The waters passed over the road and flowed down Little Red Horse Wash with a estimated peak flow of 2447 cubic feet per second but apparently dissipated in the large flat area some four miles downstream. There was no significant runoff reported beyond this area—the waters apparently disappeared and totally infiltrated into the ground (Canyon Uranium Mine EIS, 1986).

The reason the mining companies are so interested in these breccia pipes is because these same percolating and recharging waters also carried and deposited uranium as they moved downward through geologic history. Uranium was dissolved in surface waters in small amounts, and over the years it was carried to zones below the surface which were low in oxygen (like the Hermit Shale formation). In these anoxic conditions, uranium was chemically precipitated out of the dissolved phase, becoming a solid, mineable rock in a breccia pipe environment.

This breccia pipe-type of uranium mine generates ore and waste rock which is typically stockpiled on the land surface until shipment to a mill takes place. Local precipitation and surface runoff waters can be in contact with

UNLV Graduate student Jim Fitzgerald samples Page Spring (Miner's).

this surface uranium ore. Certain mining activities, such as the interception of water by wells, creation of vertical shafts, the diversion of surface water, and the collection of surface water into holding ponds, has the potential to alter the amount and quality of water recharging the aquifers surrounding Grand Canyon National Park.

Diminishment of Spring Water Quantity— Part One, Mine Water Use

Uranium mines in the arid Southwest use water, which is usually supplied from wells or imported from springs. Water is necessary at mining operations to support drilling, potable water supply and sanitary needs. Wells in the Grand Canyon region typically are over 2,000 feet deep, tapping the Redwall-Muav aquifer. This same Redwall-Muav formation is the level in the Canyon where the large majority of springs discharge (approximately halfway down the Canyon vertically). Previous uranium mining in the Grand Canyon region estimates that this water usage would be, at a minimum, over 2.5 million gallons per year for one mine (Canyon Uranium Mine EIS, 1986).

There are many springs and seeps in the Grand Canyon that, according to the U.S. Geological Survey and other investigators, have discharge similar to these amounts, or even much less. Some of these springs and seeps are ephemeral, and the biotic communities associated with them are very vulnerable to the extraction of water and reduction of flow. Multiplying potential water use of each mine by the number of potential mine sites gives a volume of water that if abstracted could eliminate and/or critically diminished a majority of springs and seeps in the Grand Canyon. The work of our research group at the University of Nevada, Las Vegas, (using environmental tracers including stable and radiogenic isotopes, trace elements, chlorofluorocarbons, and uranium isotope disequilibrium measurements, shows compelling supporting evidence for existence of a hydrologic connection between the aquifers surrounding the Canyon and the springs within the Canyon (Goings, 1985; Zukosky, 1995; Fitzgerald, 1996; Ingraham et al., 2001).

If all mining claims in the Grand Canyon region were turned into active mines and used the same amount of water as that projected by Canyon Uranium Mine (Canyon Uranium Mine EIS, 1986), the resulting water use would be over five times the use of the city of Flagstaff and would decimate Canyon springs. Fortunately, mining speculators typically stake many more claims than they will ever move into active mining sites. Even so, one mine alone could use water equivalent to several small Canyon springs or seeps.

Diminishment of Spring Water Quantity— Part Two, Piercing the Perched

The deep, drilled wells associated with projected mining operations throughout the Grand Canyon region, and the mine shafts themselves, have the potential to pierce smaller perched aquifers in the overlying Coconino Sandstone (approximately one-quarter of the way down the Canyon vertically), which supplies water to springs higher up on the wall of the Canyon. The Hermit Shale, which serves as a low permeability base holding up this aquifer, is unfortunately also the geologic unit in which much uranium is expected to have been emplaced, and which would necessarily be penetrated by vertical shafts.

In one uranium mine in the Grand Canyon region, a perched aquifer was encountered during exploratory drilling operations. Long-term downward drainage and water disruption potential of the mining operation was estimated to be over 1.3 million gallons per year (Canyon Uranium Mine EIS, 1986). Piercing a perched aquifer would have the effect of draining the perched aquifer, and disrupting flow to springs issuing from the Coconino Sandstone-Hermit Shale contact and the underlying Supai Group.

Diminishment of Spring Water Quantity— Part Three, Dam Surface Structures

The historical water recharge to the subsurface in potential mining areas could also be altered by surface mining structures. These structures include diversion channels, berms, dikes, or barriers to surface flow. These structures are designed, in part, to minimize contact of surface ore piles and waste rock with surface water runoff. Eventually this impoundment of surface water would manifest itself as diminished groundwater recharge and spring flow. Retention of surface water would unbalance the groundwater equilibrium between recharge and spring discharge, and could also affect the timing of downward water percolation, and eventually spring water quality.

Water Quality Impact

Throughout the U.S. and the world, valid claims by industry that their activities have not negatively impacted groundwater quality are buttressed by rigorous monitoring programs. These programs typically involve the emplacement of monitoring wells, regular sampling and chemical analysis of water, and hydrologic and hydrochemical mathematical modeling. No such industry program exists in the Canyon. There is no comprehensive system of monitoring wells to support mining claims that prior mining in the Canyon region have had no impact. Testifying before Congress, the mining representatives were reduced to implying that the cosmetic fix of cleaning up a former mining site after mining operations to look nice at the surface, constituted evidence that there was no subsurface pollution. It is also important to realize that the effects of pollution on groundwater many take years, decades, or even centuries to be fully manifest. Groundwater movement is very slow compared to surface water flow.

The lack of clear and consistent monitoring of groundwater undercuts claims by the mines that previous mining in the Canyon has not harmed groundwater in the past. A friend once said, "standing in the middle of a busy freeway shouting 'I'm safe, I'm safe' because you haven't been hit with a car yet, doesn't really mean you're safe."

Biting My Tongue, Saying My Piece

The questions from the Congressmen and Congresswomen went about how I expected it. My experience as an "expert witness" in court proceedings had prepared me for supportive questions from the Representatives that supported HR 644, and for questions meant to undermine (pardon the pun) my testimony and my credibility from the other side. I did have to bite my tongue one more time, however.

When the Congressman who opposed HR 644 stated in the preamble to a question that I had "speculated" about groundwater flow in the Canyon, my mind flashed to the stalwart graduate students (particularly Jim Fitzgerald and Kim Zukosky), the great Park Service personnel, the good-spirited boatmen and women, and the many "sherpas" that had assisted our spring research through the years. We had carried heavy packs, endured and enjoyed all sorts of weather, hopped over snakes, and suffered bad jokes to get water samples in the Canyon. I looked around and thought that I might be the only one in the room who has carried 90 pounds of water samples out of the Canyon in one go, carried in ultra-pure nitric acid to preserve them, hiked in 120 degree heat to get them, slept with many liters of water in the bag at night in winter to keep them from freezing, did solo hikes, backed up chemical analyses with split samples to the U.S. Environmental Protection Agency on the campus of my university to make sure the samples gave accurate numbers, and published peer-reviewed articles in reputable journals and books which might capture the science, but none of the adventure and mystery. I bit my tongue, thinking he just wouldn't understand until he really experiences the Canyon, and quietly thanked the tremendous people with whom I'd shared the wonderful, wide, wild, grand, hole-in-the-ground.

UNLV Graduate Student Kim Zukosky measures side stream flow.

What I did say, I'll write down now. I said that the science has shown that it is unreasonable to assume that the groundwater below the Rim of the Grand Canyon and in its breccia pipes does not have hydrologic connection with the Canyon's springs. It's unreasonable to assume that water supply to mines is trivial, particularly if more than one mine begins operations in the Grand Canyon region. It's unreasonable to assume that the surface mining structures, the dams, berms, dikes won't reduce recharge to the Redwall-Muav aquifer, and that's if they don't fail and flood the subsurface with contaminated water. It's unreasonable to assume that mining in the Hermit Shale aquitard won't pierce the perched aquifer system in the Grand Canyon. It's unreasonable to assume that potential pollution to springs and drainages in the Canyon won't occur—we've already found it. And it unreasonable to assume that no potential huge cleanup costs will be associated with any pollution that does occur.

I then borrowed part of a wonderful quote that I had heard early in my environmental career. I said, by allowing uranium mining in the Grand Canyon region we were, like the sorcerer's apprentice, opening an environmental box, ignoring the precautionary principles that good scientists and responsible industry follow, principles that I teach to my students in the most basic environmental geology courses.

The Task Ahead

Scientific evidence suggests that the exploitation of uranium resources near the Grand Canyon will be intimately connected with the groundwater aquifers and springs in the region. The hydrologic impacts have a great potential to be negative to people and biotic systems. I believe that an assumption that uranium mining will have minimal impact on springs, people and ecosystems in the Grand Canyon is unreasonable, and is not supported by past investigations, research, and data. In my best professional judgment, I believe HR 644 will help preserve clean water and the sustainable natural resources that water supports, in this treasured region of our country. In my view, at the same time it will support recreational economic interests and indigenous peoples of the region.

This last summer, Secretary of the Interior Salazar temporarily placed one million acres of public lands surrounding Grand Canyon off limits to development of existing, unpatented claims. The order also halts new mining claims and exploration, in compliance with a June 2008 Congressional House Resolution by the Committee on Natural Resources. Much of the effort to enact protections across this area have been spearheaded by Congressman Raul Grijalva of Arizona. Unfortunately, the protections are not permanent, and do not affect the exploration of existing patented claims, or three existing mines in the area scheduled to reopen.

Responsible industry works hard to account for the long-term effects of its activities. Conscientious miners do this, not only with realistic projections of what those long term effects will be, but also with credible and continuing monitoring, accountability for past mistakes, and true adherence to a precautionary principle that does not allow short-term gain to outweigh public and ecological safety. Unfortunately, not all businesses are dependable, diligent, and answerable to this principle. Aldo Leopold once wrote, "One of the penalties of an ecological education is that one lives alone in a world of wounds". For every environmental battle won, there appear more threats, often from unreliable, unknowledgeable, and/or unscrupulous individuals and companies.

In Greek mythology, King Sisyphus was condemned by the Gods for eternity to roll a rock up a hill in Tartarus, only to watch it roll down the hill, and start the task again. And so, the Sisyphean Grand Canyon environmentalist pushes the rock containing one percent uranium up the hill, with shoulders and head to the mineral. I wonder if the Greek King would have made a good shoe-tapper in an underground mining operation? Perhaps Camus said it best: "The struggle itself…is enough to fill a man's heart. One must imagine Sisyphus happy." So—Joy, Environmental Shipmates, Joy!

Dave Kreamer

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The Washington Post

Opinions

Congress must reach across the aisle and protect the Grand Canyon

By Cindy McCain and
Mark Udall
February 17

Cindy McCain is the widow of Sen. John McCain and chair of the Board of Trustees of the McCain Institute. Mark Udall, son of the late Rep. Mo Udall, served as a Democratic congressman and senator from Colorado.

Every year, Americans of all political persuasions make pilgrimages to Grand Canyon National Park, which will mark its 100th anniversary on Feb. 26. They stand in awe at the rim of this natural wonder, grateful for the forebears who preserved it for generations — and, for the most part, unaware that the Grand Canyon isn't nearly as protected as people think it is.

The clock is ticking on a 20-year ban on new mining claims on about 1 million acres of public land surrounding the national park. Thousands of uranium claims were put on hold in 2012 because of mounting evidence that uranium mining in the headwaters of Grand Canyon creeks can contaminate life-giving seeps and springs in the desert basins below.

After examining evidence of harmful effects, five federal agencies recommended the temporary halt to new uranium claims. Ken Salazar, then the interior secretary, said his precautionary decision would allow more time to assess the impacts of active and abandoned mines, adding, "We have chosen a responsible path that makes sense for this and future generations."

Last week , the Senate voted 92 to 8 to approve the Natural Resources Management Act. Among other things, it protects Yellowstone National Park from mining on adjacent public lands.

Though the bill doesn't benefit the canyon, this burst of bipartisanship bodes well for Grand Canyon National Park as it approaches its 100th birthday. It's time for the new Congress to reach across the aisle and carry on our long bipartisan tradition of stewardship for this crown jewel of our national park system.

It was a Republican president, Theodore Roosevelt, who first proclaimed the Grand Canyon a national monument in 1908. After bipartisan votes in both houses, President Woodrow Wilson, a Democrat, signed the bill establishing the Grand Canyon as a national park in 1919. A half-century later, Republican Sen. Barry Goldwater of Arizona introduced the bill that nearly doubled the size of Grand Canyon National Park, while returning about 188,000 acres of aboriginal homeland to the Havasupai Tribe. Arizona congressman Mo Udall, a liberal Democrat, helped unite bipartisan support for the Grand Canyon Enlargement Act, and Republican President Gerald Ford signed it into law in 1975.

Arizona Republican Sen. John McCain later teamed up with Udall and others from both sides of the aisle in passing the National Parks Overflight Act of 1987. The two leaders joined Democratic Sen. Bill Bradley in cosponsoring the Grand Canyon Protection Act in 1992, one of the last laws that Udall signed on to before retiring. McCain subsequently thanked "my friend Mo Udall" for being "a strong protector of the pristine beauty of the Grand Canyon and our other national parks."

The people living closest to the canyon are fervent in supporting the mining ban. Ninety-six percent of Arizonans agree that keeping public lands and waters healthy benefits the Arizona economy and quality of life. And nearly two-thirds support the ban on new uranium claims around the Grand Canyon, including 56 percent of Republicans, 67 percent of independents and 69 percent of Democrats.

In particular, the Havasupai people — who live at the bottom of the canyon and whose sole source of water is at risk — want to permanently ban uranium mining. They are joined by Hopi, Navajo, Hualapai, Zuni and other tribal nations in opposing the desecration of their homeland.

Now is the time to protect the Grand Canyon's sacred waters from permanent uranium-mining pollution. As we prepare to commemorate the 100th anniversary of Grand Canyon National Park, let's remember that good stewardship, like good citizenship, strengthens and unites our nation.

Let's challenge all of America's elected officials to become better caretakers not only of the Grand Canyon but also of all public lands. In this new Congress, let's sit down and see what we can do — together — to permanently ban uranium mining around the Grand Canyon as our gift to the next generation. Let's carry the tradition of bipartisan stewardship into the Grand Canyon's next century.

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– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;

– to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

Cover photos: Atucha 2 NPP, Argentina (Nucleoeléctrica Argentina S.A.); uranium ore: uranophane (Areva); Cigar Lake mine, Canada (Cameco).

Preface

Since the mid-1960s, with the co-operation of their member countries and states, the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) have jointly prepared periodic updates (currently every two years) on world uranium resources, production and demand. Such updates have been published in what are commonly known as the "Red Books". The 26th edition of the Red Book reflects information current as of 1 January 2015.

This 26th edition features a comprehensive assessment of uranium supply and demand in 2015 and projections to the year 2035. The basis of this assessment is a comparison of uranium resource estimates (according to categories of geological certainty and production cost) and mine production capability with anticipated uranium requirements arising from projected installed nuclear capacity. In cases where longer-term projections of installed nuclear capacity were not provided by national authorities, projected demand figures were developed with input from expert authorities. Current data on resources, exploration, production and uranium stocks are also presented, along with historical summaries of exploration and production, and plans for future mine production. Available information on secondary sources of uranium is provided and the potential impact of secondary sources on the market is assessed. Individual country reports offer detailed information on recent developments in uranium exploration and production, on environmental activities, regulatory requirements and on relevant national uranium policies.

This publication has been prepared on the basis of data obtained through questionnaires sent by the NEA to OECD member countries and by the IAEA to other countries. It contains official data provided by 37 countries and 12 national reports prepared by the NEA and the IAEA. The opinions expressed in Chapters 1 and 2 do not necessarily reflect the position of the member countries or international organisations concerned. This report is published on the responsibility of the OECD Secretary-General.

Acknowledgements

The Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) gratefully acknowledge the co-operation of those organisations that replied to the questionnaire (see Appendix 1).

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Executive summary

In addition to updated resource figures, *Uranium 2016 – Resources, Production and Demand* presents the results of the most recent review of world uranium market fundamentals and offers a statistical profile of the world uranium industry as of 1 January 2015. It contains official data provided by 37 countries and 12 national reports prepared by the NEA and IAEA Scientific Secretaries on uranium exploration, resources, production and reactor-related requirements. Projections of nuclear generating capacity and reactor-related uranium requirements through 2035 are presented, as well as a discussion of long-term uranium supply and demand issues.

Resources[1]

Total identified uranium resources have increased by only 0.1% since 2013. The resource base has changed very little due to lower levels of investment and associated exploration efforts reflecting current, depressed uranium market conditions.

Total identified resources (reasonably assured and inferred) as of 1 January 2015 amounted to 5 718 400 tonnes of uranium metal (tU) in the <USD 130/kgU (<USD 50/lb U_3O_8) category, a decrease of 3.1% compared to 1 January 2013. In the highest cost category (<USD 260/kgU or <USD 100/lb U_3O_8), total identified resources amount to 7 641 600 tU, an increase of only 0.1% compared to the total reported for 2013.

A decrease in reasonably assured resources (RAR) was reported for this edition in all cost categories, with the exception of the <USD 80/kgU category (<USD 30/lb U_3O_8). The decrease in RAR was offset by increases in inferred resources reported for all cost categories. The most significant change is reported in the <USD 80/kgU category, with an increase of 20.9% in inferred resources, compared to values reported in 2013. This can be primarily attributed to the addition of 208 400 tU of inferred resources from China and Kazakhstan. At the 2014 level of uranium requirements, identified resources are sufficient for over 135 years of supply for the global nuclear power fleet. Moreover, an

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[1] Uranium resources are classified by a scheme (based on geological certainty and costs of production) developed to combine resource estimates from a number of different countries into harmonised global figures. **Identified resources** (which include *reasonably assured resources,* or *RAR*, and *inferred resources*) refer to uranium deposits delineated by sufficient direct measurement to conduct pre-feasibility and sometimes feasibility studies. For *RAR*, high confidence in estimates of grade and tonnage are generally compatible with mining decision-making standards. *Inferred resources* are not defined with such a high degree of confidence and generally require further direct measurement prior to making a decision to mine. **Undiscovered resources** (*prognosticated* and *speculative*) refer to resources that are expected to exist based on geological knowledge of previously discovered deposits and regional geological mapping. *Prognosticated resources* refer to those expected to exist in known uranium provinces, generally supported by some direct evidence. *Speculative resources* refer to those expected to exist in geological provinces that may host uranium deposits. Both *prognosticated* and *speculative resources* require significant amounts of exploration before their existence can be confirmed and grades and tonnages can be defined. For a more detailed description, see Appendix 3.

additional 72 700 tU of resources have been identified by the NEA/IAEA as resources reported by companies that are not yet included in national resource totals.

Total undiscovered resources (prognosticated resources and speculative resources) as of 1 January 2015 amounted to 7 422 700 tU, a minor decrease from the 7 697 700 tU in the previous edition (NEA/IAEA, 2014). It is important to note that in some cases, including those of major producing countries with large identified resource inventories (e.g. Australia, Canada and the United States), estimates of undiscovered resources are either not reported or estimates have not been updated for several years.

The uranium resource figures presented in this volume are a snapshot of the situation as of 1 January 2015. Resource figures are dynamic and related to commodity prices. Identified resources have changed very little since the last reporting period because of lower levels of investment and associated exploration efforts reflecting current, depressed market conditions.

Exploration

Uranium exploration and mine development expenditures increased between 2013 and 2015. Nevertheless, no significant resources were added to the resource base during this reporting period as the expenditure increase can be largely attributed to the development of the Cigar Lake mine in Canada and the Husab mine in Namibia. Exploration expenditures continued to decrease because of low uranium prices.

Worldwide exploration and mine development expenditures as of 1 January 2015 totalled USD 2.9 billion, a 10% increase over 2013 figures. Over 38% of these exploration and development expenditures were devoted to non-domestic activities with the majority of expenditures made by China.

From 2012 to 2014, domestic exploration and mine development expenditures decreased in many countries, mainly as a result of the declining uranium price which slowed down many exploration and mine development projects, particularly in the junior uranium mining sector. Significant decreases are reported for Argentina, Australia, Canada, Finland, Kazakhstan, Russia, South Africa, Spain and the United States. In contrast, Brazil, China, the Czech Republic, Jordan, Mexico and Turkey reported increases in expenditures during this period. The most significant increases in domestic expenditures are reported by China with a steady increase in expenditures of USD 131 000 in 2012, USD 189 000 in 2013 and USD 197 000 in 2014. Despite a slowdown in the industry in more recent years, following peak levels of activity associated with high uranium prices in 2007-2008, the majority of reporting countries have maintained domestic exploration and mine development expenditures above pre-2007 levels.

Non-domestic exploration and development expenditures, although reported only by China, France, Japan and Russia, increased from USD 185 million in 2012 to more than USD 692 million in 2013 and USD 812 million in 2014. Non-domestic development expenses for China have been projected to reach over USD 777 million in 2015 principally because of investment in the Husab mine in Namibia, pushing non-domestic exploration and development expenditures to a total of more than USD 846 million in 2015.

For this reporting period, China accounts for the highest non-domestic and domestic exploration and development expenditures supporting reports of their strong commitment to growth in nuclear power.

Production

Global uranium mine production has decreased by 4% since 2013. However, production is still above 2011 levels, and Kazakhstan, currently the world's leading producer, continues to increase production, but at a slower pace.

Overall, world uranium production decreased by 4.1%, from 58 411 tU in 2012 to 55 975 tU as of 1 January 2015. The changes are principally the result of decreased production in Australia, and lower uranium mining output from Brazil, the Czech Republic, Malawi, Namibia and Niger. Within OECD countries, production decreased from 17 956 tU in 2012 to 16 185 tU in 2014, primarily as a result of decreased production in Australia and, to a smaller extent, in the Czech Republic. From 2012 to 2014, uranium was produced in 21 different countries; the same number as in the last reporting period, with Germany, Hungary and France producing uranium as the result of mine remediation activities. Kazakhstan's growth in production continued, but at a much slower pace, and it remains the world's largest producer, reporting production of 22 781 tU in 2014 and 23 800 tU in 2015. Production in Kazakhstan in 2014 totalled more than the combined production that same year in Canada and Australia, the second and third largest producers of uranium, respectively.

In situ leaching (ISL, sometimes referred to as in situ recovery, or ISR) production continued to dominate uranium production accounting for 51% of world production as of 1 January 2015, largely as a result of continued production increases from Kazakhstan and other ISL projects in Australia, China, Russia, the United States and Uzbekistan. Underground mining (27%), open-pit mining (14%) and co-product and by-product recovery from copper and gold operations (7%), heap leaching (<1%) and other methods (<1%) accounted for the remaining uranium production shares.

Environmental and social aspects of uranium production

With uranium production projected to expand, efforts are being made to develop safe mining practices and to continue to minimise environmental impacts.

Although the focus of this publication remains uranium resources, production and demand, environmental and social aspects of the uranium production cycle are gaining increasing importance and, as in the last few editions, updates on activities in this area are included in the national reports. With uranium production ready to expand, in some cases to countries hosting uranium production for the first time, the continued development of transparent, safe and well-regulated operations that minimise environmental impacts is crucial.

In Botswana, A-Cap Resources established the Safety, Health, Radiation, Environment and Community Group aimed at informing, educating and involving local communities through meetings held on a regular basis. An environmental and social impact assessment study of the Letlhakane Project was completed and submitted to the Department of Environmental Affairs (DEA) in 2015. Specialist studies have determined that with appropriate mitigation, all environmental and social aspects during the construction and planned operations will be addressed.

Namibia continues to make progress in a number of environmental and social issues, building on the establishment of the Rössing Foundation in 1978. The foundation's activities focus on education, health care, environmental management and radiation safety in the uranium industry. With the development of the Husab mine, Swakop Uranium has also engaged in social responsibility programmes, including committing itself to local procurement, recruitment and employment, training, education and responsible environmental management practices. To this end, projects were initiated to address research needs identified in the company's environmental management plan, including groundwater monitoring.

In several other countries with closed uranium production facilities (i.e. Brazil, Canada, the Czech Republic, France, Hungary, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Ukraine and the United States), updates of remedial and monitoring activities are provided in the respective country reports.

Additional information on environmental aspects of uranium production may be found in *Managing Environmental and Health Impacts of Uranium Mining* (NEA, 2014), which outlines significant improvements that have been undertaken in these areas since the early strategic period of uranium mining to the present day.

Uranium demand

Demand for uranium is expected to continue to rise for the foreseeable future as nuclear power is projected to grow considerably in regulated electricity markets with increasing electricity demand and a growing need for clean air electricity generation.

As of 1 January 2015, a total of 437 commercial nuclear reactors were connected to the grid with a net generating capacity of 377 GWe requiring about 56 600 tU annually. Taking into account changes in policies announced in several countries and revised nuclear development plans, world nuclear capacity is projected to grow to between 418 GWe net in the low demand case and 683 GWe net in the high demand case by 2035, representing increases of 11% and 81%, respectively. Accordingly, world annual reactor-related uranium requirements (excluding mixed oxide fuel [MOX]) are projected to rise to between 66 995 tU and 104 740 tU by 2035.

Nuclear capacity projections vary considerably from region to region. The East Asia region is projected to experience the largest increase, which, by the year 2035, could result in the installation of between 48 GWe and 166 GWe of new capacity in the low and high cases, respectively, representing increases of more than 54% and 188% over 2014 capacity. Nuclear capacity in non-EU member countries on the European continent is also projected to increase significantly, with additions of between 21 and 45 GWe of capacity projected by 2035 (increases of about 49% and 105%, respectively). Other regions projected to experience significant nuclear capacity growth include the Middle East, Central and Southern Asia and South-East Asia, with more modest growth projected in Africa and the Central and South American regions. For North America, the low case projection sees nuclear generating capacity remaining about the same by 2035 and increasing by 11% in the high case, depending largely on future electricity demand, lifetime extension of existing reactors and government policies with respect to greenhouse gas emissions. In the European Union, nuclear capacity in 2035 is either projected to decrease by 48% in the low case scenario or increase by 2% in the high case.

These projections are subject to even greater uncertainty than usual following the Fukushima Daiichi accident, since the role that nuclear power will play in the future generation mix in some countries has not yet been determined and China did not report official targets for nuclear power capacity beyond 2020 for this edition. Key factors influencing future nuclear energy capacity include projected electricity demand, the economic competitiveness of nuclear power plants, as well as funding arrangements for such capital-intensive projects, the cost of fuel for other electricity generating technologies, non-proliferation concerns, proposed waste management strategies and public acceptance of nuclear energy, which is a particularly important factor in some countries after the Fukushima Daiichi accident. Concerns about longer-term security of fossil fuel supply and the extent to which nuclear energy is seen to be beneficial in meeting greenhouse gas reduction targets and enhancing security of energy supply could contribute to even greater projected growth in uranium demand.

Supply and demand relationship

The currently defined resource base is more than adequate to meet high case uranium demand through 2035, but doing so will depend upon timely investments to turn resources into refined uranium ready for nuclear fuel production. Challenges remain in the global uranium market with high levels of oversupply and inventories, resulting in continuing pricing pressures. Other concerns in mine development include geopolitical factors, technical challenges and increasing expectations of governments hosting uranium mining.

As of 1 January 2015, world uranium production (55 975 tU) provided about 99% of world reactor requirements (56 585 tU), with the remainder supplied by previously mined uranium (so-called secondary sources). The secondary supply includes excess government and commercial inventories, spent fuel reprocessing, underfeeding and uranium produced by the re-enrichment of depleted uranium tails, as well as low-enriched uranium (LEU) produced by blending down highly enriched uranium (HEU).

Uranium miners vigorously responded to the market signal of increased prices and projections of rapidly rising demand prior to the Fukushima Daiichi accident. However, the continued decline in uranium market prices following the accident and lingering uncertainty about nuclear power development in some countries has at least temporarily reduced uranium requirements, further depressed prices and slowed the pace of mine production and development. The uranium market is currently well-supplied and projected primary uranium *production capabilities* including existing, committed, planned and prospective production centres would satisfy projected low and high case requirements through 2035 if developments proceed as planned. Meeting high case demand requirements to 2035 would consume less than 30% of the total 2015 identified resource base (resources recoverable at a cost of <USD 130/kg). Nonetheless, significant investment and technical expertise will be required to bring these resources to the market. Producers will have to overcome a number of significant and, at times, unpredictable issues in bringing new production facilities on stream, including geopolitical factors, technical challenges and risks at some facilities, the potential development of ever more stringent regulatory requirements, and the heightened expectations of governments hosting uranium mining. To do so, strong market conditions will be fundamental to bringing the required investment to the industry.

Although information on secondary sources is incomplete, the availability of these sources is generally expected to decline somewhat after 2015. However, available information indicates that there remains a significant amount of previously mined uranium (including material held by the military), some of which could feasibly be brought to the market in the coming years. With the successful transition from gas diffusion to centrifuge enrichment now complete and capacity at least temporarily in excess of requirements following the Fukushima Daiichi accident, enrichment providers are well-positioned to reduce tails assays below contractual requirements and in this way create additional uranium supply. In the longer term, alternative fuel cycles (e.g. thorium), if successfully developed and implemented, could have a significant impact on the uranium market, but it is far too early to say how cost-effective and widely implemented these proposed alternative fuel cycles could be.

Although declining market prices have led to a delay in some mine development projects, other projects have advanced through regulatory and further stages of development. However, the overall time frame for mine development should be reduced if market conditions warrant renewed development activity. The current global network of uranium mine facilities is, at the same time, relatively sparse, creating the potential for supply vulnerability should a key facility be put out of operation. Utilities have been building significant inventory over the last few years at reduced prices, which should help to protect them from such events.

Conclusions

Despite recent declines in electricity demand in some developed countries, global demand is expected to continue to grow in the next several decades to meet the needs of a growing population, particularly in developing countries. Since nuclear power plant operation produces competitively priced, baseload electricity that is essentially free of greenhouse gas emissions, and the deployment of nuclear power enhances the security of energy supply, it is projected to remain an important component of energy supply. However, the Fukushima Daiichi accident has eroded public confidence in nuclear power in some countries, and prospects for growth in nuclear generating capacity are thus being reduced and are subject to even greater uncertainty than usual. In addition, the abundance of low-cost natural gas in North America and the risk-averse investment climate have reduced the competitiveness of nuclear power plants in liberalised electricity markets. Government and market policies that recognise the benefits of low-carbon electricity production and the security of energy supply provided by nuclear power plants could help alleviate these competitive pressures. Nuclear power nonetheless is projected to grow considerably in regulated electricity markets with increasing electricity demand and a growing need for clean air electricity generation.

Regardless of the role that nuclear energy ultimately plays in meeting future electricity demand, the uranium resource base described in this publication is more than adequate to meet projected requirements for the foreseeable future. The challenge in the coming years is likely to be less one of adequacy of resources than adequacy of production capacity development due to poor uranium market conditions.

Chapter 1. Uranium supply

This chapter summarises the current status of worldwide uranium resources, exploration and production.

Uranium resources

Identified conventional resources

Identified resources consist of ***reasonably assured resources*** (RAR) and ***inferred resources*** (IR) recoverable at a cost of less than USD 260/kgU. Relative changes in different resource and cost categories of identified resources between this edition and the 2014 edition of the Red Book are summarised in Table 1.1. The overall picture is one of resources increasing only modestly with the main increase noted in the inferred resource category, while RAR decreased overall. Identified resources recoverable at costs <USD 260/kgU increased only slightly, by 0.1% to 7 641 600 tU.

Identified resources recoverable at costs of <USD 130/kgU decreased by 3.1% from 5 902 900 tU in 2013 to a total of 5 718 400 tU in 2015.

An increase in the <USD 80/kgU category by 8.6% from 1 956 700 tU to 2 124 700 tU between 2013 and 2015 is largely a result of an increase in inferred resources. In the lowest cost category (<USD 40/kgU) a 5.3% decrease was reported amounting to 646 900 tU. This reflects increasing costs and depletion by mining of low-cost resources.

Current estimates of identified resources, RAR and IR, on a country-by-country basis, are presented in Tables 1.2, 1.3 and 1.4, respectively. Table 1.5 summarises major changes in resources between 2013 and 2015 in selected countries.

The most significant changes during this reporting period are observed in the inferred resources category with increases of 6.8%, 2.5% and 20.9% reported in the <USD 260/kgU, <USD 130/kgU and <USD 80/kgU categories, respectively. Inferred resources comprise 42% of the identified resource total, a 2% increase over the last reporting period.

Australia, Jordan, Namibia, Niger and Uzbekistan in particular reported increases in inferred resources, but a decrease or only a very minor increase in resources was noted for the RAR category. Mauritania and Spain reported new inferred resource estimates for this edition. Significant increases in inferred resources are reported for Kazakhstan as a result of a transfer of prognosticated resources to the inferred resource category, and for China, a significant increase in inferred resources is the result of intensified exploration activities in several sedimentary basins within the country.

Canada reported increases in both the inferred and RAR categories with a significant transfer of resources from lower cost categories to higher cost categories. Botswana and Peru reported increases in both RAR and inferred resources as new resource evaluations have been recently made.

Greenland, India, Russia and South Africa reported increases in RAR and a decrease in inferred resources as resources were re-evaluated and transferred from inferred to the RAR category.

The United States only reports in the RAR category and a significant decrease of 334% for the <USD 260/kgU is noted from 2013 to 2015. This is a result of a re-evaluation of historical estimates, and it is believed that this new data provides more reliable estimates of the uranium recoverable at the specified forward cost.

Australia still dominates the world's uranium resources with 29% of the total identified resources (<USD 130/kgU) and 23% of identified resources in the highest cost category (<USD 260/kgU). A total of 79% of Australia's uranium resources are attributed to the world class polymetallic Fe-oxide breccia complex, the Olympic Dam deposit. Kazakhstan is a distant second with approximately 13% in both the <USD 130/kgU and <USD 260/kgU cost categories, with all other countries having less than a 10% share. Only 15 countries represent approximately 95% of the total resources in the <USD 130/kgU cost category (see Figure 1.1). In the lower cost categories, Australia does not report any resources and thus Kazakhstan leads with 31%, followed by Canada with 15% of the total resources in the <USD 80/kgU category. Only seven countries report resources in the <USD 40/kgU category with Canada having the largest share at 39%, followed by Brazil at 21% and China and Kazakhstan both having about 15% each of the total in this cost range.

Table 1.1. Changes in identified resources (recoverable) 2013-2015

Resource category	2013	2015	Change (1 000 tU)[a]	% change
Identified (total) (1 000 tU)				
<USD 260/kgU	7 635.2	7 641.6	6.4	0.1
<USD 130/kgU	5 902.9	5 718.4	-184.5	-3.1
<USD 80/kgU	1 956.7	2 124.7	168.0	8.6
<USD 40/kgU[b]	682.9	646.9	-36.0	-5.3
Reasonably assured resources (1 000 tU)				
<USD 260/kgU	4 587.2	4 386.4	-200.8	-4.4
<USD 130/kgU	3 698.9	3 458.4	-240.5	-6.5
<USD 80/kgU	1 211.6	1 223.6	12.0	1.0
<USD 40/kgU(b)	507.4	478.5	-28.9	-5.7
Inferred resources (1 000 tU)				
<USD 260/kgU	3 048.0	3 255.1	207.1	6.8
<USD 130/kgU	2 204.0	2 260.1	56.1	2.5
<USD 80/kgU	745.1	901.1	156.0	20.9
<USD 40/kgU[b]	175.5	168.4	-7.1	-4.0

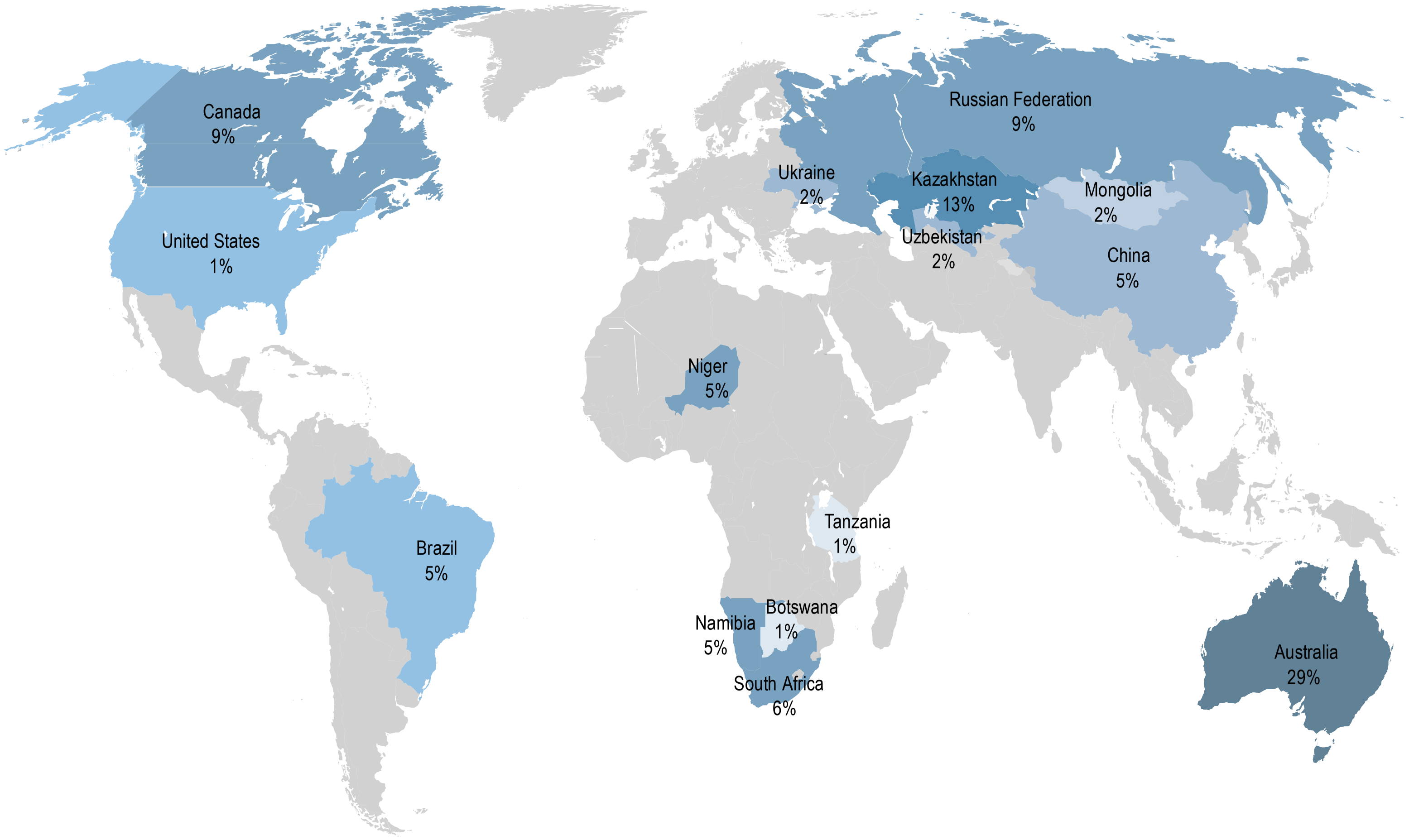
(a) Changes might not equal differences between 2013 and 2015 because of independent rounding.

(b) Resources in the cost category of <USD 40/kgU are likely higher than reported, because some countries have indicated that detailed estimates are not available, or the data are confidential.

For this edition, a summary has been prepared of worldwide in situ identified resources (see Tables 1.2b, 1.3b and 1.4b). Table 1.2c is a summary comparison of in situ identified resources and recoverable identified resources by cost category. Overall, there is a 26% to 33% increase in the resources when they are reported as in situ. This corresponds to average recoveries ranging from approximately 67% to 74%. Reporting in situ resources provides a more optimistic view of the available resource base and gives some indication of how the resource base could increase with improvements in mining and processing methods, which would lead to better recovery. However, recoverable resources still provide the best and more realistic estimate of uranium supply.

Figure 1.1. Global distribution of identified resources

(<USD 130/kgU as of 1 January 2015)



The global distribution of identified resources among 15 countries that are either major uranium producers or have significant plans for growth of nuclear generating capacity illustrates the widespread distribution of these resources. Together, these 15 countries are endowed with 95% of the identified global resource base in this cost category (the remaining 5% are distributed among another 22 countries). The widespread distribution of uranium resources is an important geographic aspect of nuclear energy in light of security of energy supply.

Table 1.2a. Identified resources (recoverable)

(as of 1 January 2015, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Algeria(c, d)	0	0	0	19 500
Argentina	2 400	9 100	18 500	19 600
Australia	N/A	N/A	1 664 100	1 780 800
Botswana*	0	0	73 500	73 500
Brazil(d)	138 100	229 400	276 800	276 800
Canada	251 200	321 800	509 000	703 600
Central African Republic*(a)	0	0	32 000	32 000
Chad*(a, d)	0	0	0	2 400
Chile	0	0	0	1 500
China(d)	98 900	206 300	272 500	272 500
Congo, Dem. Rep.*(a, c, d)	0	0	0	2 700
Czech Republic	0	0	1 300	119 300
Egypt(a, c, d)	0	0	0	1 900
Finland(c, d)	0	0	1 200	1 200
Gabon(a, c)	0	0	4 800	5 800
Germany(c)	0	0	0	7 000
Greece(a, c)	0	0	0	7 000
Greenland	0	0	0	228 000
Hungary(c, d)	0	0	0	13 500
India(d, e)	N/A	N/A	N/A	138 700
Indonesia(b, d)	0	1 500	7 200	7 200
Iran(d)	0	0	3 900	3 900
Italy(a, c)	0	6 100	6 100	6 100
Japan(c)	0	0	6 600	6 600
Jordan(b, d)	0	0	47 700	47 700
Kazakhstan(d)	97 500	667 200	745 300	941 600
Malawi*	0	0	6 200	14 300
Mali*(d)	0	0	13 000	13 000
Mauritania*	0	0	16 400	23 800
Mexico(d)	600	1 800	2 700	3 400
Mongolia	0	141 500	141 500	141 500
Namibia*	0	0	267 000	463 000
Niger*	0	17 700	291 500	411 300
Peru(d)	0	33 400	33 400	33 400
Portugal(a, c)	0	5 500	7 000	7 000
Romania*(a, c)	0	0	6 600	6 600
Russia(b)	0	47 700	507 800	695 200
Slovak Republic(b, d)	0	12 700	15 500	15 500
Slovenia(a, c, d)	0	5 500	9 200	9 200
Somalia*(a, c, d)	0	0	0	7 600
South Africa	0	229 500	322 400	449 300
Spain	0	0	0	33 900
Sweden*(a, c, d)	0	0	9 600	9 600
Tanzania*(a, b)	0	46 800	58 100	58 100
Turkey(b, d)	0	6 600	6 600	6 600
Ukraine	0	59 000	115 800	220 700
United States	0	17 400	62 900	138 200
Uzbekistan*	58 200	58 200	130 100	130 100
Viet Nam(d)	0	0	0	3 900
Zambia*	0	0	24 600	24 600
Zimbabwe(a, c, d)	0	0	0	1 400
Total(f)	**646 900**	**2 124 700**	**5 718 400**	**7 641 600**

See notes on page 23.

Table 1.2b. Identified resources (in situ)**

(as of 1 January 2015, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Algeria(c)	0	0	0	26 000
Argentina(d)	3 400	12 700	25 700	27 200
Australia(d)	N/A	N/A	2 466 600	2 630 500
Botswana*	0	0	118 600	118 600
Brazil	184 300	314 600	382 300	382 300
Canada	326 200	418 000	661 100	913 800
Central African Republic*	0	0	42 700	42 700
Chad*(a)	0	0	0	3 200
Chile(d)	0	0	0	1 900
China	133 700	277 700	366 200	366 200
Congo, Dem. Rep.*(a, c)	0	0	0	3 600
Czech Republic(d)	0	0	2 000	197 500
Egypt(a, c)	0	0	0	2 500
Finland(c)	0	0	1 500	1 500
Gabon(a, c, d)	0	0	6 400	7 700
Germany(c, d)	0	0	0	9 300
Greece(a, d)	0	0	0	9 300
Greenland	0	0	0	350 700
Hungary(c)	0	0	0	17 900
India(e)	N/A	N/A	N/A	183 600
Indonesia(b, d)	0	2 000	9 600	9 600
Iran	0	0	4 500	4 500
Italy(a, c, d)	0	8 100	8 100	8 100
Japan(c, d)	0	0	8 800	8 800
Jordan(b)	0	0	59 600	59 600
Kazakhstan	109 500	749 700	836 500	1 072 900
Malawi*(d)	0	0	7 800	19 000
Mali*	0	0	17 400	17 400
Mauritania*	0	0	18 800	28 600
Mexico	800	2 400	3 700	4 500
Mongolia(d)	0	188 700	188 700	188 700
Namibia*	0	0	354 200	621 500
Niger*	0	19 800	356 500	443 600
Peru	0	47 700	47 700	47 700
Portugal(a, d)	0	6 000	9 300	9 300
Romania*(a)	0	0	8 800	8 800
Russia(b, d)	0	59 600	634 700	869 000
Slovak Republic(b)	0	15 800	19 300	19 300
Slovenia(a, c)	0	7 700	12 200	12 200
Somalia*(a, d)	0	0	0	10 200
South Africa(d)	0	322 000	450 300	630 600
Spain(d)	0	0	0	39 900
Sweden*(a, c)	0	0	12 800	12 800
Tanzania*(a, b)	0	58 500	72 700	72 700
Turkey(b)	0	9 100	9 100	9 100
Ukraine(d)	0	68 200	132 300	251 000
United States(d)	0	23 900	86 400	189 800
Uzbekistan*	83 100	83 100	185 800	185 800
Viet Nam	0	0	0	5 200
Zambia*	0	0	30 700	30 700
Zimbabwe(a, c)	0	0	0	1 800
Total(f)	**841 000**	**2 695 300**	**7 659 400**	**10 188 700**

See notes on page 23.

** In situ resources do not take into account mining and milling losses.

Table 1.2c. Comparison of in situ and recoverable identified resources

(as of 1 January 2015)

Identified resources	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Total in situ (tU)	841 000	2 695 300	7 659 400	10 188 700
Total recoverable (tU)	646 900	2 124 700	5 718 400	7 641 600
Difference (tU)	194 100	570 600	1 941 000	2 547 100
% difference	30.0	26.9	33.9	33.3

Table 1.3a. Reasonably assured resources (recoverable)

(as of 1 January 2015, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Algeria(c, d)	0	0	0	19 500
Argentina	0	5 100	8 600	8 600
Australia	N/A	N/A	1 135 200	1 150 000
Botswana*	0	0	13 700	13 700
Brazil(d)	138 100	155 900	155 900	155 900
Canada	226 100	240 100	374 200	486 400
Central African Republic*(a)	0	0	32 000	32 000
Chile	0	0	0	600
China(d)	38 900	95 000	128 300	128 300
Congo, Dem. Rep.*(a, c, d)	0	0	0	1 400
Czech Republic	0	0	1 200	51 000
Finland(c, d)	0	0	1 200	1 200
Gabon(a, c)	0	0	4 800	4 800
Germany(c)	0	0	0	3 000
Greece(a, c)	0	0	0	1 000
Greenland	0	0	0	102 800
India(d, e)	N/A	N/A	N/A	121 000
Indonesia(b, d)	0	1 500	5 300	5 300
Iran(d)	0	0	1 200	1 200
Italy(a, c)	0	4 800	4 800	4 800
Japan(c)	0	0	6 600	6 600
Kazakhstan(d)	38 500	229 300	275 800	363 200
Malawi*	0	0	4 400	9 700
Mali*(d)	0	0	8 500	8 500
Mauritania*	N/A	N/A	700	1 000
Mexico(d)	0	1 200	1 800	1 800
Mongolia	0	108 100	108 100	108 100
Namibia*	0	0	189 600	298 400
Niger*	0	17 700	235 300	316 000
Peru(d)	0	14 000	14 000	14 000
Portugal(a, c)	0	4 500	6 000	6 000
Romania*(a, c)	0	0	3 000	3 000
Russia(b)	0	27 300	228 400	273 800
Slovak Republic(b, d)	0	8 800	8 800	8 800
Slovenia(a, c, d)	0	1 700	1 700	1 700
Somalia*(a, c, d)	0	0	0	5 000
South Africa	0	167 900	237 600	259 600
Spain	0	0	0	12 900
Sweden*(a, c, d)	0	0	4 900	4 900
Tanzania*(a, b)	0	38 300	40 400	40 400
Turkey(b, d)	0	6 100	6 100	6 100
Ukraine	0	42 000	82 900	139 400
United States	0	17 400	62 900	138 200
Uzbekistan*	36 900	36 900	54 600	54 600
Viet Nam(d)	0	0	0	900
Zambia*(d)	0	0	9 900	9 900
Zimbabwe(a, c, d)	0	0	0	1 400
Total(f)	**478 500**	**1 223 600**	**3 458 400**	**4 386 400**

See notes on page 23.

Table 1.3b. Reasonably assured resources (in situ)

(as of 1 January 2015, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Algeria(c)	0	0	0	26 000
Argentina(d)	0	7 100	11 900	11 900
Australia(d)	N/A	N/A	1 688 000	1 707 800
Botswana*	0	0	22 100	22 100
Brazil	184 300	209 700	209 700	209 700
Canada(d)	293 700	311 800	486 000	631 700
Central African Republic*	0	0	42 700	42 700
Chile(d)	0	0	0	700
China	53 400	128 800	173 300	173 300
Congo, Dem. Rep.*(a, c)	0	0	0	1 900
Czech Republic(d)	0	0	1 900	83 900
Finland(c)	0	0	1 500	1 500
Gabon(a, c, d)	0	0	6 400	6 400
Germany(c, d)	0	0	0	4 000
Greece(a, d)	0	0	0	1 300
Greenland	0	0	0	158 200
India(e)	N/A	N/A	N/A	160 000
Indonesia(b, d)	0	2 000	7 000	7 000
Iran	0	0	1 400	1 400
Italy(a, c, d)	0	6 400	6 400	6 400
Japan(c, d)	0	0	8 800	8 800
Kazakhstan	43 200	257 700	309 100	414 400
Malawi*(d)	0	0	5 500	13 000
Mali*	0	0	11 400	11 400
Mauritania*	0	0	800	1 200
Mexico	0	1 500	2 400	2 400
Mongolia(d)	0	144 100	144 100	144 100
Namibia*	0	0	251 700	401 000
Niger*	0	19 900	285 800	321 400
Peru	0	20 000	20 000	20 000
Portugal(a, d)	0	6 000	8 000	8 000
Romania*(a)	0	0	4 000	4 000
Russia(b, d)	0	34 100	285 500	342 200
Slovak Republic(b)	0	10 900	10 900	10 900
Slovenia(a, c)	0	2 200	2 200	2 200
Somalia*(a, d)	0	0	0	6 700
South Africa(d)	0	239 800	338 100	369 100
Spain(d)	0	0	0	15 200
Sweden*(a, c)	0	0	6 500	6 500
Tanzania*(a, b)	0	47 900	50 600	50 600
Turkey(b)	0	8 400	8 400	8 400
Ukraine(d)	0	48 900	95 100	159 100
United States(d)	0	23 900	86 400	189 800
Uzbekistan*	52 700	52 700	78 000	78 000
Viet Nam	0	0	0	1 200
Zambia*	0	0	12 300	12 300
Zimbabwe(a, c)	0	0	0	1 800
Total(f)	**627 300**	**1 583 800**	**4 683 900**	**5 861 600**

See notes on page 23.

Table 1.4a. Inferred resources (recoverable)

(as of 1 January 2015, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Argentina	2 400	4 000	9 900	11 000
Australia	N/A	N/A	528 900	630 800
Botswana*	0	0	59 800	59 800
Brazil(d)	0	73 500	120 900	120 900
Canada	25 100	81 800	134 800	217 200
Chad*(a, d)	0	0	0	2 400
Chile	0	0	0	900
China(d)	60 000	111 200	144 200	144 200
Congo, Dem. Rep.*(a, c, d)	0	0	0	1 300
Czech Republic	0	0	100	68 300
Egypt(a, c, d)	0	0	0	1 900
Gabon(a, c)	0	0	0	1 000
Germany(c)	0	0	0	4 000
Greece(a, c)	0	0	0	6 000
Greenland	0	0	0	125 100
Hungary(c, d)	0	0	0	13 500
India(d, e)	N/A	N/A	N/A	17 700
Indonesia(b, d)	0	0	1 900	1 900
Iran(d)	0	0	2 700	2 700
Italy(a, c)	0	1 300	1 300	1 300
Jordan(b, d)	0	0	47 700	47 700
Kazakhstan(d)	59 000	437 900	469 500	578 400
Malawi*	0	0	1 800	4 600
Mali*(d)	0	0	4 500	4 500
Mauritania*	0	0	15 700	22 800
Mexico(d)	600	600	900	1 600
Mongolia	0	33 400	33 400	33 400
Namibia*	0	0	77 500	164 600
Niger*	0	0	56 200	95 300
Peru(d)	0	19 400	19 400	19 400
Portugal(a, c)	0	1 000	1 000	1 000
Romania*(a, c)	0	0	3 600	3 600
Russia(b)	0	20 400	279 400	421 400
Slovak Republic(b, d)	0	3 900	6 700	6 700
Slovenia(a, c, d)	0	3 800	7 500	7 500
Somalia*(a, c, d)	0	0	0	2 600
South Africa	0	61 700	84 800	189 700
Spain	0	0	0	21 000
Sweden*(a, c, d)	0	0	4 700	4 700
Tanzania*(a, b)	0	8 500	17 700	17 700
Turkey(b, d)	0	500	500	500
Ukraine	0	16 900	32 900	81 300
Uzbekistan*	21 300	21 300	75 500	75 500
Viet Nam(d)	0	0	0	3 000
Zambia*	0	0	14 700	14 700
Total(f)	**168 400**	**901 100**	**2 260 100**	**3 255 100**

See notes on page 23.

Table 1.4b. Inferred resources (in situ)

(as of 1 January 2015, tonnes U, rounded to nearest 100 tonnes)

Country	Cost ranges			
	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Argentina(d)	3 400	5 600	13 800	15 300
Australia(d)	N/A	N/A	778 600	922 700
Botswana*	0	0	96 500	96 500
Brazil	0	104 900	172 600	172 600
Canada(d)	32 500	106 200	175 100	282 100
Chad*(a)	0	0	0	3 200
Chile(d)	0	0	0	1 200
China	80 300	148 900	192 900	192 900
Congo, Dem. Rep.*(a, c)	0	0	0	1 700
Czech Republic(d)	0	0	100	113 600
Egypt(a, c)	0	0	0	2 500
Gabon(a, c, d	0	0	0	1 300
Germany(c, d)	0	0	0	5 300
Greece(a, d)	0	0	0	8 000
Greenland	0	0	0	192 500
Hungary(c)	0	0	0	17 900
India(e)	N/A	N/A	N/A	23 600
Indonesia(b, d)	0	0	2 500	2 500
Iran	0	0	3 100	3 100
Italy(a, c, d)	0	1 700	1 700	1 700
Jordan(b)	0	0	59 600	59 600
Kazakhstan	66 300	492 000	527 400	658 500
Malawi*(d)	0	0	2 800	6 000
Mali*	0	0	6 000	6 000
Mauritania*	0	0	18 100	27 500
Mexico	800	800	1 300	2 100
Mongolia(d)	0	44 600	44 600	44 600
Namibia*	0	0	102 500	220 500
Niger*	0	0	70 700	122 200
Peru	0	27 700	27 700	27 700
Portugal(a, d)	0	1 300	1 300	1 300
Romania*(a)	0	0	4 800	4 800
Russia(b, d)	0	25 500	349 300	526 800
Slovak Republic(b)	0	4 900	8 400	8 400
Slovenia(a, c)	0	5 000	10 000	10 000
Somalia*(a, d)	0	0	0	3 500
South Africa(d)	0	82 200	112 200	261 500
Spain(d)	0	0	0	24 700
Sweden*(a, c)	0	0	6 300	6 300
Tanzania*(a, b)	0	10 600	22 200	22 200
Turkey(b)	0	700	700	700
Ukraine(d)	0	19 300	37 300	91 900
Uzbekistan*	30 400	30 400	107 800	107 800
Viet Nam(c)	0	0	0	4 000
Zambia*	0	0	18 400	18 400
Total(f)	**213 700**	**1 112 300**	**2 976 300**	**4 327 200**

* NEA/IAEA estimate; (a) Not reported in 2015 responses, data from previous Red Book; (b) Assessment partially made within the last five years; (c) Assessment not made within the last five years; (d) Recoverable resources were adjusted by the NEA/IAEA to estimate in situ resources using recovery factors provided by countries or estimated by the NEA/IAEA according to the expected production method (Appendix 3); (e) Cost data not provided; therefore resources are reported in the <USD 260/kgU category; (f) Totals related to cost ranges <USD 40/kgU and <USD 80/kgU are higher than reported in the tables because certain countries do not report low-cost resource estimates, mainly for reasons of confidentiality.

Table 1.5. Major identified resource changes by country

(recoverable resources in 1 000 tonnes U)

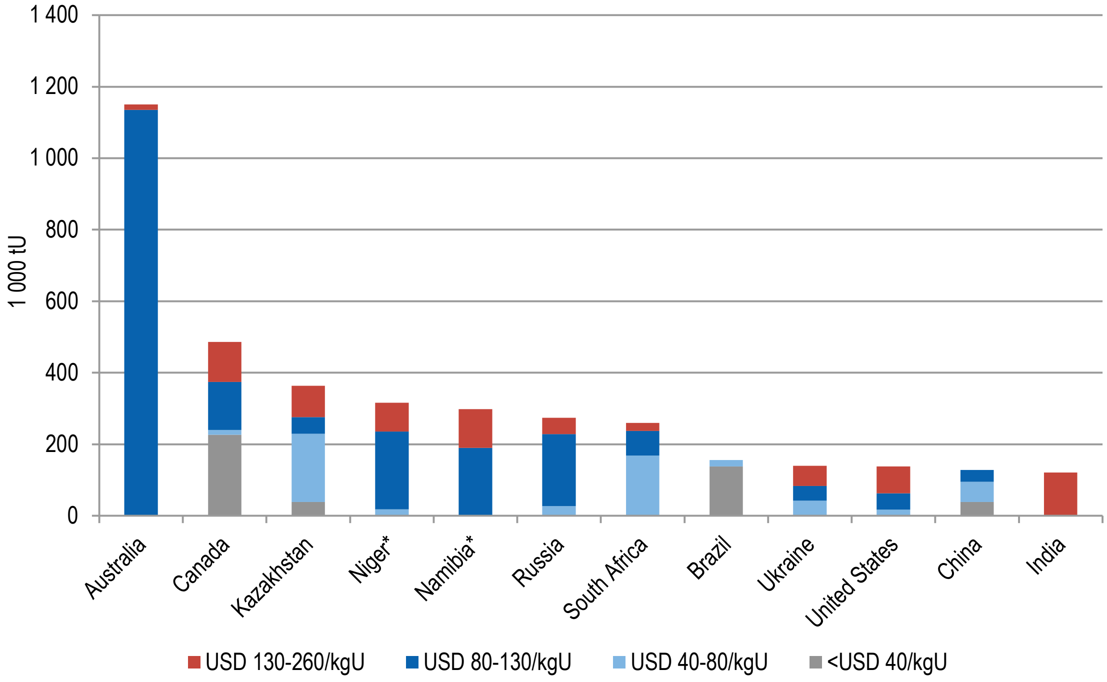
Country	Resource category	2013	2015	Changes	Reasons
Australia	RAR				Additional resources were defined at known deposits, offset by the transfer of resources into higher cost categories.
	<USD 130/kgU	1 174	1 135.2	-38.80	
	<USD 260/kgU	1 208	1 150	-58.00	
	Inferred				
	<USD 130/kgU	532.1	528.9	-3.20	
	<USD 260/kgU	590.3	630.8	40.50	
Botswana	RAR				Increase in the total resources as a result of better recovery factor following processing tests.
	<USD 130/kgU	12.8	13.7	0.90	
	<USD 260/kgU	12.8	13.7	0.90	
	Inferred				
	<USD 130/kgU	56	59.8	3.80	
	<USD 260/kgU	56	59.8	3.80	
Canada	RAR				Decrease of the identified resources in the <USD 40/kgU and USD 80/KgU cost categories, due to mining depletion and transfer of resources into the higher cost categories.
	<USD 40/kgU	256.2	226.1	-30.10	
	<USD 80/kgU	318.9	240.1	-78.80	
	<USD 130/kgU	357.5	374.2	16.70	
	<USD 260/kgU	454.5	486.4	31.90	
	Inferred				Increase of the total resources in the higher cost categories due to new resources being identified as the result of exploration activities (Shea Creek, Wheeler River, Roughrider and Triple R deposits).
	<USD 40/kgU	65.6	25.1	-40.50	
	<USD 80/kgU	99.4	81.8	-17.60	
	<USD 130/kgU	136.4	134.8	-1.60	
	<USD 260/kgU	196	217.2	21.20	
China	RAR				Increase in the total resources as a result of exploration activities in the Yili, Erlian, Erdos, Songliao, Bayingebi Basins, and in the Ruoergai and Ganzhou areas.
	<USD 40/kgU	51.8	38.9	-12.90	
	<USD 80/kgU	93.8	95	1.20	
	<USD 130/kgU	120	128.3	8.30	
	<USD 260/kgU	120	128.3	8.30	
	Inferred				
	<USD 40/kgU	13.9	60	46.10	
	<USD 80/kgU	24.8	111.2	86.40	
	<USD 130/kgU	79.1	144.2	65.10	
	<USD 260/kgU	79.1	144.2	65.10	
Greenland	RAR				Feasibility study and new resource evaluation.
	<USD 260/kgU	0	102.8	102.8	
	Inferred				
	<USD 260/kgU	221	125	-96	
India	RAR				Additional resources in the extensions of known deposits in the Cuddapah Basin, in the Sinhbhum shear zone and in the North Dehli Fold Belt. Conversion of part of the inferred resources to RAR.
	<USD 260/kgU	97.8	121.0	23	
	Inferred				
	<USD 260/kgU	22.1	16.3	-6	
Jordan	Inferred				New resource calculation.
	<USD 130/kgU	40	47.7	7.70	
	<USD 260/kgU	40	47.7	7.70	
Kazakhstan	RAR				Identified resources increased as a result of geological exploration during the past two years.
	<USD 80/kgU	199.7	229.3	30	
	<USD 130/kgU	285.6	275.8	-10	
	<USD 260/kgU	373	363.2	-10	
	Inferred				A total of 90 761 tU (in situ) were transferred from prognosticated resources to inferred resources (Inkai and Moinkum deposits).
	<USD 80/kgU	316	437.9	122	
	<USD 130/kgU	393.7	469.5	76	
	<USD 260/kgU	502.5	578.4	76	

Table 1.5. Major identified resource changes by country *(cont'd)*

(recoverable resources in 1 000 tonnes U)

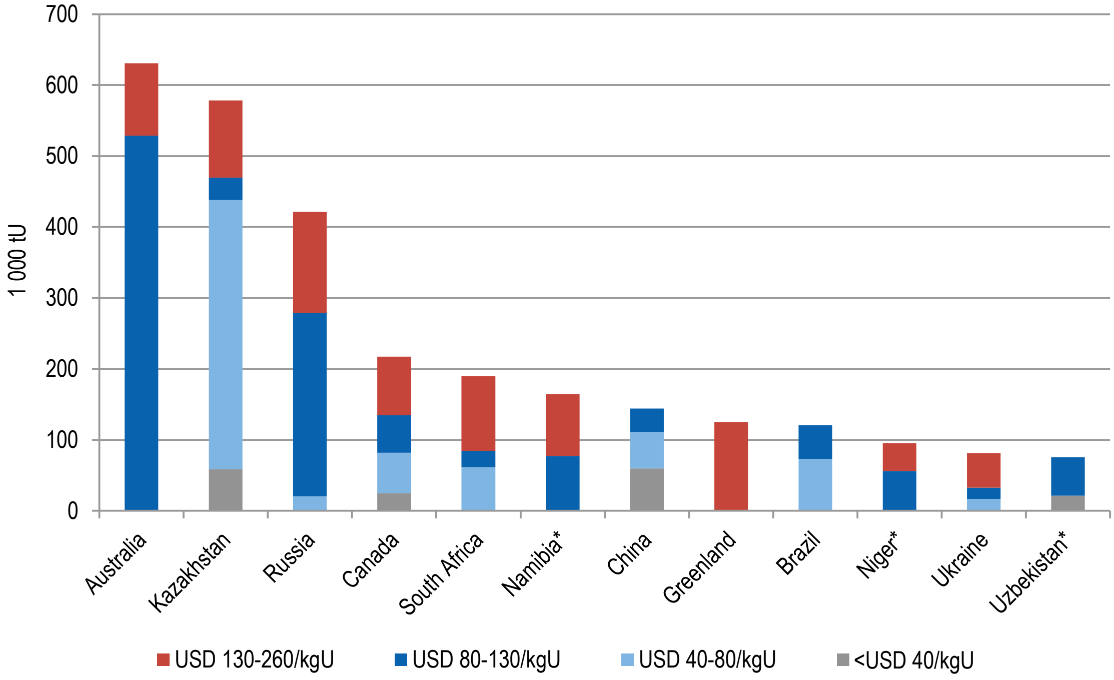
Country	Resource category	2013	2015	Changes	Reasons
Mauritania	Inferred				Mauritania reported resources at A 328, Bir En Nar and Reguibat deposits.
	<USD 130/kgU	0	15.7	16	
	<USD 260/kgU	0	22.8	23	
Namibia	RAR				New resource estimations. Additional resources associated with the Husab deposit, but mainly in the higher cost category.
	<USD 130/kgU	248.2	189.6	-59	
	<USD 260/kgU	296.5	298.4	2	
	Inferred				
	<USD 130/kgU	134.6	77.5	-57	
	<USD 260/kgU	159.1	164.6	6	
Niger	RAR				New resource estimations. Additional resources associated with the Dasa/Dajy deposits.
	<USD 80/kgU	14.8	17.7	3	
	<USD 130/kgU	325	235.3	-90	
	<USD 260/kgU	325	316	-9	
	Inferred				
	<USD 130/kgU	79.9	56.2	-24	
	<USD 260/kgU	79.9	95.3	15	
Peru	RAR				New resource estimations.
	<USD 80/kgU	1.4	14	13	
	<USD 130/kgU	1.4	14	13	
	<USD 260/kgU	1.4	14	13	
	Inferred				
	<USD 80/kgU	1.5	19.4	18	
	<USD 130/kgU	1.5	19.4	18	
	<USD 260/kgU	1.5	19.4	18	
Russia	RAR				Additional resources in the sandstone deposits of the Khiagda district.
	<USD 80/kgU	11.8	27.3	16	
	<USD 130/kgU	216.5	228.4	12	
	<USD 260/kgU	261.9	273.8	12	
	Inferred				Conversion of part of the inferred resources to RAR.
	<USD 80/kgU	30.5	20.4	-10	
	<USD 130/kgU	289.4	279.4	-10	
	<USD 260/kgU	427.3	421.4	-6	
South Africa	RAR				New resource estimations including additional information from drilling and mining activities.
	<USD 80/kgU	113	167.9	55	
	<USD 130/kgU	175.3	237.6	62	
	<USD 260/kgU	233.7	259.6	26	
	Inferred				A portion of the inferred resources, below the depth of 2 500 m in the Witwatersrand Basin, has been transferred to prognosticated resources.
	<USD 80/kgU	66.3	61.7	-5	
	<USD 130/kgU	162.8	84.8	-78	
	<USD 260/kgU	217.1	189.7	-27	
Spain	Inferred				Discovery of the Zona 7 deposit.
	<USD 260/kgU	0	21	21	
United States	RAR				New resources estimations. Resources estimates are available for only 75 mines and properties, compared to approximately 200 mines and properties in the previous estimates.
	<USD 80/kgU	39.1	17.4	-22	
	<USD 130/kgU	207.4	62.9	-145	
	<USD 260/kgU	472.1	138.2	-334	
Uzbekistan	RAR				Depletion due to production.
	<USD 80/kgU	41.7	36.9	-5	
	<USD 130/kgU	59.4	54.6	-5	
	<USD 260/kgU	59.4	54.6	-5	
	Inferred				Addition of resources associated with black shales.
	<USD 80/kgU	24.7	21.3	-3	
	<USD 130/kgU	31.9	75.5	44	
	<USD 260/kgU	31.9	75.5	44	

Figure 1.2. Distribution of reasonably assured resources among countries with a significant share of resources



* NEA/IAEA estimate.

Figure 1.3. Distribution of inferred resources among countries with a significant share of resources



* NEA/IAEA estimate.

Distribution of resources by production method

For this report, countries once again were asked to report identified resources by cost categories and by the expected production method, i.e. open-pit or underground mining, in situ leaching (ISL, sometimes referred to as in situ recovery, or ISR), heap leaching or in-place leaching, co-product/by-product or unspecified.

In the lowest cost category, <USD 40/kgU, underground mining is the predominant production method for RAR (see Table 1.6), mainly from Canada and to a lesser extent from Brazil and China. Resources in the co-product/by-product production category make a significant contribution, mainly from Brazil, with ISL from China and Kazakhstan making up most of the rest. The total is likely underestimated because of the difficulty in assigning mining costs accurately in the co-product/by-product category, particularly in Australia. In the <USD 80/kgU category, resources produced by underground mining and ISL methods make the largest contributions. The <USD 130/kgU category is dominated by resources in the co-product category; this is predominately a result of the world class Olympic Dam deposit in Australia. There is now a more even distribution of resources associated with open-pit, underground and co-product/by-product categories in the <USD 260/kgU category (see Table 1.6). Whereas the last reporting period was dominated by the underground mining category, the co-product-product category is now in the highest position. This increase can be attributed to the addition of resources from the Kvanefjeld deposit in Greenland. Canada holds the largest resource total for underground mining while Namibia and Niger make the largest contributions to open-pit production. Olympic Dam is responsible for the majority of the by-product category, with Brazil, Greenland and South Africa making significant contributions. ISL makes an important contribution in all cost categories with Kazakhstan being the major player.

The pattern of production method for IR is slightly different from that of RAR (see Table 1.7). In the lowest cost categories (<USD 40/kgU and <USD 80/kgU) ISL is dominant. In the <USD 130/kgU category, ISL continues to dominate but is followed closely by underground mining, co-product/by-product and open-pit categories. In the highest cost category (<USD 260/kgU), underground mining dominates with co-product/by-product, ISL and open-pit mining making significant contributions. The United States does not report IR, leading to under-representation in the ISL alkaline category for the inferred resources.

Table 1.6. Reasonably assured resources by production method

(recoverable resources as of 1 January 2015, tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining	8 309	79 874	763 770	1 014 455
Underground mining	292 454	417 643	851 063	1 277 231
In situ leaching acid	90 578	421 000	479 492	535 245
In situ leaching alkaline	16 100	22 120	23 800	81 805
Co-product/by-product	71 050	256 704	1 221 151	1 388 942
Unspecified	-	26 338	118 900	88 520
Total	**478 491**	**1 223 679**	**3 458 176**	**4 386 198**

Table 1.7. Inferred resources by production method

(recoverable resources as of 1 January 2015, tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining	2 431	35 328	453 542	615 022
Underground mining	44 625	183 864	547 933	942 083
In situ leaching acid	117 952	540 791	596 104	689 004
In situ leaching alkaline	2 800	6 020	6 300	6 300
Co-product/by-product	0	92 876	541 075	783 543
Unspecified	633	42 285	115 366	219 291
Total	**168 441**	**901 164**	**2 260 320**	**3 255 243**

Distribution of resources by processing method

In 2015, countries were once again requested to report identified resources by cost categories and by the expected processing method, i.e. conventional from open-pit or conventional from underground mining, ISL, in-place leaching, heap leaching from open pit or heap leaching from underground, or unspecified. It should be noted that not all countries reported their resources according to processing method.

The overall distribution has changed very little since the last reporting period. In all cost categories for RAR (see Table 1.8) conventional processing from underground mining is the major contributor, with Australia dominating because of Olympic Dam. In the higher cost categories, conventional processing from open pit and ISL make increasing contributions, but even when combined do not surpass the underground resources. In the IR category (see Table 1.9), ISL dominates in the two lower cost categories, but in the two higher cost categories it is replaced by underground conventional methods with totals more than twice that of ISL. The amount that is reported as unspecified is important because the exploration of many deposits is insufficiently advanced for any mine planning to have been carried out. Note that the United States does not report IR by production method, leading to under-representation in the ISL alkaline category in Table 1.9.

Table 1.8. Reasonably assured resources by processing method

(recoverable resources as of 1 January 2015, tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP	6 851	56 174	535 950	761 428
Conventional from UG	292 454	585 517	1 973 204	2 328 489
In situ leaching acid	90 578	421 000	468 792	517 445
In situ leaching alkaline	16 100	22 120	23 800	81 805
In-place leaching*	-	-	500	3 653
Heap leaching** from OP	1 458	23 700	215 661	330 580
Heap leaching** from UG	-	-	11 980	14 982
Unspecified	71 050	115 168	228 289	347 816
Total	**478 491**	**1 223 679**	**3 458 176**	**4 386 198**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Table 1.9. Inferred resources by processing method

(recoverable resources as of 1 January 2015, tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from OP	2 431	15 911	317 751	416 791
Conventional from UG	44 625	245 520	986 294	1 431 997
In situ leaching acid	117 952	540 791	597 804	695 504
In situ leaching alkaline	2 800	6 020	6 300	6 300
In-place leaching*	-	-	2 100	15 968
Heap leaching** from OP	-	19 417	97 575	124 727
Heap leaching** from UG	-	-	4 000	11 779
Unspecified	633	73 505	248 496	552 177
Total	**168 441**	**901 164**	**2 260 320**	**3 255 243**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Distribution of resources by deposit type

In 2015, countries also reported identified resources by cost categories and by geological types of deposits using a new deposit classification scheme which was introduced in the 2014 edition (Appendix 3). In the lowest cost RAR (<USD 40/kgU) category, Proterozoic unconformity-related deposits in Canada dominate, with smaller contributions from sandstone, metasomatite, phosphate, granite-related and unspecified-type deposits (see Table 1.10).

Table 1.10. Reasonably assured resources by deposit type

(recoverable resources as of 1 January 2015, tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	226 120	240 050	486 829	569 386
Sandstone	106 678	526 209	922 146	1 153 281
Polymetallic Fe-oxide breccia complex	-	-	902 000	902 000
Paleo-quartz-pebble conglomerate(a)	-	167 874	230 321	255 147
Granite-related	17 780	40 060	46 900	82 425
Metamorphite	-	2 604	7 051	38 521
Intrusive	-	-	161 431	400 467
Volcanic-related	-	46 249	137 723	140 663
Metasomatite	66 663	101 958	284 724	448 828
Surficial deposits	-	-	91 044	117 323
Carbonate	-	-	-	58 024
Collapse breccia	405	405	405	405
Phosphate	53 270	53 270	120 627	120 627
Lignite – coal	-	-	-	23 112
Black shale	-	-	-	-
Unspecified	7 575	45 000	66 975	75 989
Total	**478 491**	**1 223 679**	**3 458 176**	**4 386 198**

(a) In South Africa, Paleo-quartz-pebble conglomerate resources include tailings resources.

Sandstone resources (in Kazakhstan, Niger, Russia and Uzbekistan) dominate the <USD 80/kgU category. Polymetallic iron-oxide breccia complex deposits in Australia become important in the <USD 130/kgU category, and are only surpassed by sandstone-related resources with Proterozoic unconformity-related, paleo-quartz-pebble conglomerate and metasomatite resources still making important contributions. Other types of deposits take larger shares of the total only in the two highest cost categories with some significant shares of resources attributed to metasomatite, intrusive and paleo-quartz-pebble conglomerate types in the <USD 260/kgU category (see Table 1.10).

Similar observations can be made in the IR category (see Table 1.11). In the <USD 260/kgU and <USD 130/kgU category, sandstone-hosted resources dominate with metasomatite and polymetallic iron-oxide breccia complex resources being the next most important deposit types. Sandstone deposits dominate the <USD 80/kgU cost category, followed by Proterozoic unconformity deposits and paleo-quartz-pebble conglomerate deposits. In the lowest cost category (<USD 40/kgU), sandstone deposits dominate, followed by the Proterozoic unconformity-type, which makes a moderate contribution, and volcanic-related deposits, which make a very small contribution.

Table 1.11. Inferred resources by deposit type

(recoverable resources as of 1 January 2015, tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	25 050	81 790	177 063	222 285
Sandstone	123 336	571 659	856 930	1 064 025
Polymetallic Fe-oxide breccia complex	-	-	371 800	421 100
Paleo-quartz-pebble conglomerate(a)	-	72 306	85 011	134 724
Granite-related	-	1 000	51 949	88 480
Metamorphite	-	710	2 742	16 472
Intrusive	-	-	68 344	298 280
Volcanic-related	480	59 831	103 138	123 813
Metasomatite	-	19 585	286 964	489 355
Surficial deposits	-	-	93 274	136 745
Carbonate	-	-	-	-
Collapse breccia	-	18 744	18 744	18 744
Phosphate	-	30 705	33 505	36 205
Lignite – coal	-	-	7 022	87 081
Black shale	-	-	-	-
Unspecified	19 575	44 925	103 925	117 934
Total	**168 441**	**901 255**	**2 260 411**	**3 255 243**

(a) In South Africa, Paleo-quartz-pebble conglomerate resources include tailings resources.

Proximity of resources to production centres

A total of ten countries provided estimates on the availability of resources for near-term production by reporting the percentage of identified resources (RAR and inferred resources) recoverable at costs of <USD 80/kgU and <USD 130/kgU that are proximal to

existing and committed production centres (see Table 1.12). Resources proximal to existing and committed production centres in the ten countries listed a total 1 345 999 tU at <USD 80/kgU (about 88% of the total resources reported in this cost category). This is 23% higher than the 2013 value of 1 099 921 tU. This modest increase can be attributed primarily to an increase of resources in this cost category for Kazakhstan and South Africa. Resources proximal to existing and committed production centres in the ten countries listed total 2 974 059 tU at <USD 130/kgU (about 65% of the total resources reported in this cost category). This is 6% lower than the 3 154 147 tU reported for 2013, and mainly results from an update in this cost category for Niger, including re-evaluation and transfer of some of the resources into the highest cost category.

Table 1.12. Identified resources proximate to existing or committed production centres*

Country	RAR and inferred recoverable at <USD 80/kgU in existing or committed production centres			RAR and inferred recoverable at <USD 130/kgU in existing or committed production centres		
	Total resources (tU)	%	Proximate resources (tU)	Total resources (tU)	%	Proximate resources (tU)
Australia	N/A		N/A	1 664 100	58	965 178
Brazil	229 400	66	151 404	276 800	66	182 688
Canada	321 800	98	315 364	509 000	62	315 580
Czech Republic	0	-	-	1 300	100	1 300
Iran	0	-	-	3 800	59	2 242
Kazakhstan	667 200	95	633 840	745 300	86	640 958
Namibia	0		-	267 000	93	249 498
Niger	17 700	100	17 700	291 500	87	253 747
Russia	47 700	78	37 206	507 800	34	172 652
South Africa	229 500	83	190 485	322 400	59	190 216
Total	**1 513 300**	**88**	**1 345 999**	**4 589 000**	**65**	**2 974 059**

N/A = not available.

* Identified resources only in countries that reported proximity to production centres; not world total.

Additional conventional resources

The NEA/IAEA provided estimates on additional identified resources (see Table 1.13). This was included for the first time in the 2011 Red Book. Some countries do not include resource determinations by junior exploration companies in national totals until additional information is provided to the pertinent agencies or until a mining licence application is filed (e.g. Peru). Other countries do not always have sufficient human resources to provide detailed information and evaluation as requested in the questionnaire. The table represents an NEA/IAEA estimate based on technical reports of resources that have been classified either as JORC, NI 43-101 or South African Mineral Resource Committee (SAMREC) compliant.

These additional resources amount to a total of 72 700 tU classified as RAR and IR in several countries, which represents a decrease of 46 400 tU since the last reporting period, as some of the resources for Mauritania, Peru and Spain that were reported last time in this table are now reported in the national totals. The most significant "additional resources" occur in Cameroon (24 100 tU) and Peru (12 400 tU).

Table 1.13. Additional identified resources

(rounded to nearest 100 tU)

Country	Deposit/project	RAR and inferred resources
Bulgaria	ISL mineable deposits	7 900
Cameroon	Poli	13 100
	Lolodorf	11 000
Columbia	Berlin	8 200
Egypt	Gabal Gutter	2 000
	Abu Zenima	100
Guinea	Firawa	7 500
Guyana	Kurupung	6 200
Paraguay	Yuty	4 300
Peru	Kihitian	11 200
	Triunfador	1 200
Total		**72 700**

(a) Amount not reported in RAR and IR national totals.

Source: NEA/IAEA estimate based on publicly available data.

Undiscovered resources

Undiscovered resources (*prognosticated* and *speculative*) refer to resources that are expected to occur based on geological knowledge of previously discovered deposits and regional geological mapping. *Prognosticated resources* (PR) refer to those expected to occur in known uranium provinces, generally supported by some direct evidence. *Speculative resources* (SR) refer to those expected to occur in geological provinces that may host uranium deposits. Both prognosticated and speculative resources require significant amounts of exploration before their existence can be confirmed and grades and tonnages can be more accurately determined. All PR and SR are reported as in situ resources (see Table 1.14).

Worldwide, reporting of PR and SR is incomplete; a total of 22 countries (including 2 NEA/IAEA estimates) reported undiscovered resources for this edition, compared to the 36 with RAR (including 10 NEA/IAEA estimates). Only 11 countries of those reporting provided updated undiscovered resource figures for this edition, and two of these updates were NEA/IAEA estimates. Twenty countries report both prognosticated and speculative resources, including Chile, which estimates SR and PR as one combined figure. Germany, Italy, Jordan, Mauritania, Poland, Venezuela and Zimbabwe reported only speculative resources. Only prognosticated resources are reported for Bulgaria, Greece, Hungary, Indonesia, Portugal, the Slovak Republic, Slovenia and Uzbekistan. Some of the countries that do not report undiscovered resources, such as Australia are considered to have significant resource potential in as yet sparsely explored areas. The United States completed part of their re-evaluation of undiscovered resources in 2015. Using a geology-based assessment methodology, the US Geological Survey (USGS) estimated that a mean 85 000 tU of recoverable U_3O_8 remain as potential undiscovered resources in southern Texas. However, this is yet to be classified into cost categories in either speculative or prognosticated resource categories and so was not reported in Table 1.14.

Table 1.14. Reported undiscovered resources

(in 1 000 tU as of 1 January 2015)

Country	Prognosticated resources			Speculative resources			Total SR
	Cost ranges			Cost ranges			
	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	<USD 130/kgU	<USD 260/kgU	Cost range unassigned	
Argentina	N/A	13.8	13.8	N/A	56.4	N/A	56.4
Brazil(a)	300.0	300.0	300.0	N/A	N/A	500.0	500.0
Bulgaria(b)	N/A	N/A	25.0	N/A	N/A	N/A	N/A
Canada(a)	50.0	150.0	150.0	700.0	700.0	0.0	700.0
Chile(a)	0.0	0.0	2.3	0.0	0.0	2.4	2.4
China(b)	3.6	3.6	3.6	4.1	4.1	N/A	4.1
Colombia(b)	N/A	11.0	11.0	217.0	217.0	N/A	217.0
Czech Republic	0.0	0.3	223.0	0.0	0.0	17.0	17.0
Germany(a)	N/A	N/A	N/A	N/A	N/A	74.0	74.0
Greece(b)	6.0	6.0	6.0	N/A	N/A	N/A	N/A
Hungary(a)	0.0	0.0	13.4	0.0	0.0	0.0	0.0
India	N/A	N/A	106.0	N/A	N/A	46.6	46.6
Indonesia	0.0	0.0	27.6	0.0	0.0	0.0	0.0
Iran(c)	0.0	12.4	12.4	0.0	0.0	32.7	32.7
Italy(a)	0.0	0.0	0.0	10.0	10.0	N/A	10.0
Jordan(a)	0.0	0.0	0.0	0.0	50.0	N/A	50.0
Kazakhstan	121.4	234.1	235.6	266.9	300.0	N/A	300.0
Mauritania*	0.0	0.0	0.0	N/A	N/A	19.6	19.6
Mexico(b)	N/A	3.0	3.0	N/A	N/A	10.0	10.0
Mongolia(a)	21.0	21.0	21.0	1 390	1 390	N/A	1 390.0
Namibia*	0.0	0.0	57.0	0.0	0.0	110.7	110.7
Niger(b)	0.	13.6	13.6	0.0	51.3	0.0	51.3
Peru(a)	6.6	20.0	20.0	19.7	19.7	0.0	19.7
Poland	0.0	0.0	0.0	0.0	0.0	20.0	20.0
Portugal(b)	1.0	1.5	1.5	N/A	N/A	N/A	N/A
Romania(b)	N/A	3.0	3.0	3.0	3.0	N/A	3.0
Russia	0.0	126.3	126.3	N/A	N/A	538.0	538.0
Slovak Republic(c)	0.0	3.7	10.9	0.0	0.0	0.0	0.0
Slovenia(b)	0.0	1.1	1.1	0.0	0.0	0.0	0.0
South Africa	0.0	74.0	159.0	243.0	411.0	280.0	691.0
Ukraine	0.0	8.4	22.5	0.0	120.0	255.0	375.0
United States	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Uzbekistan(b)	24.8	24.8	24.8	0.0	0.0	0.0	0.0
Venezuela(b)	N/A	N/A	N/A	0.0	0.0	163.0	163.0
Viet Nam	N/A	N/A	81.2	N/A	N/A	321.6	321.6
Zimbabwe(b)	0.0	0.0	0.0	25.0	25.0	N/A	25.0
Total	**534.4**	**1 031.6**	**1 674.6**	**2 878.7**	**3 357.5**	**2 390.6**	**5 748.1**

N/A = Data not available.

(a) Reported in 2015 responses, but values have not been updated within last five years.

(b) Not reported in 2015 response, data from previous Red Book.

(c) Reported in 2015 responses, but only partially assessed within last five years.

* NEA/IAEA estimate.

Total PR in the highest cost category (<USD 260/kgU) amounted to 1.67 million tU, which is only a 5% decrease compared to 2013. In parallel with the trends observed in the <USD 260/kgU category, the lower cost categories (i.e. <USD 130/kgU and <USD 80/kgU) dropped by 2% and 20%, respectively. These decreases can be attributed primarily to the lower SR reported by Kazakhstan, as prognosticated resources were transferred to the inferred resource category. Increases were reported for the Czech Republic, India, Indonesia and Russia, with most other countries reporting no change since the last reporting period.

Total SR in the <USD 260/kgU cost category increased by 21% compared to 2013, with this increase entirely attributed to an update from South Africa, which added 411 000 tU to this category. In the unassigned category, there was an overall decrease of 20%, with decreases reported only for South Africa; and additions or increases for Chile, India, Poland, Russia and Ukraine. The total SR in the <USD 130/kgU cost category increased by 20% from the last report, with additions made from South Africa and a very small decrease reported by Kazakhstan. Other countries reported no change in this cost category.

High cost (<USD 260/kgU) PR and total SR amount to a combined total of 7 422 700 tU, a minor decrease of 4% from the 7 697 700 tU reported for 2013.

Other resources and materials

Conventional resources are defined as resources from which uranium is recoverable as a primary product, a co-product or an important by-product, while *unconventional resources* are resources from which uranium is only recoverable as a minor by-product, such as uranium associated with phosphate rocks, non-ferrous ores, carbonatite, black shale and lignite. Most of the unconventional uranium resources reported to date are associated with uranium in phosphate rocks, but other potential sources exist (e.g. black shale and seawater).

Since 2009, a combination of expectations of rising medium-term demand and sustainability issues, have stimulated investigation of a variety of projects, extraction technologies and business models on the part of both governments and commercial entities. Interest in recovery of uranium from phosphates has been the primary focus for both economic and environmental reasons. This prompted a series of IAEA supported consultancies and technical meetings in 2010 and 2011, as well as a sequence of capacity-building workshops and training courses, beginning with a major workshop in Marrakech, Morocco (November 2011), followed by Amman, Jordan (2012) and Tunis, Tunisia (2013). A national project was active in Tunisia (2012-2013) and new projects were initiated in Philippines (2014-2015) and Egypt (2014-2015 and 2016-2017). A regional Asia-Pacific project and an inter-regional project were also initiated and will run from 2016-2019 to support these concepts. However, since the Fukushima Daiichi accident in 2011, uranium market prices have declined, and though these types of investigations continue, they are occurring at a slower pace than in the years leading up to the accident.

Since few countries reported updated information, a comprehensive compilation of unconventional uranium resources and other potential nuclear fuel materials is not possible. Instead, a summary of information documented over recent years and data reported in this edition is provided. Table 1.15 summarises unconventional resource estimates reported in Red Books between 1965 and 2003 (NEA, 2006) and incorporates unconventional resource assessments included in the national reports of this 2016 edition in order to illustrate the evolution of these resource estimates.

Unconventional uranium resources were reported occasionally by countries in Red Books beginning in 1965. Earlier estimates for Jordan appear to have overestimated U contained in phosphate, whereas estimates of black schists (shales) in Finland and Sweden appear to have underestimated contained U (see Table 1.15). Other estimates of uranium resources associated with marine and organic phosphorite deposits point to the existence of almost 9 million tU in Jordan, Mexico, Morocco and the United States alone (IAEA, 2001). Others have estimated the global total to amount to 22 million tU (De Voto and Stevens, 1979). Recent data from the International Fertilizer Development Centre (IFDC) indicates that the latter figure is probably a very conservative estimate of total resources but is likely to be a reasonably accurate reflection of commercially exploitable resources (Hilton et al., forthcoming).

The figures presented in Table 1.15 can be expected to continue to evolve and are clearly incomplete, since large uranium resources associated with the Chattanooga (United States) and Ronneburg (Germany) black shales – which combined are estimated to contain a total of 4.2 million tU – are not listed. Neither are large uranium resources associated with monazite-bearing coastal sands provided for Brazil, Egypt, India, Malaysia, Sri Lanka and the United States. Unconventional resources are also not regularly reported in former Soviet Union countries. The total uranium reported in previous Red Books as unconventional resources, dominated by phosphorite deposits in Morocco (>85%), were conservatively estimated to amount to about 6.5 million tU. The potential to expand the unconventional uranium resource base is clear but will likely not be fully realised until market conditions strengthen considerably.

Table 1.15. Unconventional uranium resources (1 000 tU) reported in 1965-2003 Red Books, with updated data[#] from 2011-2015 in parentheses

Country	Phosphate rocks	Non-ferrous ores	Monazite	Carbonatite	Black schist/shales, lignite
Brazil*	28.0-70.0 (84.5)	2		13	
Chile	0.6-2.8 (0.4)	4.5-5.2 (0.8)			
Columbia	20.0-60.0				
Egypt**	35.0-100.0				
Finland	1 (1[a])			2.5 (2.5)	3.0-9.0 (35)
Greece	0.5				
India	1.7-2.5	6.6-22.9			4
Indonesia			(25.9)		
Iraq	(19-42.8)				
Jordan	100-123.4 (60[a])				
Kazakhstan	58 (29[b])				
Mexico	100-151 (240[a])	1			
Morocco	6 526				
Peru	20 (41.6)	0.14-1.41			
South Africa	(180)				70.7[b]
Sweden	(42.3)				300 (1 012.0)
Syria	60.0-80.0				
Thailand	0.5-1.5				
United States	14.0-33.0	1.8			
Venezuela	42				
Viet Nam					0.5

[#] Updated data from publicly available sources and information provided by countries in the Red Book questionnaire.

* Uranium from phosphate rocks is considered as a conventional resource in Brazil and is thus included in conventional resource figures (see Tables 1.4a and 1.4b).

** Includes an unknown quantity of uranium contained in monazite.

(a) Not reported in 2015 questionnaires; data from 2011 Red Book.

(b) Reported as conventional resources in the country report.

The potential to expand the unconventional uranium resource base is strongly tied to the ability to bring these resources into production. This will depend on i) market conditions, notably for the commercial recovery of phosphate reserves, since these determine the underlying economics of by-product uranium recovery; ii) changing business models and perceptions in the mineral industry consequent to recent market downturns resulting in expansion of portfolios to include multiple value-added products; iii) changing policy, notably to require uranium and other critical resources such as rare earth elements to be extracted for strategic and sustainability reasons rather than entirely on a commercial basis; and iv) a drive towards better environmental management and waste minimisation. Examples of possible policy drivers include the need to enhance the security of uranium supply to the national nuclear fuel cycle or to reap the environmental benefits of extracting uranium from phosphoric acid rather than by conventional mining, along with minimising the already very low amounts of uranium contained in fertiliser products.

Uranium as a co-product/by-product

A pre-feasibility report was released in 2011 for the Kvanefjeld rare earth element project of the Ilimausaq intrusion. In 2013, Greenland's parliament voted in favour of lifting the country's long-standing ban on the extraction of radioactive materials, including uranium. The move could enable the Kvanefjeld project to proceed, which is currently the subject of a definitive feasibility study to evaluate a mining operation for the production of uranium, rare earth elements and zinc. If the deposit were to be mined, about 425 tU/yr could be recovered as a by-product while thorium would be precipitated with other impurities such as iron, aluminium and silica and stored in a residue storage facility with the possibility of recovering the Th in the future.

Nolans Bore, Northern Territory, Australia is a rare earths-phosphate-uranium deposit, discovered in 1995. There is a conceptual plan to mine, concentrate and chemically process rare earths at the Nolans site, then transport a rare earths-rich intermediate product to an offshore refinery for final processing into high-value rare earth products. About 7 488 tU of resources have been estimated. A feasibility study is in progress with a comprehensive technical and commercial work stream. The project is projected to start in 2019 and could produce 14 000 t of rare earth oxides and possibly uranium, thorium and phosphoric acid (110 000 t/a) as by-products.

Pitinga deposit, Amazonas, Brazil is one of the largest tin deposits in the world. Thick rhyolitic ashflow and tuffs are intruded by 1 800 Ma granite. After a period of deposition of locally derived sandstone and shales, a series of rapakivi, porphyritic and sub-alkaline biotite granites were emplaced, which contain ore minerals such as zircon, pyrochlore, columbite, tantalite, xenotime and cassiterite. Apart from tin, minor tantalum is currently also produced. However, the columbite mineral also contains 3.16% U_3O_8 and 4.90% ThO_2. This along with Nb, Ta, Zr and rare earth elements (REEs) are currently not being recovered. A pre-feasibility study is under progress to study the possibility of by-product recovery of Ta, Nb, Y, REE, U and Th, with production forecasted to start by 2020.

Alum (black) shale in Sweden has been investigated since 2011 for potential recovery of molybdenum, vanadium, nickel, zinc, petroleum products and uranium. The major deposits are Häggån (307 692 tU), MMS Vicken (447 308 tU) and Narke (257 000 tU). A scoping study, which examined a range of heap leach options including bioheap leaching, was completed in 2012 with positive results reported. Expected production is about 3 000 tU/yr, but no definite start dates have been announced. In December 2013, Aura Energy Ltd announced that given the current market conditions, a remodelling of the 2012 scoping study for smaller size options, is more likely to attract funding than a project with a high initial capital cost.

The Talvivaara Ni-Zn-Cu-Co deposits in Finland reports 22 000 tU. Although mining and production of other metals started in 2008, uranium present at 0.0017% in the ore started appearing as a contaminant in the downstream products. A licence for uranium extraction was granted in 2012, for annual production of 350 tU. However, a waste water leak in 2012 and 2013 stopped the operations completely and the operator filed for bankruptcy protection in 2014. In 2015, the Finnish government took control of the mine and plans have been made to inject funds to restart operations if other private investors can be found.

Elliot Lake district, Ontario, Canada, has a previous history of uranium and REE production. Between 1955 and 1996, the paleo-quartz pebble conglomerate deposit produced about 115 394 tU, as well as a small quantity of rare earth oxides. Recent exploration in the area has resulted in a proposal (Eco Ridge project) which would produce rare earth oxides and uranium as co-products. A NI 43-101 resource estimate, that was updated in 2013, reported 23 147 tU and 93 180 t of rare earth oxides. A 2013 economic review indicated that approximately 1 173 tU/yr could be produced over 14 years of mine life.

South Africa has reported a significant resource base in paleo-quartz-pebble conglomerates and derived tailings and coal-hosted deposits, all of which could be sources of by-product uranium. Uranium is hosted primarily by coal (with minor amounts in the mudstones) in the Springbok Flats. A pre-feasibility study has been completed in Springbok Flats and a bankable feasibility study is in progress. The development of this project envisages an annual production capacity of about 600 tU, and production is planned from 2020 if the feasibility study is successful. For this edition of the Red Book, 70 775 tU for lignite and coal deposits were reported as inferred conventional resources. This is a good example of a reclassification of resources from "unconventional" to "conventional" resources. This reclassification is subjective since there are some parts of the definition of these resource classes that are open to different interpretations. In addition, uranium production and resources from tailings is reported as conventional and in association with the paleo-quartz pebble conglomerate deposit type.

If uranium prices reach long-term levels in excess of USD 260/kgU (USD 100/lb U_3O_8), and/or improvements are made in reducing mining and processing costs, by-product recovery of uranium from unconventional resources could once again become commercially viable, even without the policy changes noted above.

Uranium from phosphates

In the market scenario, phosphate deposits will only be processed commercially when it is economically viable to do so. Hence, the phosphate market acts as the determining factor of how much uranium can even theoretically be extracted from phosphate resources.

In the policy-driven scenario, the value of other recoverable elements will be added by various means, such as long-term government contracts, to the overall economic evaluation. Governments could also place a premium on securing the supply of nuclear fuel, especially where this can come from national resources, thereby eliminating dependency on third parties. In some countries, uranium extraction from phosphates could perhaps be mandated.

A hybrid situation (market and policy-driven scenario) may, however, be the most sustainable scenario over the long term. The need to combine fuel security for the utility company with commercial viability to the phosphate company and to align these requirements with the equally significant role of phosphates in providing food security could drive new business models. One benchmark in Brazil has already been set for this scenario, the Santa Quitéria greenfield joint venture between the government company, Industrias Núcleares do Brasil S.A (INB), and Galvani phosphates, with the prime customer being Eletrobras, the leading producer of nuclear power. This project will produce both yellow cake and diammonium phosphate (DAP) in a single integrated process, thus spreading business risk across both phosphates and uranium. The alternative model is when the government steps in as the customer, as in the case of India, on the premise that the wider challenge of sustaining energy production as the fundamental driver of economic development justifies an offset of risk from the commercial producer to the tax payer. Under the hybrid option, both phosphate and uranium are managed as utility products and not as market-dependent commodities.

PhosEnergy Limited (PEL) and global uranium company Cameco Corporation are jointly commercialising a process for the extraction of uranium from phosphate streams produced in the production of phosphate-based fertilisers. The process is being conducted by a Colorado company, Urtek LLC, which is 73% owned by Cameco and 27% by PEL. An independent pre-feasibility (PFS) level engineering study was completed in March 2013. Results are encouraging with recoveries of 92% and an operating cost of USD 18/lb U_3O_8. Capital costs are estimated at USD 156 million and potential production is 0.88 million lbs U_3O_8/year with a facility life of at least 25 years.

Uranium from seawater

Seawater has long been regarded as a possible source of uranium because of the large amount of contained uranium (over 4 billion tU) and its almost inexhaustible nature. However, because seawater contains such a low concentration of uranium (3-4 parts per billion), developing a cost-effective method of extraction remains a challenge.

Research on uranium recovery from seawater was carried out initially from the 1950s to the 1980s in Germany, Italy, the United Kingdom and the United States. In Japan from 1981 to 1988, the Agency for Natural Resources and Energy, the Ministry of International Trade and Industry, and the Metal Mining Agency of Japan teamed up to operate an experimental marine uranium adsorption plant based on TiO_2 adsorbents. Japanese efforts restarted in the 1990s when amidoxime-based fibres in the form of both stacks and braids were tested in marine environments. The fibre stacks were tested from 1999 to 2001 in the Pacific Ocean off the coast of the Aomori prefecture of Japan and showed an average uranium adsorption capability over 30 days of 0.5 g U/kg-adsorbent, five times higher than that of the TiO_2. In 2012, researchers at the US Department of Energy's Oak Ridge National Laboratory and Pacific Northwest National Laboratory published encouraging results using this Japanese technology (Ferguson, 2012). They report that they have been able to double the amount of uranium recovered using plastic fibres with ten times more surface area than the Japanese design. This reduces the production costs of a kilogram of uranium extracted from seawater from about USD 1 232 to USD 660. Many Chinese research groups in universities and institutions have also shown great interest in uranium extraction from seawater. In 2013, a workshop on the extraction of uranium from seawater was held in Shanghai, with more than 80 attendees from China and 5 delegates from the United States. A symposium entitled Uranium in Seawater was organised in March 2015 by the American Chemical Society which featured 42 presentations with speakers from around the world and provided the updates on research sponsored by the US Department of Energy since 2011 (Alexandratos and Kung, 2016).

Thorium

Thorium (Th) is a silvery white, radioactive metal found in small quantities in most rocks and soils. Its global crustal abundance in the earth's crust is between three and five times that of uranium. Thorium in mineral form occurs as oxides, silicates and phosphates, often with REE, niobium and tantalum.

Various classification schemes have been proposed for thorium-bearing deposits. At the simplest level, thorium is found in four main types of deposits, which are (in decreasing order of importance): placer, carbonatite-hosted, vein-type and alkaline rock-hosted deposits (see Table 1.16). Other, less important deposit types are also known to exist.

Table 1.16. Major thorium deposit types and resources (ThDEPO)

Deposit type	Resources (1 000 t Th)
Placer	2 182
Carbonatite	1 783
Vein-type	1 528
Alkaline rocks	584
Other/unknown	135
Total	**6 212**

Placer-type deposits range in age from the Archean, such as the paleo-quartz-pebble conglomerates in the Witwatersrand Basin, to Tertiary and recent deposits of heavy mineral coastal sands in Australia, Brazil, India, Mozambique, South Africa and the eastern United States. Carbonatite-hosted thorium deposits are common around the world and are documented in Argentina, Australia, Brazil, Canada, Russia, Scandinavia (Finland, Norway and Sweden), South Africa and the United States. Vein-type and alkaline-rock-hosted deposits are equally widespread, occurring on all continents. Some thorium-rich deposits, such as the enormous Bayan Obo deposit in China, are difficult to assign to a specific deposit-type category since they display characteristics of carbonatite, alkaline and vein-type deposits, and accordingly several genetic theories have been proposed. Currently, beach sand deposits in Brazil and India are the only sources of thorium, and this type of deposit is likely to remain an important source of thorium production.

The by-product nature of the occurrence of thorium and a lack of economic interest has meant that thorium resources have seldom, if ever, been accurately defined. Information on thorium resources was published in Red Books between 1965 and 1981, typically using the same terminology as for uranium resources at that time (e.g. reasonably assured resources and estimated additional resources I and II: the latter two categories are now termed inferred and prognosticated resources, respectively). No further information was published until 2003 when a global estimate of thorium resources of 4.5 million tonnes Th was presented in the 2003 Red Book. A more comprehensive report was presented in the 2007 Red Book where resource estimates were given by deposit type and by countries, and this was updated in the 2009 edition.

Currently, the worldwide thorium resources by major deposit types are estimated to total about 6.2 million tonnes Th including undiscovered resources (see Table 1.16).

In 2011 and 2013, the IAEA conducted technical meetings on thorium resources. Based on the inputs given in the meetings and details available in other open sources, total thorium resources, regardless of resource category or cost category, have been updated for 16 of the 35 countries listed (see Table 1.17). Based on this data, worldwide thorium resources are 6.35 to 6.37 million tonnes Th, which is very similar to the total reported in the Table 1.16.

Thorium as a nuclear fuel

Similar to uranium, thorium can be used as a nuclear fuel. Although not fissile itself, ^{232}Th, when loaded into a nuclear reactor, absorbs neutrons to produce ^{233}U, which is fissile (and long-lived). Much of the ^{233}U will then fission in the reactor. The used fuel can then be unloaded from the reactor and the remaining ^{233}U can be chemically separated from the thorium and used as fuel in a nuclear reactor.

Table 1.17. Identified[1] thorium resources

Region	Country	Total thorium resources, tTh (in situ)
Europe	Turkey*	374 000
	Norway	87 000
	Greenland (Denmark)	86 000-93 000
	Finland*	60 000
	Russia, European part of	55 000
	Sweden	50 000
	France	1 000
	Total	**713 000-720 000**
Americas	United States#	595 000
	Brazil	632 000
	Venezuela*	300 000
	Canada	172 000
	Peru	20 000
	Uruguay*	3 000
	Argentina	1 300
	Total	**1 723 300**
Africa	Egypt*	380 000
	South Africa	148 000
	Morocco*	30 000
	Nigeria*	29 000
	Madagascar*	22 000
	Angola*	10 000
	Mozambique	10 000
	Malawi*	9 000
	Kenya*	8 000
	Democratic Republic of the Congo*	2 500
	Others*	1 000
	Total	**649 500**
Asia	CIS* (excluding Russia, European part)	1 500 000
	- includes Kazakhstan, estimated	(>50 000)
	- includes Russia, Asian part, estimated	(>100 000)
	- Uzbekistan, estimated	(5 000-10 000)
	- others	Unknown
	India	846 500
	China, estimated	>100 000 (including 9 000* Chinese Taipei)
	Iran*	30 000
	Malaysia	18 000
	Thailand* estimated	10 000
	Viet Nam* estimated	5 000-10 000
	Korea*	6 000
	Sri Lanka* estimated	4 000
	Total	**>2 674 500-2 684 500**
Australia		595 000
	World total	**6 355 300-6 372 300**

1. Identified Th resources may not have the same meaning in terms of classification as identified U resources. The higher range of estimates, wherever given, is used for a region.

* Data not updated.

\# The estimate of identified resources (RAR and inferred) of thorium in the United States is based on a comprehensive review of published data by the US Geological Survey (Staatz et al, 1979, 1980). Earlier estimates in the Red Book indicated thorium resources as much as 770 000 tonnes in the United States, which may have included estimates of undiscovered resources (prognosticated and speculative). This higher value cannot be replicated or substantiated, so it is not repeated here.

A report by the NEA (2011) noted an interest in several countries to use thorium as a nuclear fuel over the last few decades. Basic research and development, as well as operation of reactors with thorium fuel, has been conducted in Canada, Germany, India, Japan, Russia, the United Kingdom and the United States. Some examples include:

- Germany: The 15 MWe AVR (Arbeitsgemeinschaft Versuchsreaktor) experimental pebble-bed reactor at Jülich operated between 1967-1988, partly as a test bed for various fuel pebbles, including thorium. The 300 MWe thorium high-temperature reactor, developed from the AVR, operated between 1983 and 1989 with 674 000 pebbles, over half containing Th/Highly enriched uranium (HEU) fuel. In addition to these high-temperature reactors, thorium fuel was tested at the 60 MWe boiling water reactor in Lingen.
- United Kingdom: Thorium fuel elements with a 10:1 Th/U (HEU) ratio were irradiated in the 20 MWth Dragon reactor at Winfrith, for 741 full power days. The Dragon reactor was run between 1964 and 1973 as an NEA/Euratom co-operation project, involving Austria, Denmark, Sweden, Norway and Switzerland in addition to the United Kingdom.
- United States: Fuel was tested in one light-water reactor (Shippingport) and two gas-cooled reactors: i) Shippingport operated as a light-water breeding reactor between August 1977 and October 1982; ii) General Atomics' Peach Bottom high-temperature, graphite-moderated, helium-cooled reactor operated between 1967 and 1974 at 110 MWth, using high-enriched uranium with thorium and iii) The Fort St Vrain reactor, the only commercial thorium-fuelled nuclear plant in the United States, was a high-temperature (700°C), graphite-moderated, helium-cooled reactor with a Th/HEU fuel designed to operate at 842 MWth (330 MWe). The fuel was arranged in hexagonal columns ("prisms") rather than as pebbles. Almost 25 tonnes of thorium were used as fuel for the reactor, and this achieved 170 GWd/t burn-up. The reactor operated from 1979 to 1989.
- Canada: Atomic Energy Canada Limited has more than 50 years of experience with thorium-based fuels, including burn-up to 47 GWd/t. Thus far, some 25 tests have been performed in three research reactors and one pre-commercial reactor.
- India: The Kamini 30 kWth experimental neutron-source research reactor using ^{233}U started up in 1996 near Kalpakkam. The Kamini reactor was built adjacent to the 40 MWt fast breeder test reactor (FBTR), in which the ThO_2 is irradiated, producing ^{233}U for Kamini.

Recent developments

A recent report by the NEA (2015) identified general conditions under which a transition to a thorium fuel cycle would become a practical option, providing details of the technical challenges associated with the various stages and options during that transition. The use of thorium in the nuclear fuel cycle as a complement to the uranium-plutonium cycle may have potential for improving the medium-term flexibility of nuclear energy and its long-term sustainability. More specifically, the following options for its introduction into the nuclear fuel cycle could continue to be investigated:

- the use of thorium as a means of burning plutonium (and possibly other higher actinides) as an option for plutonium management;
- the possibility of reaching higher conversion factors in thermal or epithermal neutron spectra in evolutionary generation III+ systems that use thorium-based fuels, with the aim of recovering the fissile material from the used fuel;
- the promising physicochemical characteristics of thorium-dioxide, which may allow improved performance of thoria-based fuels over current fuel designs.

Current research and development is being carried out on several concepts for advanced reactors including the: high-temperature gas-cooled reactor; molten salt reactor (MSR); CANDU-type reactor; advanced heavy-water reactor (AHWR); and fast breeder reactor (FBR).

Since 2008, Candu Energy of Canada and China National Nuclear Corporation are co-operating in the development of thorium and recycled uranium as alternative fuels for new CANDU reactors. Advanced fuel CANDU reactor technology will be designed to use recycled uranium or thorium as fuel, thus reducing spent fuel inventories and significantly reducing fresh uranium requirements. Another Canadian company, Terrestrial Energy, has proposed the use of the integral molten salt reactor. It is based on the molten salt breeder reactor concept, but is a tank-type reactor, where heat exchangers are enclosed in the reactor vessel.

In India, during mid-2010, a pre-licensing safety appraisal of the planned experimental thorium-fuelled 300 MW(e) AHWR was completed by the Atomic Energy Regulatory Board. The site-selection process started in 2011; the reactor is expected to become operational by 2020. An experimental assembly with AHWR-type (Th-Pu) mixed oxide (MOX) fuel pins completed its test irradiation, and another with (Th-LEU) MOX fuel pins has been loaded in the Dhruva research reactor. Several test facilities have been set up for the AHWR design validation. However, full commercialisation of the AHWR is not expected before 2030. A 500 MWe prototype fast breeder reactor is in the final stages of construction, and is expected to be completed in 2016. More 500 MWe FBRs are planned for immediate deployment and for beyond 2025; in addition, a series of 1 000 MWe FBRs with metallic fuel, capable of high breeding potential have been proposed. The large-scale deployment of thorium is expected to be about three to four decades after the commercial operation of FBR, with short doubling time, when thorium can be introduced to generate ^{233}U.

India is also considering the use of thorium in a compact high-temperature reactor and innovative high-temperature reactor for hydrogen production (IHTR). Both of the designs use ^{233}U-Th-based thermal conductivity of tri-isotropic-coated particle fuel. India has started to also consider MSRs as one of the promising options for thorium utilisation. Conceptual design of the Indian molten salt breeder reactors (IMSBRs) is currently under research and design. India also has an active research programme for thorium utilisation in accelerator driven systems.

In January 2011, the China Academy of Sciences launched a research and development programme on a liquid fluoride thorium reactor, known at the academy as the thorium-breeding molten salt reactor (Th-MSR or TMSR). The TMSR program is divided into three stages. In the early stage, a 10 MWt solid-fuelled molten salt test reactor (TMSR-SF1) and a 2 MWt liquid-fuelled molten salt experimental reactor (TMSR-LF1) are planned for construction and operation by 2016. In the engineering experimental stage, a 100 MWt solid-fuelled TMSR demonstration system (TMSR-SF2) is planned by 2025 and a 10 MWt liquid-fuelled molten salt experimental reactor (TMSR-LF2) is planned by 2018. The third industrial promotion stage will aim for the commercialisation of a 1 GWe TMSR-SF3 by 2030. A fast spectrum TMSFR-LF fast reactor optimised for burning of minor actinide is also envisaged.

China is developing HTR-PM, which is a graphite-moderated, helium-cooled high-temperature reactor. It is possible to use thorium in this type of reactor. Construction of a twin HTR-PM unit started in 2014 and is expected to be operational by 2017.

In April 2013, Thor Energy of Norway commenced a thorium-MOX fuel testing programme in the Halden research reactor in Norway. A Th-Pu fuel irradiation is being tested to determine if thorium-plutonium mixed oxide fuel can be used in commercial nuclear power plants. Thor has commenced discussions with several utilities about the use of these thorium-mixture fuels in commercial light-water reactors (LWRs) and with several regulators about the licensing of thorium fuels.

The Generation IV International Forum (GIF) programme for the MSR includes the concepts of the molten salt fast reactor (MSFR) where Th fuel can be used. The GIF 2015 annual report indicates that a great deal of work must be undertaken on salts before demonstration reactors are operational, suggesting 2025 as the end of the viability research and development phase.

The molten salt fast reactor (SAMOFAR) is a consortium that consists of 11 participants in Europe, which include universities and research laboratories, such as the French National Center for Scientific Research (CNRS), JRC (European Commonwealth), CIRTEN (Italy), TU Delft (Netherlands), the Center for Research and Advanced Studies of the National Polytechnic Institute (Mexico), and Paul Scherrer Institute (Switzerland). Industrial partners include L'Institut de Radioprotection et de Sûreté Nucléaire (IRSN, France), Areva (France), KIT (Germany), EDF (France) and the French Alternative Energies and Atomic Energy Commission (CEA). The objective of SAMOFAR is to prove the innovative safety concepts of the MSFR by advanced experimental and numerical techniques.

Steenkampskraal Thorium Ltd (STL), South Africa, is undertaking several activities related to the thorium fuel cycle. STL owns the rights to the thorium that will be produced at the Steenkampskraal rare earths and thorium mine in South Africa. STL has designed a thorium refinery for the production of reactor-grade thorium. STL is designing a generation IV high-temperature gas-cooled pebble-bed reactor, the 100 MWth high-temperature modular reactor (HTMR-100).

Several companies in the United States are developing innovative thorium fuel for LWRs, and high-temperature gas-cooled reactor and MSR concepts for thorium utilisation. Lightbridge is developing advanced metallic nuclear fuel for maximum power levels and operating cycle length extension in LWRs. X-energy is designing the Xe-100 reactor, a high-temperature gas-cooled pebble-bed nuclear reactor. Transatomic Power Corp has finalised the preliminary design of an advanced MSR, and began experimental testing of key materials and components. Martingale is developing a simple thorium MSR called ThorCon. Flibe Energy is planning to develop and commercialise a liquid fluoride thorium reactor.

Moltex Energy, United Kingdom has a conceptual design of a stable salt reactor (SSR) with no pumps (only impellers in the secondary salt bath) that relies on convection from vertical fuel tubes in the core to convey heat to the integral steam generators. The SSR can be run with thermal or fast neutron spectrums and thorium can potentially be used.

Russia's molten salt actinide recycler and transmuter is a fast reactor fuelled only by transuranic fluorides from uranium and MOX LWR used fuel, but thorium can also be used. It is part of the minor actinide recycling in molten salt project involving the Scientific Research Institute of Atomic Reactors (RIAR, Russia), Kurchatov and other research organisations. The 2 400 MWt design has a homogenous core of Li-Na-Be or Li-Be fluorides without graphite moderator and has reduced reprocessing requirements.

The Institute for Solid-State Nuclear Physics (IFK) in Germany is designing a reactor concept called the dual fluid reactor (DFR). The DFR can use versatile nuclear fuels, for example thorium, natural uranium, or even depleted uranium and spent nuclear fuel.

Copenhagen Atomics, Denmark plans to design an MSR-based system, preferably to fit in a shipping container, called the Copenhagen Atomics Waste Burner (CAWB). The CAWB will use thorium to burn out actinides from spent nuclear fuel to convert long-lived radioactive waste into short-lived radioactive waste, while producing energy.

The Japan based International Thorium Molten Salt Forum (ITMSF) and Thorium Tech Solution Inc. (TTS) are developing the FUJI MSR. The proposed design is rated at 200 MWe output. The consortium plans to first build a much smaller MiniFUJI, a 7 MWe reactor of the same design. A 1 000 MWe capacity Super-FUJI is also under preliminary design phase. Kyoto Neutronics is designing a small thorium MSR integrated with an accelerator neutron source, which they refer to as universally operable molten salt reactor integrated (UNOMI).

Thorium production

Despite these tests and designs using thorium as reactor fuel, its use has yet to be fully commercialised in a modern power reactor. As a result of the low demand for thorium, it has never been a primary exploration target. Its common association with uranium and/or especially REE has meant that thorium resources have been identified as a spin-off of exploration activities aimed at those commodities. In current market conditions, primary production of thorium is not economically viable.

Extraction of thorium as a by-product of REE recovery from monazite seems to be the most feasible source of thorium production at this time. Due to its high density and weak magnetism, the recovery of monazite from raw sand or crushed ore is possible by physical separation techniques involving gravity and electrostatic methods. The monazite is then dissolved in either sodium hydroxide or sulphuric acid. The resulting solutions contain REE, uranium and thorium. This is followed by a multistage process using organic phases to achieve separation with a final product of ThO_2.

Processing of monazite to recover rare earths and thorium has been done in the past in many countries. Monazite concentrate production is currently taking place in Brazil, India, Malaysia and Viet Nam (USGS, 2011).

A few REE mining-development projects with possible Th by-product and Th containing residues have the potential to come into production in the near term. A few such projects are mentioned in the previous section, where uranium and thorium are the potential by-products. One such project is Nolans Bore in Australia, which contains about 81 810 tonnes of Th in 30.3 Mt of measured, indicated and inferred resources grading 2.8% rare earth oxides, 12.9% P_2O_5, 0.017% U and 0.27% Th. Proponents are considering the establishment of an intermediate processing facility to recover REEs at the Nolans Bore mine site in Northern Territory. The Kvanefjeld project in Greenland and Pitinga project in Brazil are other examples.

At Steenkampskraal, South Africa, from the 1950s to 1963, about 50 000 tonnes of monazite concentrates, which contained between 3.3% and 7.6% Th, were extracted before operation of the mine was halted. Historical resource estimates are 15 000 tonnes Th. Total rare earth oxides (TREO) including yttrium estimates (in situ and in tailings) were updated in 2012 to NI 43-101 compliant resources of 86 900 tonnes TREO. A preliminary economic assessment was completed in 2012 and the refurbishment of the mine is under progress for a planned restart in the near future. Thorium will be extracted from the mixed rare earth chloride concentrate, then mixed with concrete and stored in designated areas, before being stockpiled at an expected rate of about 360 t/yr.

Indonesia has estimated 1.5 billion tonnes of speculative resources, which is to be targeted for its REE and Th content by forming a consortium of 16 research, academic and government institutions and industry partners. A pilot plant with 50 kg monazite concentrate/day capacity was commissioned in 2015. Other activities and pilot-scale investigations on rare-element metallurgy are being envisaged from 2016-2019.

Malaysia started to explore the viability of thorium for nuclear power generation under a Cabinet initiative in 2012, and in 2014 started a four-year national programme on thorium for nuclear power generation, with a closely related programme on the establishment of rare earth industry in the country. The thorium programme includes activities on thorium mineral exploration, extraction including pilot plant development, thorium fuel engineering and fabrication. The medium- and long-term plans include exploring the option of small and medium reactor technology for thorium use. The IAEA is supporting this programme through a national Technical Cooperation project on

“Exploring the Potential of Thorium Resources for Possible Commercial By-product Extraction” (2016-2019).

Uranium exploration

Non-domestic

Only four countries (China, France, Japan and Russia) reported non-domestic exploration and development expenditures since 2008 (see Table 1.18). In the last reporting period, non-domestic exploration expenditures were much lower and the total expected expenditures for 2015 are expected to be 24% higher than they were in 2013. The increase during this reporting period is due principally to China’s investment in the Husab mine in Namibia. China reported the development portion of total expenditures as 97% and 99% in 2013 and 2014, respectively. Russia reported development expenditures in 2013 and 2014 as 36% and 38%, of total expenditures, respectively, and this is expected to decline to only 3% of total expenditures in 2015. France and Japan reported only exploration expenditures. Total expenditures in Japan increased from 2013 to 2014 with the same level of expenditures expected for 2015. France reports a decrease from 2013 to 2014 with a small increase expected for 2015. Several countries do not report non-domestic expenditures or have not reported these expenditures recently, and thus the data are incomplete. Canada reported expenditures of USD 139 million in 2007, and it is likely that Canada continues to be a leading investor in foreign exploration and development, but no information was reported for this edition. Australia is also known to make non-domestic investments, but figures have not been reported since 2006.

Table 1.18. Non-domestic uranium exploration and mine development expenditures

(USD thousands in year of expenditures)

Country	Pre-2008	2008	2009	2010	2011	2012	2013	2014	2015 (expected)
Australia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Belgium	4 500	0	0	0	0	0	0	0	0
Canada	355 644	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
China	160 000[1]	220 000[1]	193 020[2]	94 950	94 740	81 690	599 100	752 980	777 670
France	1 079 880	87 092	77 356	61 652	68 670	68 320	71 710	50 950	47 560
Germany	403 158	0	0	0	0	0	0	0	0
Japan	419 901	3 810[2]	4 779[2]	3 020[2]	3 030[2]	5 371[2]	3 512[2]	3 692[2]	3 274[2]
Korea	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Russia	N/A	49 724	95 613	26 300	31 100	30 100	18 200	4 900	17 700
Spain	20 400	0	0	0	0	0	0	0	0
Switzerland	29 679	0	0	0	0	0	0	0	0
United Kingdom	61 263	0	0	0	0	0	0	0	0
United States	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	**2 534 425**	**360 626**	**370 768**	**185 922**	**197 540**	**185 481**	**692 522**	**812 522**	**846 204**

Note: Domestic exploration and development expenditures represent the total expenditure from domestic and foreign sources within each country. Expenditures abroad are thus a subset of domestic expenditures.

N/A = Data not available.

1. Government development expenditures only.

2. Government expenditures only.

Domestic

Twenty-four countries reported domestic exploration and development expenditures in this edition. Despite a slowdown in the industry in more recent years, following peak levels of activity associated with high uranium prices in 2007-2008, the majority of reporting countries have maintained domestic exploration and mine development expenditures above pre-2007 levels (see Table 1.19). From 2012 to 2014, expenditures decreased in a number of countries, partly because of the declining uranium price, which slowed down many exploration and mine development projects, particularly in the junior uranium mining sector. Significant decreases are reported for Argentina, Australia, Canada, Finland, Kazakhstan, Russia, South Africa, Spain and the United States. In contrast, Brazil, China, the Czech Republic, Jordan, Mexico and Turkey reported increases in expenditures from 2012 to 2014.

Expenditures are expected to decrease in 2015 by 44% to USD 934 916 000. For Kazakhstan, a significant increase in exploration expenditures is expected in 2015. For 2012 to 2014, of the countries that reported exploration and development expenditures separately, China, Kazakhstan, Namibia, Russia, South Africa, Turkey and Ukraine reported more exploration than development expenditures (92-93%, 74-97%, 65-99%, 82-92%, 61-68%, 66-90% and 64-72% of total exploration and development expenditures, respectively). In contrast, Canada and the United States reported mainly higher percentages of development expenditures (68-81% and 80-90%, respectively). For Finland, 80 to 95% of the total expenditures from 2012 to 2013 were related to development expenses associated with the construction of the uranium recovery circuit at the Talvivaara nickel mine. However, mining was suspended as a result of the bankruptcy of Talvivaara Sotkamo Ltd, the operative subsidiary of Talvivaara Mining Company Plc. In addition, the licensing process for uranium production was incomplete as of January 2015. In 2014, all expenditures in Finland were related to exploration. In Iran, expenditures have been more evenly balanced between exploration and development, with 63% and 52% of total expenditures in 2012 and 2013, spent on exploration and 52% of the total in 2014 spent on development. Greenland reported exploration expenditures for the first time since 1985.

Based on the information provided in national reports, 25 countries reported exploration and development expenditures for this edition and 17 countries reported drilling activities. In terms of exploration drilling from 2012 to 2014, Brazil, India, Kazakhstan, Russia and Spain reported an increase from 2012 to 2013, followed by a decrease in 2014. Canada, South Africa and the United States also reported increases from 2012 to 2013, but South Africa reports no activities for 2014 and the United States and Canada are both not reporting data for that year. Only Turkey reported increases from 2012 to 2014 in total metres drilled, but a decrease is expected for 2015. China's activities remained relatively consistent, although the length drilled dropped somewhat from 2012 to 2013, increasing again in 2014, and it is expected to drop slightly in 2015. Finland, Argentina, Iran, Namibia, Slovak Republic and Ukraine all reported a decline in expenditures from 2012 to 2014. The overall trend for this reporting period is a decline in exploration drilling with some minor increases expected in 2015, but still remaining below that reported for 2012.

Seven countries reported development drilling: Canada, Kazakhstan, Namibia, South Africa, Turkey, Ukraine and the United States. Canada, Kazakhstan, South Africa and Turkey reported an increase from 2012 to 2013 and Kazakhstan, South Africa and Turkey all report a decline for 2014, while Canada did not report data for 2014. The United States efforts decreased from 2012 to 2013 and data for 2014 has not been made available. Ukraine reported almost the same levels for drilling for 2012 and 2013, with a decrease in 2014, but drilling activity is expected to increase again in 2015.

Table 1.19. Industry and government uranium exploration and mine development expenditures – domestic (in countries listed)

(USD thousands in year of expenditures)

Country	Pre-2008	2008	2009	2010	2011	2012	2013	2014	2015 (expected)
Algeria	N/A	0	0	0	0	0	0	0	0
Argentina	54 669	7 153	6 854	12 222	14 296	10 647	9 812	4 242	5 915
Australia	761 806	211 612	144 605	166 084	198 742	98 695	48 787	37 124	36 645
Bangladesh	453	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Belgium	2 487	0	0	0	0	0	0	0	0
Bolivia	9 343	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Botswana*	825	377	3 727	5 421	1 218	1 061	N/A	N/A	N/A
Brazil	186 577	0	0	223	126	1 198	1 608	0	3 730
Cameroon	1 282	0	0	0	N/A	N/A	N/A	N/A	N/A
Canada	2 401 148	514 751	457 936	750 484	948 223	847 721	845 124	525 677	463 457
Central African Rep.	21 800	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chile	7 326	480	540	1 272	N/A	N/A	N/A	N/A	N/A
China	114 000	44 000	55 000	89 000	118 000	131 000	189 000	197 000	199 000
Colombia	25 946	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Costa Rica	364	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cuba	972	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Czech Republic(a)	314 317	373	114	5	12	203	176	1 327	563
Ecuador	1 945	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Egypt	114 893	2 378	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ethiopia	N/A	22	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Finland	18 306	2 449	506	2 367	19 657	58 894	22 295	1 753	N/A
France	907 240	0	0	0	0	0	0	0	0
Gabon	102 433	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Germany(c)	2 002 789	0	0	0	0	0	0	0	0
Ghana	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Greece	17 547	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Greenland (Denmark)	4 140	N/A	N/A	N/A	N/A	N/A	70	73	65
Guatemala	610	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hungary	3 812	239	N/A	N/A	N/A	N/A	N/A	N/A	N/A
India	382 364	25 093	39 905	55 778	56 227	49 771	38 510	43 954	44 234
Indonesia	16 151	74	266	327	455	275	490	100	449
Iran	25 961	8 047	23 084	32 165	53 156	82 070	43 197	50 179	79 594
Ireland	6 200	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Italy	75 060	N/A	N/A	N/A	0	0	0	0	0
Jamaica	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Japan	16 697	0	0	0	0	0	0	0	0
Jordan	920	419	10 306	11 434	6 766	1 839	3 175	3 820	3 531
Kazakhstan	91 958	78 155	59 740	57 584	70 955	94 303	76 420	34 674	46 159
Korea	17 886	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lesotho	21	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Madagascar	5 293	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

See notes on page 48.

Table 1.19. Industry and government uranium exploration and mine development expenditures – domestic (in countries listed) *(cont'd)*

(USD thousands in year of expenditures)

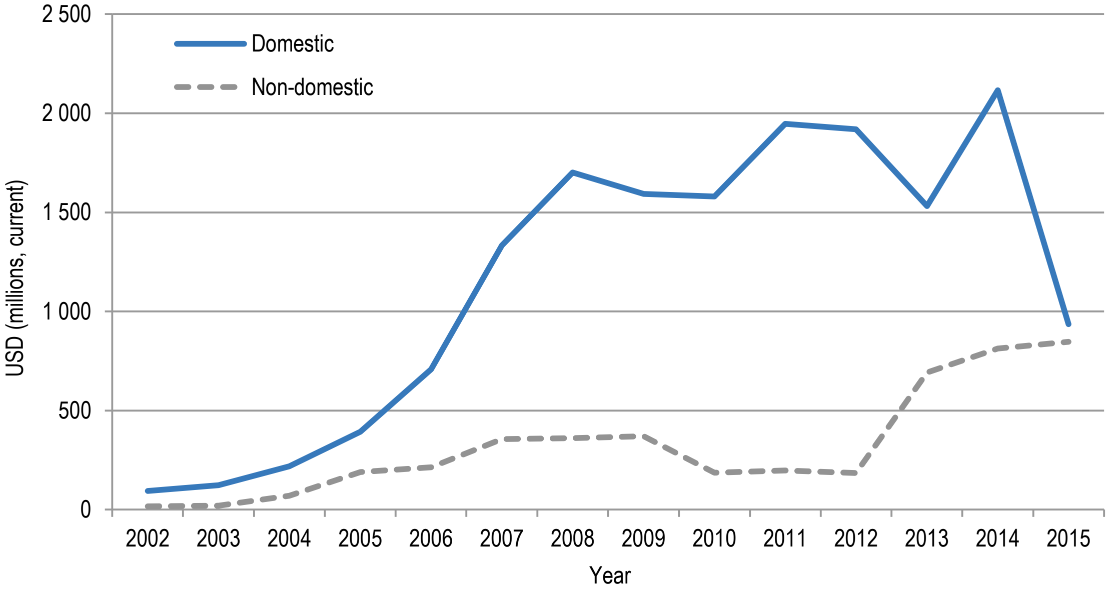
Country	Pre-2008	2008	2009	2010	2011	2012	2013	2014	2015 (expected)
Malawi	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Malaysia	10 478	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mali	56 693	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mexico(b)	30 306	50	100	150	N/A	62	93	106	99
Mongolia	46 818	29 156	11 332	18 284	30 051	26 040	15 856	15 436	N/A
Morocco	2 752	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Namibia	39 488	46 560*	44 911*	32 984	84 627	76 533	19 079	1 041 434	10 459
Niger	392 180	207 173	306 828	20 424	5 032	117 290	N/A	N/A	N/A
Nigeria	6 950	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Norway	3 180	0	0	0	0	0	0	0	0
Paraguay	26 360	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Peru	4 776	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Philippines	3 492	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Poland	N/A	0	0	90	1 388	1 452	724	229	0
Portugal	17 637	0	0	0	N/A	N/A	N/A	N/A	N/A
Romania	10 060	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Russia	192 314	221 783	233 998	117 647	99 786	64 731	46 746	39 917	16 915
Rwanda	1 505	0	0	0	0	0	0	0	0
Slovak Republic	N/A	7 465	7 454	3 576	5 579	2 484	1 956	408	N/A
Slovenia(d)	1 581	0	N/A	N/A	0	0	0	0	0
Somalia	10 000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
South Africa(e)	183 068	11 386	14 552	18 761	35 072	32 788	1 890	1 655	5 164
Spain	144 769	4 552	3 354	10 223	14 786	12 106	13 000	5 400	7 000
Sri Lanka	43	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sudan	200	0	0	0	N/A	N/A	N/A	N/A	N/A
Sweden	47 900	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Switzerland	3 359	0	0	0	0	0	0	0	0
Syria	1 151	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tanzania	N/A	N/A	N/A	23 783	25 557	28 871	N/A	N/A	N/A
Thailand	11 299	N/A	N/A	N/A	0	0	0	N/A	N/A
Turkey	22 117	74	66	91	2 230	2 815	3 048	4 875	8 385
Ukraine	37 442	7 548	3 362	3 207	1 992	2 633	1 324	1 338	891
United Kingdom	3 815	0	0	0	0	0	0	0	0
United States(f)	3 076 213	246 400	139 300	144 000	150 400	166 000	140 500	101 200	N/A
Uruguay	231	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
USSR	3 692 350	0	0	0	0	0	0	0	0
Uzbekistan	220 265	23 798	25 652	N/A	N/A	N/A	N/A	N/A	N/A
Viet Nam	3 729	N/A	N/A	3 137	5 383	1 697	1 427	1 875	2 663
Zambia(g)	25	N/A	N/A	N/A	2 438	3 518	3 751	N/A	N/A
Zimbabwe	6 902	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	**16 027 109**	**1 701 567**	**1 593 492**	**1 580 723**	**1 952 154**	**1 916 699**	**1 528 060**	**2 113 796**	**934 916**

Notes: Domestic exploration and development expenditures represent the total expenditure from both domestic and foreign sources in each country for the year. N/A = Data not available; * NEA/IAEA estimate; (a) Includes USD 312 560 expended in the former Czechoslovakia (pre-1996); (b) Government exploration expenditures only; (c) Includes USD 1 905 920, spent in the former German Democratic Republic between 1946 and 1990; (d) Includes expenditures in other parts of the former Yugoslavia; (e) Includes expenditures for both uranium and gold in the Witwatersrand Basin until 2012; (f) Includes reclamation and restoration expenditures from 2004 to 2012. Reclamation expenditures amounted to USD 49.1 million, 62.4 million, 41.7 million and 46.3 million in 2008, 2009, 2010, 2011 and 2012, respectively; (g) Non-government industry expenditures between 2011 and 2013.

For the countries reporting in this edition, total drilling in 2012 amounted to 5 368 268 m (3 951 246 m exploration; 1 417 022 m development), 4 502 255 (3 154 254 m exploration; 1 348 001 m development) in 2013 and 1 720 205 m (1 513 463 m exploration; 206 742 m development) in 2014. This is expected to increase somewhat in 2015, and it should be noted that the United States and Canada did not report data for 2014 and did not provide a forecast for 2015. Additionally, development totals exclude some of the activities being undertaken by Russia as the government reports the number of development holes but not the actual length drilled.

Domestic and non-domestic uranium exploration and development expenditures since 2002 are depicted in Figure 1.4.

Figure 1.4. Trends in exploration and development expenditures*



* 2015 values are estimates.

Current activities and recent developments

North America

In Canada, overall uranium exploration and development expenditures in 2013 amounted to CAD 884 million. This is about CAD 10 million more than expenditures in 2012, resulting from Cigar Lake mine development and McClean mill upgrades. Provisional data suggests a sharp decrease in expenditures in 2014 and 2015, by CAD 563 million and CAD 539 million, respectively. Uranium exploration expenditures alone were CAD 167 million in 2013, down 18.5% from 2012 exploration expenditures of CAD 205 million. Preliminary data for exploration expenditures of CAD 179 million and CAD 165 million for 2014 and 2015, respectively indicate that exploration expenditures will remain relatively steady and that the decline in total exploration and development expenditures in 2014 and 2015 can be mainly attributed to a decrease in development expenditures.

Recent domestic exploration activity has led to new uranium discoveries in the Athabasca Basin, Saskatchewan which includes: Shea Creek (Areva Resources Canada Inc.), Wheeler River (Denison Mines Inc.), and Roughrider (Río Tinto) and the Triple R deposit (Fission Uranium). Drilling conducted on the Triple R deposit in 2013 and 2014 outlined a significant uranium resource, making it currently the third largest uranium deposit in the Athabasca Basin.

In the **United States**, total exploration and development expenditures have been steadily declining from USD 166 million in 2012 to USD 140.5 million in 2013 and USD 101.2 million in 2014. This is a reverse in exploration trends where increases were reported beginning in 2009 and continued to 2012. This decrease is primarily the result of the current depressed uranium market and concomitant global oversupply of uranium.

A significant assessment being undertaken by the USGS is the re-estimation of the country's undiscovered resources. The first of the new undiscovered resource estimates was completed in 2015. Using a geology-based assessment methodology, the USGS estimated that a mean 85 000 tU of potential undiscovered recoverable U_3O_8 remains in southern Texas.

Central and South America

Note that expenditures are compared in Argentine Pesos (ARS) for **Argentina** as a result of the extreme currency fluctuations in recent years, making it difficult to make reasonable comparisons in USD. Argentina reported domestic exploration expenditures in 2013 of ARS 52.7 million, a 10% increase over 2012 expenditures of ARS 48 million. This declined to ARS 34.5 million in 2014, but an increase is expected for 2015 with forecasted expenditures of ARS 50.6 million. However, it is worth noting that exploration and development expenditures and drilling totals, as reported by the government, likely do not reflect all activity within the private sector as there is no requirement for private industry to report these expenditures. In particular, the decrease in expenditures noted for 2014 may not reflect actual expenditures for the year as industry did not report exploration expenditures in 2014.

The most significant uranium ore deposit in the assessment/exploration stage in Argentina is Cerro Solo, located in Chubut Province. Also under study within the Chubut Province is the Cuadrada Hill Uranium District. Exploration is relatively active, and there are several other areas where exploration is taking place including shallow low-grade calcrete-type deposits within the Santa Cruz province; uranium mineralisation associated with either limestone deposits or granites, Province of La Rioja; the Mina Franca deposit, classified as granite-related type, Province of Catamarca; five exploration areas near Catriel town, Province of Río Negro; Don Otto sandstone-type deposit, Province of Salta; and reconnaissance-type studies in Gobernador Ayala, Province of La Pampa.

In **Brazil**, USD 1.2 million was reportedly spent on domestic exploration activities in 2012, an increase of over USD 1 million from 2011, with a further increase to USD 1.6 million reported for 2013. During 2013/2014, exploration efforts were focused on favourable albititic areas in the northern part of the Lagoa Real province. Expenditures are predicted to increase even further to 3.7 million in 2015. This increase will primarily result from drilling of about 18 000 m in the Lagoa Real province.

Chile did not report exploration and development expenditures for this edition. Alliance Chile Pty Ltd has two projects in northern Chile's iron-oxide copper-gold belt with potential for copper, gold, silver and uranium. In 2015, Alliance completed an airborne magnetic and radiometric survey over the eastern limb on the Monardes Basin in Chile and identified two sub-parallel uranium-anomalous units with a combined strike length of 9 km (Alliance Resources, 2015).

The government of **Paraguay** did not report domestic exploration or development expenditures for this edition. However, there have been recent exploration activities in the country including the Yuty project in the Paraná Basin. NI 43-101 compliant measured, indicated and inferred resources for the project were updated in 2011 to 9.98 Mt at 507 ppm eU_3O_8 for 11.1 Mlbs eU_3O_8 (4 300 tU). Uranium Energy Corporation (UEC) also holds rights to approximately 399 425 ha in the Coronel Oviedo region in central Paraguay. No significant exploration updates for these projects have been reported for 2013 through 2015. However, in 2015, UEC was granted regulatory approval to advance its Yuty in situ leach project from the exploration phase to the exploitation phase.

An IAEA initiative was undertaken in 2013-2015, within the context of the Technical Cooperation project in Paraguay: “Developing National Capacities for the Exploration and Exploitation of Uranium”. The primary objective of the programme was to improve the national capacity to support the exploration and exploitation of radioactive minerals. This was facilitated primarily through national workshop and consultation meetings in health and safety, exploration and assisting with review of the legal, policy and regulatory requirements for uranium exploration and mining.

Peru does not report exploration and development expenditures, and industry is not required to report expenditures to the government. Currently, there are a few active exploration companies in Peru including Plateau Uranium Inc. and Fission 3.0 Corp.

European Union

In the **Czech Republic**, exploration and development expenditures decreased from USD 203 000 in 2012 to USD 176 000 in 2013 and then increased to USD 1 327 000 in 2014. This increase is related to the preparation of the new state energy concept as well as the “concept of the raw materials and energy security” of the Czech Republic. As a result, technical and economic re-evaluation of remaining uranium resources has been undertaken.

Greenland reported exploration expenditures for the first time since 1985. Expenditures were USD 70 000 in 2013, USD 73 000 in 2014 and expected expenditures for 2015 are USD 65 000. Since 2007, Greenland Minerals and Energy Ltd (GMEL) has conducted REE (U-Zn) exploration activities in the Kvanefjeld area. This has included drilling of 57 710 m of core. The Kvanefjeld feasibility study, as well as the environment and social impact assessments (EIA and SIA), were carried out in 2014-2015 and will form the basis for an exploitation licence application expected during 2015.

There is currently no actual uranium exploration in **Finland**. However, uranium is included as a so-called mining mineral in some exploration permits and exploration permit applications of Mawson Resources Ltd Exploration and development expenditures in Finland decreased significantly from USD 58.9 million in 2012 to USD 22.3 million in 2013 and then declined even further to USD 1.7 million in 2014. The sharp decline in expenditures is primarily a result of a decrease in development expenditures following the completion of the uranium solvent extraction plant at Talvivaara in 2013.

The government of **Hungary** did not report any exploration or development expenditures.

In 2009, the government of **Poland** decided to introduce nuclear energy, and the possibility of mining domestic uranium resources is being studied. As a result, exploration expenditures were reported for the first time in 2010. However, in recent years these expenditures have declined, from USD 1.4 million and USD 0.7 million, in 2012 and 2013 respectively, to only USD 0.2 million in 2014. From 2012 to 2013, three concessions for prospecting for polymetallic uranium deposits were granted to a private company.

Recently, Poland completed geological and technological analysis and modelling for the process of uranium extraction from low-grade Ordovician shale (black shale-type uranium deposit). The analysis indicated that the costs of production would be several times higher than the current market price of uranium.

In the **Slovak Republic**, exploration and development expenditures were USD 2.5 million in 2012 and USD 2 million in 2013, decreasing sharply to USD 0.4 million in 2014.

Crown Energy Ltd (a subsidiary of GB Energy) completed exploration programmes over the Kluknava and Vitaz-II exploration areas in 2012. Activities and exploration results of Beckov Minerals Ltd in the exploration area Horka nad Vahom-Kalnica were not reported.

Ludovika Energy Ltd (a subsidiary of European Uranium Resources) continued exploration in two prospecting areas in eastern areas of the country. In 2014, European Uranium Resources Ltd announced that it had executed a definitive agreement that allows Forte Energy NL to earn a 50% interest in the company's Slovakian uranium projects. The interest will be held through ownership of 50% of the company's currently wholly owned Slovak subsidiaries, Ludovika Energy and Ludovika Mining, which hold the mineral licences covering the Kuriskova and Novoveska Huta uranium projects.

Spain reported increases in domestic expenditures from USD 12 million in 2012 to USD 13 million in 2013, but this amount decreased by over 50% to USD 5.4 million in 2014, and projected expenditures are USD 7 million for 2015.

Work continues by Berkeley Resources, which has been actively exploring for uranium for several years, focusing on a number of historically known uranium projects located within their tenements. Recent developments include granting of one mining licence in the province of Salamanca covering 2 720 Ha and a total of 25 investigation licences spanning the provinces of Salamanca Cáceres and Badajoz, which covers a total of 105 762 Ha.

The government of **Sweden** did not report exploration and development expenditures, but a number of exploration programmes have been ongoing in the country since 2007. Most activity during 2013 and 2014 has been related to the potential of alum (black) shale, where uranium can be recovered as a by-product along with other co-products such as molybdenum, vanadium, nickel, zinc and petroleum products. Exploration expense figures for the course of these two years are however not available.

Although no domestic uranium activities have been carried out in **France** since 1999, Areva and its subsidiaries have been active abroad. During 2012-2014, Areva and its subsidiaries have been working outside France focusing on targets aimed at the discovery of exploitable resources in Australia, Canada, Gabon, Kazakhstan, Mongolia, Namibia and Niger. Total non-domestic exploration expenditures reported by the government increased from USD 52.0 million in 2012 to 55 million in 2013, but then decreased to USD 37.5 million in 2014. Expenditures are expected to be USD 39 million in 2015. No development expenditures were reported.

Europe (non-EU)

An **Armenian**-Russian joint venture CJ-SC "Armenian-Russian Mining Company" was established in April 2008 for geological exploration, mining and processing of uranium. Exploration of the block 1st Voghchi zone identified reserves of uranium ores classified in category C2, and inferred resources of the Voghchi zone of the Pkhrut deposit indicate that the deposit is prospective. However, based on these investigations and for economic reasons, the activity of the Armenian-Russian joint venture was suspended in 2013.

Russia reported a decline in domestic exploration and development expenditures from USD 64.7 million in 2012 to USD 46.7 million in 2013, and a further decline to 39.9 million in 2014 with forecasted expenditures of only USD 16.9 million in 2015. The decreases were primarily by industry as government exploration expenditures have increased somewhat over the past few years.

There are two types of uranium exploration activities in Russia, one aimed at new deposit discovery and the second directed at exploration of earlier discovered deposits with a view to developing resource estimates and deposit delineation.

During 2013-2014, several activities were undertaken including the main exploration and resources estimation for the group of Khiagda ore deposits in Vitim district, exploration at Khokhlovskoe deposit in Kurgan region and exploration focused on new high-grade deposits within the Streltsovsk uranium district (Trans-Baikal region).

The activities of 2013-2014 resulted in identification of prognosticated uranium resources of 56 400 tU and total speculative resources of 426 0600 tU.

Overseas, the Canadian company Uranium One Inc. (a State Corporation Rosatom subsidiary) performed geologic exploration in Kazakhstan and feasibility studies to start a new uranium deposit development in Tanzania. Total non-domestic exploration and development expenditures decreased over the reporting period, from USD 30.1 million in 2012, to USD 18.2 million in 2013 and then to USD 4.9 million in 2014. Expenditures are forecast to increase to USD 17.7 million in 2015, but this is still far below the levels of expenditures over the last several years.

Exploration and development expenditures in **Turkey** have continued to increase in recent years, from USD 2.8 million in 2012 to USD 3 million and USD 4.9 million in 2013 and 2014 respectively, while projected expenditures are expected to increase even further to around USD 8.4 million in 2015. Public sector activities were focused on granitic, acidic igneous and sedimentary rocks in several areas. In 2015, exploration for radioactive raw materials will be conducted in licensed areas inside Manisa and Nevşehir. Private sector activities included work by Adur, a wholly owned subsidiary of Anatolia Energy, which conducted exploration and resource evaluation drilling at the Temrezli and Sefaatli uranium sites. Regional exploration identified new areas of mineralisation, at West Sorgun and Akoluk, similar to what is seen at the Temrezli uranium deposit.

A limited drilling programme in the Sefaatli area confirmed sporadic uranium mineralisation that was first discovered by the General Directorate of Mineral Research and Exploration in the 1980s. This is the region's second most significant occurrence of uranium mineralisation, and work so far suggests that the mineralisation style appears similar to that observed at Temrezli, and it thus may be amenable to ISL mining.

Exploration and development expenditures in **Ukraine** declined 50% from 2012 expenditures of USD 2.6 million to USD 1.3 million in both 2013 and 2014. Expenditures are expected to decline further to USD 0.9 million for 2015.

Africa

In 2014, an IAEA Technical Cooperation project for the African region: "Supporting Sustainable Development of Uranium Resources" was initiated and the project will continue through 2017. The main objective of the project is to increase and improve the current capacity in the member states for optimising production, implementation of good practices and overall effective management of the region's natural uranium endowment.

In **Algeria**, no uranium prospecting or mine development work was carried out between January 2007 and January 2015.

Although the government of **Botswana** has not reported exploration expenditures, some activities have occurred during this reporting period. Exploration over the past several years has focused on uranium occurrences in the Karoo Group, targeting similar deposits as those currently being mined by Paladin Energy in Malawi (i.e. the sandstone-type Kayelekera deposit). Surficial calcrete-type mineralisation is a secondary target.

The Letlhakane uranium deposit has been the focus of detailed technical work by A-Cap since 2010, resulting in the February 2013 release of a positive scoping study. Impact Minerals Ltd, another Australian junior company, acquired permits around A-Cap's exploration areas in early 2008. At the end of 2014, exploration by Impact Minerals Ltd in Botswana was on hold pending a recovery in the uranium price and market conditions. During the year, the majority of Impact's prospecting licences within the Botswana Uranium Project licences were not renewed.

Mauritania, does not report exploration and development expenditures. Recent activities include a scoping study by Aura Energy confirming that the Reguibat project could be upgraded through simple beneficiation to high-grade leach feed. The study indicated that some 4 200 tU could be produced over an initial mine life of 15 years, using only 20% of the project's known mineral resources. Additionally, extensive radiometric surveys indicated an exploration target of an additional 19 000 tU, inferring a global mineral resource target of around 38 000 tU at Reguibat.

Support in the uranium production cycle is provided through IAEA Technical Cooperation project Mauritania "Establishing an Effective Monitoring Mechanism for Environmental Protection related to Uranium and Mining Activities". The project began in 2014 and will continue through 2017. The specific objectives of the project will be to put in place a framework for environment management, build capacity for environmental and radiological site characterisation leading to baseline generation of potential uranium mining sites in Mauritania and build capacity for monitoring of radionuclides in the environment.

The Bakouma deposit in the **Central African Republic** was discovered in the 1960s. Areva suspended investment in the development of the Bakouma mine in 2011 because of current market conditions, even though inferred resources at Bakouma had been raised from 32 224 tU to 36 475 tU.

Namibia reported a decrease in exploration and development expenditures from USD 76.5 million in 2012 to USD 19.1 million in 2013. However, a large increase to USD 1 billion was reported for 2014, principally related to development of the Husab mine. Expenditures are projected to drop again to USD 10.5 million in 2015.

Two major types of deposits are currently being targeted: the intrusive type associated with alaskites, as at Rössing, and the surficial, calcrete-type, as at Langer Heinrich and Trekkopje. There have been few significant changes to the status of the projects in Namibia since the last reporting period, and the current market conditions have contributed to a decline in the overall progression of projects, with some projects on hold until uranium prices increase.

Uranium exploration and development expenditures in **Niger** have been variable over the past few years as a result of security risks and market conditions. Expenditures in the previous reporting period were estimated by the NEA/IAEA. However, these were based on limited publicly available data, and because of difficulties in verification of these data, they are not reported for this edition.

Excavation of the first pit at the Imouraren project started in the middle of 2012. However, in May 2014, with current uranium prices not sufficient to allow profitable mining of the deposit, the government and Areva agreed to set up a joint strategic committee that will determine when mining should start, which may not be until 2020.

GoviEx has developed an NI 43-101 Integrated Development Plan (IDP) for five deposits (Marianne, Marilyn, Miriam, MSNE and Maryvonne). In April 2015, NI 43-101 compliant resources of the Madaouela Uranium Project were reported at 42 700 tU measured and indicated resources and 10 660 tU inferred resources.

Global Atomic Fuels Corp., a private Canadian company, has six exploration permits north of Agadez, four at Tin Negouran (the "TN permits") and two at Adrar Emoles (the "AE Permits"). The Adrar Emoles permit hosts the Dasa deposit. From 2010 to 2014, Global Atomics Fuels Corp had drilled 969 holes (867 rotary drill holes and 102 diamond drill holes), for a total of 119 120 m. In January 2014, SRK released an initial resource estimation that totalled 43 850 tU grading 540 ppm U, using a 85 ppm U cut-off.

In addition to Dasa, two other deposits are located on the Adrar Emoles permits: Dajy and Isakanan. The Dajy deposit contains 6 400 tU grading 584 ppm U (inferred resources). The Isakanan deposit hosts 13 000 tU grading 760 ppm U. The Tin Negouran Permits 1-4 host the Tagadamat deposit. The Tagadamat deposit hosts 3 500 tU. An environmental baseline study was completed in 2009, but the project is currently on hold.

URU Metals Limited reported a SAMREC compliant inferred resource of 1 654 tU on their In Gall deposit and in 2011 continued to drill the Aboye, Akenzigui and Fagochia targets within their Irhazer and In Gall permits. Project commitments elsewhere and security risks in Niger caused URU Metals to take steps to terminate activities in Niger by 2014.

In December 2010, Paladin completed the takeover of NGM Resources Ltd, the owner of the local company Indo Energy Ltd that held concessions in the Agadez region. This project has been put on hold because of security concerns, and all fieldwork has ceased. *Force Majeure* has been requested from the government authorities for an indefinite suspension of further expenditures.

Egypt last reported exploration expenditures in 2008. It has had ongoing support over the last several years in developing uranium exploration and production capacities through a number of IAEA Technical Cooperation projects. The most recent one covered the period 2014 to 2015 and was entitled: "Separation and Estimation of Valuable Rare Metal during Uranium Ore Processing in the Eastern Desert". The project primarily focused on developing a pre-feasibility study for extraction of uranium from the Nile valley phosphate deposit.

The Karoo Group of the Morondava Basin in **Madagascar** has a similar geological setting to sandstone-hosted uranium deposits in the Karoo Group in other African countries including Botswana, Malawi, South Africa, Tanzania and Zambia. These similarities have prompted some interest in exploration for deposits of this type that may be of potential economic interest.

Uranium exploration activities have been suspended in **Malawi** as a result of a moratorium imposed by the government of Malawi on applications and grants of all mining and exploration tenements, while it introduces a new cadastral system and a new minerals act. As a result, Paladin has suspended exploration activities in Malawi until there is more clarity on the provisions of the new mining code, and its exclusive prospecting licence (EPL) applications have been granted.

According to the Ministry of Mines in **Mali**, uranium potential exists in three main regions. The best covers 150 km^2 of the Falea-North Guinea Basin where the estimated potential is thought to be 5 000 tU. The 19 930 km^2 Kidal Project in north-eastern Mali is part of a large crystalline geological province known as L'Adrar Des Iforas. The sedimentary basin of the Gao region hosts the Samit deposit that contains an estimated potential of 200 tU.

As of 1 January 2013, seven uranium exploration permits had been granted to five exploration companies. However, because of the rebellion in the north-eastern part of the country, exploration activities are only being undertaken in the western part of the country.

In 2014, Denison Mines spent CAD 269 000 on the Falea project, and during the fourth quarter of 2013, minimal exploration expenditures of CAD 39 000 were spent on Falea after acquiring the property from Rockgate. In early 2015, the company submitted an application for a new exploration licence to the authorities in Mali so as to allow exploration activity to continue at Falea.

Total exploration and development expenditures in **South Africa** decreased dramatically from USD 32.8 million in 2012 to USD 1.9 million and USD 1.7 million in 2013 and 2014, respectively, and projected expenditures for 2015 are only modestly higher at USD 5.2 million. This sharp decline is somewhat misleading as the expenditures for 2012 include exploration for both gold and uranium in the Witwatersrand Basin. However, notwithstanding this, exploration has decreased in recent years as a result of current market prices, which are influencing expenditures and investment in the uranium sector.

Exploration efforts have been focused on the uranium prospective Karoo Group sediments of southern **Tanzania** and to a lesser extent paleochannel associated calcrete and sandstone-hosted uranium targets within the Bahi catchment of central Tanzania. Exploration and development expenditures totalled USD 25.6 million in 2011 and increased to USD 28.9 million in 2012. However, a sharp decline to USD 7.96 million was forecast for 2013; there is no data for expenditures in 2014 or for expected expenditures in 2015.

Mantra Resources, who operated the Nyota project, was acquired in 2011 by the Russian Atomredmetzoloto (ARMZ). Uranium One Inc. was appointed as the project operator. The Mkuju River feasibility study was completed in November 2013. Front-end engineering and design (FEED) and pre-FEED initiatives continued until June 2014. Current activities at the project are focused on licensing and permitting, ongoing value engineering opportunities to optimise the capital and operating costs and an ISL pilot test programme. ISL could prove to be an alternative extraction method for the MRP and similar ore bodies in the region.

Recent activity at the Mkuju River project focused on feasibility study optimisation and update, licensing and permitting.

In 2013, Australian-based East African Resources Ltd (EAR) obtained prospecting licences for the Madaba property, where work carried out from 1979-1982 by Uranerzbergbau GmbH identified six anomalous uranium zones.

In **Zambia**, exploration activities are focused on identifying sandstone-type deposits in the Karoo Group. Exploration expenditures were about USD 3.8 million in 2013, no data are available for 2014 or 2015.

In September 2013, Denison confirmed the resources for the Mutanga project as 770 tU of measured resources, 2 235 tU of indicated resources and 16 000 tU of inferred resources.

Middle East, Central and Southern Asia

In **India**, government exploration expenditures increased slightly from USD 38.5 million reported in 2013, to USD 44 million in 2014 and USD 44.2 million expected in 2015.

In recent years, exploration activities have been concentrated on Proterozoic Cuddapah Basin, Andhra Pradesh; Mesoproterozoic Singhbhum Shear Zone, Jharkhand; Mesoproterozoic North Delhi Fold Belt, Rajasthan and Haryana; Cretaceous sedimentary basin, Meghalaya; Neoproterozoic Bhima Basin, Karnataka; and Dharmapuri Shear Zone in the Southern Granulite Terrain, Tamil Nadu. Other potential geological domains include the Kotri-Dongaragarh belt, Chhattisgarh; Lesser Himalayas, Uttarakhand; Chhotanagpur Gneiss Complex, Kaladgi Basin, Karnataka and Siwana Ring Complex, Rajasthan.

Iran reported a decrease in exploration and development expenditures from USD 82.1 million in 2012 to USD 43.2 million in 2013. Expenditures then increased to USD 50.2 million in 2014 and were forecasted to increase further to USD 79.6 million in 2015.

At present, prospecting and general exploration is being undertaken in different parts of the country for granite-related, intrusive and sedimentary-type deposits, for example in the north-eastern, central and Kerman provinces.

Exploration expenditures by government and industry in **Jordan** increased from USD 1.8 million in 2012 to USD 3.2 million in 2013, and an increase was reported again in 2014 to USD 3.8 million. Similar levels of expenditures, of USD 3.5 million, are expected for 2015. During 2013-2014, both Jordan Uranium Mining Company (JUMCO) and Jordan Energy Resources Inc. (JERI) jointly carried out an exploration programme to evaluate the uranium resources within the surficial layer (0-5 m depth) in the Central Jordan area. The exploration plan for 2015 will be concentrated on the Central Jordan area.

Decreased expenditures were reported by **Kazakhstan** from USD 94.3 million 2012 to USD 76.4 million in 2013 and an almost 50% decrease in 2014 to USD 34.7 million. These are the lowest expenditures reported in the last several years since Kazakhstan started ramping up its exploration and development activities around the period 2007 to 2008. The decrease can be partially attributed to a decline in development activities. Projected estimates for exploration and development expenditures for 2015 are modestly higher at USD 46.2 million.

During 2013 and 2014, exploration of deposits was undertaken at Moinkum, Inkai, Budenovskoye in the Shu-Sarysu Uranium Province and in the Northern Kharasan and Bala-Sauskandykskoye deposits in the Syrdaria Uranium Province. The company Balausa LLP discovered a new uranium-vanadium mineralisation, the Bala-Sauskandykskoye deposit during the reporting period.

South-eastern Asia

Exploration expenditures in **Indonesia** were variable during this reporting period. In 2012, USD 0.27 million was spent, and in 2013 it increased to USD 0.49 million, with expenditures then decreasing to USD 0.10 million in 2014 and forecasted at USD 0.45 million for 2015.

Exploration drilling was carried out in Lemajung Sector, Kalan Area in 2013. In 2013 and 2014, surveys carried out at Mamuju, West Sulawesi Province identified volcanic-related anomalies of uranium and thorium. Based on the survey results, plans are to focus on uranium and thorium exploration in the Mamuju Area for the next several years.

A survey at Ella Ilir Sector consisted of detailed radiometric mapping and subsurface uranium mineralisation targeted by exploration drilling to a total depth of 400 m. Based on previous data, the survey will focus on uranium anomalies from metapelite schistose, metatuff and granite.

A general survey was also carried out at Biak Island, Papua Province in 2014. The survey delineated radiometric anomalies in Pleistocene coral limestone on the top-most and thin soil strata.

The **Philippines** does not report exploration and development expenditures; although an IAEA Technical Cooperation project entitled "Enhancing National Capacity for Extraction of Uranium, Rare Earth Elements and Other Useful Commodities from Phosphoric Acid" aimed to increase activities related to uranium production was conducted from 2014 to 2015. Philippine Phosphate Fertilizer Corporation (Philphos) has an approximately 1 million tonnes/year capacity in the production of phosphoric acid. This phosphoric acid contains considerable concentration of uranium and possibly other useful commodities. The project conducted laboratory-scale study on the possibility of extracting uranium, REE and other resources from the phosphoric acid. Follow-up, scaled up experiments and pilot-scale testing are planned.

East Asia

Total non-domestic development expenditures reported by **China** increased from USD 81.7 million in 2012 to USD 599.1 million in 2013, a dramatic rise from previous years. This trend continued into 2014 with USD 753 million reported and is forecasted to increase even further in 2015 with total expenditures of USD 777.7 million. This is primarily as a result of the acquisition and development associated with the Husab mine in Namibia, which was acquired in 2012 by CGNPC Uranium Resources Co., Ltd, a subsidiary of China General Nuclear Power Group (CGNPC). Other foreign projects include the Azelik Uranium Project in Niger and the Semizbay and Irkol mines in Kazakhstan.

In addition, the above-mentioned Chinese companies have also carried out exploration activities in Australia, Namibia and Uzbekistan, completing over 32 000 m drilling over two years.

China reports that domestic uranium prospecting and exploration have intensified and increased as a result of additional financial input between 2013 and 2014. Domestic exploration and development expenditures have steadily increased since 2004 with an all-time high of USD 197 million reported for 2014 and a similar amount of USD 199 million forecasted for 2015. The majority is exploration-related with only 7-8% of the total coming from development activities.

The exploration, including regional uranium potential assessment and further works on previously discovered mineralisation and deposits in northern China, has principally focused on the Yili, Turpan-Hami, Junggar and Tarim basins of the Xinjiang Autonomous Region; the Erdos, Erlian, Songliao, Badanjili and Bayingebi basins of Inner Mongolia; the Caidaum basin in Qinghai province and the Jiuquan basin in Gansu province.

The exploration work in southern China is directed at identifying metallogenic belts relating to volcanic-type and granite-type deposits, distributed in the Xiangshan and Taoshan uranium fields in Jiangxi province; the Xiazhuang and Zhuguang uranium fields in Guangdong province; the Miaoershan uranium field in the Guangxi Autonomous Region; the Lujing field in Hunan province; the Daqiaowu field in Zhejiang province and the Ruoergai area of Sichuan province. Potential deposits in Carbonaceous siliceous mudstones are secondary targets in this exploration campaign.

Over the past several years, the IAEA has supported China through the Technical Cooperation programme and most recently through the project, “Developing Exploration Techniques for Deep Blind Deposits in Typical Hydrothermal Uranium Ore Fields”. The project outcomes were the improvement and development of professional skills and exploration for deep blind hydrothermal uranium deposits in China. This has been achieved via national workshops, expert missions, group training, and scientific visits and fellowships.

Non-domestic government exploration expenditures from **Japan** decreased from USD 5.4 million in 2012, to USD 3.5 million in 2013, and only slighter higher expenditures of USD 3.7 million were reported for 2014, which are expected to decline to USD 3.3 million in 2015. Japan-Canada Uranium Co. Ltd, which took over JNC’s Canadian mining interests, is continuing exploration activities in Canada while the Japan Oil, Gas and Metals National Corporation (JOGMEC) continues exploration activities in Australia, Canada and elsewhere. Japanese private companies hold shares in companies developing uranium mines and also with those operating mines in Australia, Canada, Kazakhstan and Niger.

Reported domestic exploration and development expenditures in **Mongolia** decreased over the past few years from USD 26.0 million in 2012 to USD 15.9 million and USD 15.4 million in 2013 and 2014, respectively. From 2013-2014, most uranium prospecting was performed in the Zuunbayan Basins, with the objective of identifying sandstone-type uranium mineralisation suitable for ISL mining.

An IAEA Technical Cooperation project, Regional Asia Pacific was initiated in 2016 and will continue through 2019. The project is entitled “Conducting the Comprehensive Management and Recovery of Radioactive and Associated Mineral Resources” and is aimed at supporting member states in the Asia-Pacific region in relation to sustainable mining and production of minerals that have been found to be associated with radioactive minerals. Uranium production is one key aspect of economic development in the region, where efforts are being made to balance consumption and production. Though the region (especially China) is expected to grow significantly in terms of nuclear power production, a large part of the current and future uranium requirements will be met by imports. Even though potential for increasing domestic uranium production exists, several factors have prevented this growth from materialising. This project aims to address these challenges and opportunities by strengthening capacities and establishing centres of excellence in member states.

Pacific

Domestic exploration expenditures in **Australia** followed the same trend as the last reporting period and decreased significantly from USD 98.7 million in 2012 to USD 48.8 million in 2013, and then further to USD 37.1 million in 2014. The trend is expected to continue into 2015 with expected expenditures of USD 36.6 million. Exploration focused around known resources and was carried out in Western Australia, the Northern Territory, South Australia and Queensland. In addition, exploration was undertaken in New South Wales with the grant of exploration licences pending.

In Western Australia, deposits identified at Millipede, Lake Maitland, Dawson-Hinkler and Nowthanna are available for future development. The proposed Kintyre uranium mine operated by Cameco received conditional approval from Western Australia's Environmental Protection Authority early in 2015, pending further governmental approvals.

In South Australia, the state government established a Nuclear Fuel Cycle Royal Commission into the potential for nuclear power in the state, due to report in May 2016. The activities of the commission relate to the potential for the expansion of exploration and extraction of minerals, the undertaking of further processing of minerals and manufacture of materials containing radioactive substances, the use of nuclear fuels for electricity generation, and the storage and disposal of radioactive and nuclear waste.

In the Northern Territory during 2014, the operator of Ranger – Energy Resources of Australia – continued a revised drilling programme and released a resource update for the Ranger 3 Deeps project.

On 16 March 2015, the incoming Queensland government announced a plan to ban uranium mining in Queensland. The ban had been overturned by the previous government in 2014, at a time when no uranium mining had been undertaken for over 30 years.

The incoming New South Wales government overturned the state ban on uranium exploration in 2012, and six companies were invited to apply for exploration licences. One company has submitted an application to explore for uranium north of the town of Broken Hill.

From 2013 and 2014, several Australian mineral companies undertook exploration activities for uranium in Namibia and Malawi. However, non-domestic expenditures were not reported to the Red Book.

Uranium production

In 2012, 2013 and 2014, uranium was produced in 21 different countries; the same number as in the last reporting period, with Germany, Hungary and France producing uranium as the result of mine remediation activities. Kazakhstan's growth in production continued, but at a much slower pace, and it remains the world's largest producer reporting production of 22 781 tU in 2014 and 23 800 tU in 2015. Production in 2014 from Kazakhstan totals more than the combined production reported in 2014 from both Canada and Australia, the second and third largest producers of uranium, respectively. Table 1.20 summarises major changes in uranium production in a number of countries and Table 1.21 shows production in all producing countries from pre-2012 to 1 January 2015. Figure 1.5 shows 2014 production shares, and Figure 1.6 illustrates the evolution of production shares from 2008 to 2014.

Table 1.20. Production in selected countries and reasons for major changes

(tonnes U)

Country	Production 2012	Production 2014	Difference	Reason for changes in production
Australia	7 009	4 976	-2 033	Four Mile started production in 2014 with uranium processed at the Beverley plant. However, new production was offset by a number of decreases in production. Mining of Ranger Pit 3 concluded in December 2012; since that time Energy Resources of Australia has processed stockpiled ore to produce uranium. However, late in 2013, all production halted at Ranger as a result of the failure of a leach tank. Production from Beverley/Beverley North ceased in early 2014. Production at Honeymoon ceased in November 2013.
Brazil	326	55	-271	The open-pit part of the Cachoeira deposit was totally mined out in 2014.
Canada	8 998	9 136	138	The Cigar Lake mine began operations in March 2014.
Kazakhstan	21 240	22 781	1 541	New ore deposits came on stream and some ISL mines continue to ramp up (e.g. Budenovskoye 1, 3 and 4).
Malawi	1 103	369	-734	In May 2014, the Kayelekera mine was placed in care and maintenance because of market conditions.
Namibia	4 239	3 246	-993	Decrease of production at Rössing mine, and Trekkopje placed on care and maintenance. Langer Heinrich decreased production, focusing on reducing operating costs.
Niger	4 822	4 057	-765	Decrease of production at Somaïr, mainly because of less uranium recovery from heap leaching. Low production at Azelik. In February 2015, Azelik production was suspended as a result of poor economics.
United States	1 667	1 881	214	Additional production in new mines, including units at Smith Ranch-Highland and North Butte satellite. Production ramp-up at Lost Creek ISL mine (production started in 2013). Nichols Ranch/Hank started production in June 2014.

Table 1.21. Historical uranium production

(tonnes U)

Country	Pre-2012	2012	2013	2014	Total to 2014
Argentina	2 582	0	0	0	2 582
Australia	176 230	7 009	6 432	4 976	194 646
Belgium	686	0	0	0	686
Brazil	3 599	326	192	55	4 172
Bulgaria	16 364	0*	0	0	16 364
Canada	456 491	8 998	9 332	9 136	483 957
China	35 349*	1 450	1 500	1 550	39 849*
Congo, Dem. Rep. of	25 600*	0	0	0	25 600*
Czech Republic(a)	111 168	228	215	154	111 765
Finland	30	0	0	0	30
France	75 995	3(c)	5(c)	3(c)	76 006

See notes on page 61.

Table 1.21. Historical uranium production *(cont'd)*

(tonnes U)

Country	Pre-2012	2012	2013	2014	Total to 2014
Gabon	25 403	0	0	0	25 403
Germany[(b)]	219 576	50[(c)]	27[(c)]	33[(c)]	219 686
Hungary	21 061	1[(c)]	3[(c)]	2[(c)]	21 067
India*	10 243*	385*	385*	385*	11 398*
Iran	23	24	8	11	66
Japan	84	0	0	0	84
Kazakhstan	178 173	21 240	22 513	22 781	244 707
Madagascar	785	0	0	0	785
Malawi	1 613	1 103	1 132*	369*	4 217
Mexico	49	0	0	0	49
Mongolia	535	0	0	0	535
Namibia	108 670	4 239	4 264*	3 246*	120 418
Niger	118 610	4 822	4 528*	4 057*	132 017
Pakistan*	1 304*	45*	45*	45*	1 439*
Poland	650	0	0	0	650
Portugal	3 720	0	0	0	3 720
Romania	18 659*	80*	80*	80*	18 899*
Russia	149 856	2 862	3 135	2 991	158 844
Slovak Republic	211	0	0	0	211
Slovenia	382	0	0	0	382
South Africa	157 946	467	531	566	159 510
Spain	5 028	0	0	0	5 028
Sweden	200	0	0	0	200
Ukraine	126 912	1 012	926	954	129 804
United States	367 807	1 667	1 792	1 881	373 075
USSR[(d)]	102 886	0	0	0	102 886
Uzbekistan	120 391*	2 400*	2 400*	2 700*	127 591*
Zambia	86	0	0	0	86
OECD	1 439 366	17 956	17 806	16 185	1 491 242
Total	**2 644 957**	**58 411**	**59 445**	**55 975**	**2 818 415**

Note: For pre-2010, other sources cite 91 tU for Sweden.

* NEA/IAEA estimate.

(a) Includes 102 241 tU produced in the former Czechoslovakia and CSFR from 1946 through the end of 1992.

(b) Production includes 213 380 tU produced in the former German Democratic Republic from 1946 through the end of 1989.

(c) Production comes from mine rehabilitation efforts only.

(d) Includes production in the former Soviet Socialist Republics of Estonia, Kyrgyzstan, Tajikistan and Uzbekistan.

Figure 1.5. Uranium production in 2014: 55 975 tU

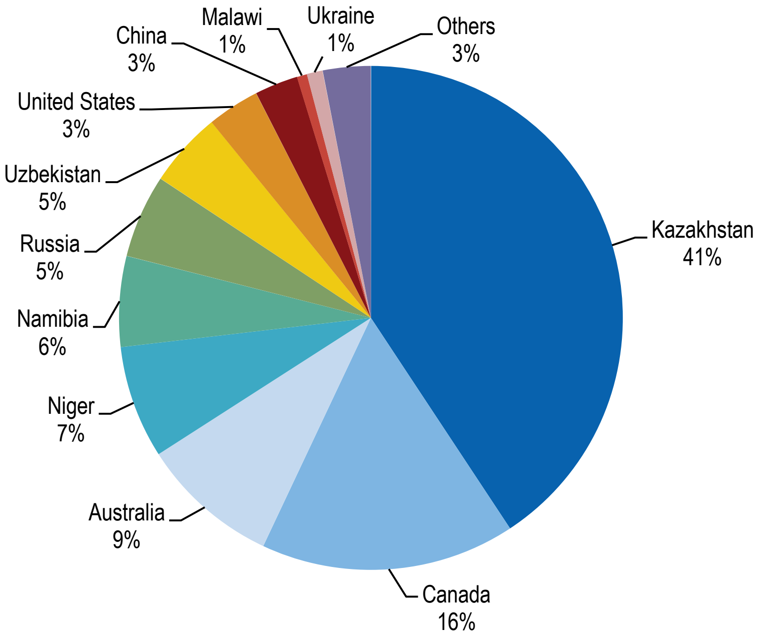
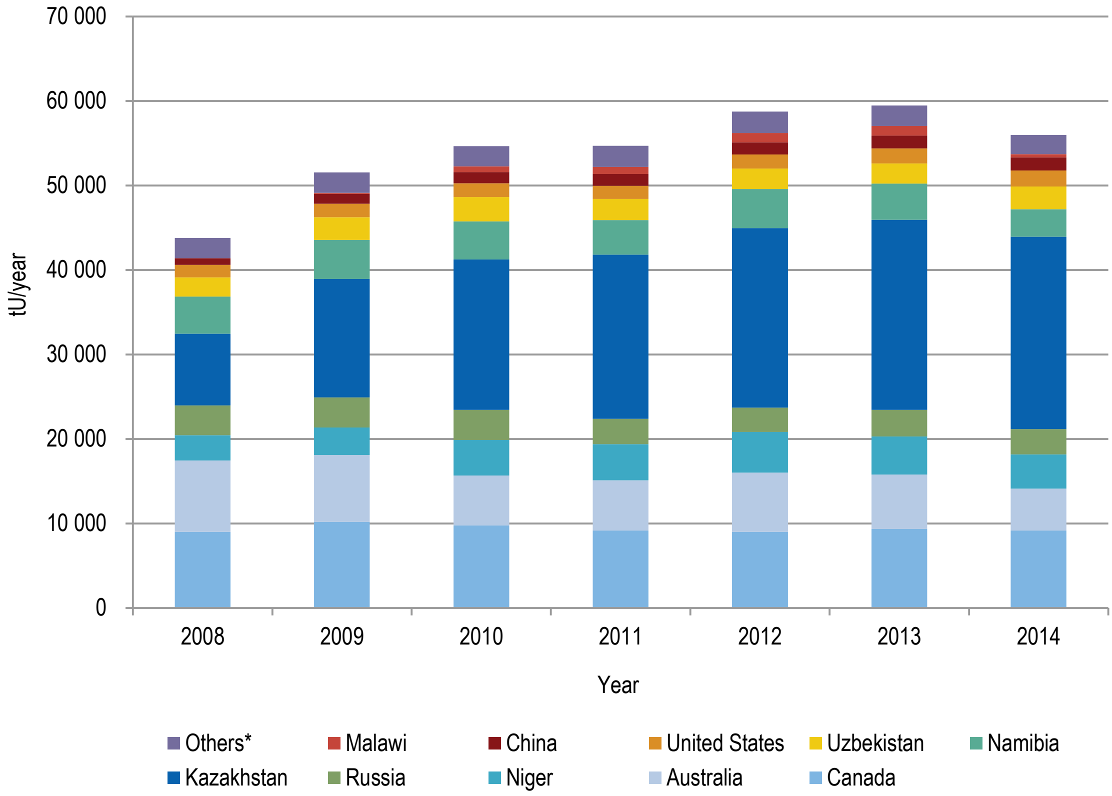


Figure 1.6. Recent world uranium production



* "Others" includes the remaining producers (see Table 1.21).

Niger produced 4 057 tU in 2014, which is somewhat more than Namibia at 3 246 tU. The top five producing countries (Kazakhstan, Canada, Australia, Niger and Namibia) retained their dominance, accounting for 80% of world production in 2014. Eleven countries: Kazakhstan (41%), Canada (17%), Australia (9%), Niger (7%), Namibia (6%), Russia (5%), Uzbekistan (5%), China (3%), the United States (3%), Malawi (1%) and Ukraine (1%) accounted for about 97% of world production in 2014 (see Figure 1.5).

Overall, world uranium production increased only 0.1% from 58 411 tU in 2012 to 59 445 tU in 2013. Production then decreased in 2014 to 55 975 tU, which was a decrease of 6% from 2013. The decreases are principally the result of decreased production in Australia and lower uranium mining output from Brazil, Malawi, Namibia and Niger (see Table 1.20). Within OECD countries, production decreased from 17 956 tU in 2012 to 16 185 tU in 2014, primarily as a result of decreased production in Australia and Canada, and to a smaller extent the Czech Republic. Total world production in 2015 increased to about 60 000 tU.

Present status of uranium production

North American production amounted to 20% (11 017 tU) of world production in 2014, an increase of 352 tU since 2012. A small increase in production in Canada during this reporting period is a result of the restarting of the Cigar Lake mine in 2014 and processing of stockpiled ore at the McClean Lake production centre. Annual production at McClean Lake is forecasted to increase to 6 900 tU by 2018. In the United States, production remained relatively steady with a slight increase in production from 2012 to 2014.

Canada lost its standing as the world's largest producer in 2009 as a result of production increases in Kazakhstan, but it remains the dominant North American producer and the second largest producer in the world. Production at the McArthur River mine, the world's largest high-grade uranium mine, was 7 684 tU and 7 312 tU in 2013 and 2014, respectively.

The Key Lake mill maintained its standing as the world's largest uranium production centre by producing 7 744 tU and 7 358 tU in 2013 and 2014, respectively. These totals represent a combination of high-grade McArthur River ore slurry and stockpiled, mineralised Key Lake special waste rock that is used to blend down high-grade McArthur River ore to produce a mill feed grade of about 5% U.

The Rabbit Lake production centre produced 1 587 tU and 1 602 tU in 2013 and 2014, respectively. Exploratory drilling in the Eagle Point mine during the last several years has increased identified resources to 18 200 tU, extending the life of the mine to at least 2018. However, more recently it was announced that Rabbit Lake will be placed on care and maintenance because of unfavourable market conditions.

In the **United States,** uranium mines produced 1 881 tU in 2014, 13% more than in 2012 and 5% more than in 2013. Production in 2014 was from ten mines: two underground mines and eight ISR mines. The main difference since the last production period is the increase in ISR facilities. Uranium ore from underground mines is stockpiled and shipped to the White Mesa Mill, to be milled into uranium concentrate.

At the end of 2014, one uranium mill (White Mesa in Utah) was operating with a capacity of 1 538 tonnes of ore a day. Two mills (Shootaring Canyon in Utah and Sweetwater in Wyoming) were on standby status with a combined capacity of 2 884 tonnes of ore per day. One mill (Piñon Ridge) was planned for Colorado and one heap leach plant (Sheep Mountain) is planned for Wyoming.

Eight ISR plants were operating in 2014 with a combined "theoretical" capacity of 5 116 tU per year (Crow Butte, Nebraska; Alta Mesa Project, Texas; Hobson ISR Plant/La Palangana Mine, Texas; Lost Creek Project, Nichols Ranch ISR Project, Smith Ranch-Highland Operation, Willow Creek Project, and Smith Ranch satellite North Butte in Wyoming). Smith Ranch, Crow Butte, Alta Mesa, and Willow Creek processed lixiviant at the mine site. However, many of these mines are facing a situation where no new capital is being invested into developing new well fields (e.g. Willow Creek).

Brazil was the only producing country in **South America,** with production declining from 326 tU in 2012 to 192 tU in 2013 and 55 tU in 2014 at the country's only production centre, Lagoa Real, Caetité. The decrease in production over the reporting period was a result of the open-pit portion of the Cachoeira deposit being mined out by 2014. Expansion of this facility to the underground part is progressing but has been delayed somewhat to around 2017 with production in 2019. Expansion of the mill facility to 670 tU/yr involves replacement of the current heap leaching process by conventional agitated leaching. The Engenho deposit, located 2 km from the currently mined Cachoeira deposit, is under study and is expected to provide additional feed to the Caetité mill after 2016. The phosphate/uranium project of Santa Quitéria, an INB – Brazilian fertiliser producer partnership agreement, remains under development. In 2012, the project applied for a construction licence and the projected start of operation is now 2020. Work continues in **Argentina** to restart production at the Sierra Pintada mine of the San Rafael complex, but regulatory and environmental issues remain to be addressed. A strategic plan recently submitted by the National Atomic Energy Commission (CNEA) to national authorities includes development of a new production centre in the province of Chubut in the vicinity of the Cerro Solo deposit, with first production optimistically targeted for 2018.

Primary uranium production in the **European Union** (EU) was from only two countries, the **Czech Republic** and **Romania**. A further three countries, **France**, **Germany** and **Hungary,** produced minor amounts of uranium from mine remediation activities only (a very small portion of Czech Republic production results from similar activities).

Total reported EU production in 2014 was 272 tU, a decrease of 25% from the 362 tU reported for 2012. The decline is primarily a result of decreases in production from the Czech Republic at its main production centre, Dolni Rozinka, as resources are depleted and being recovered from greater depths. Romania has not reported production data in almost a decade, but the NEA/IAEA estimates that it produces about 80 tU per year.

Output from **non-EU countries in Europe** in 2014 amounted to 3 945 tU, which is a very small increase compared to 2012, as production increased in **Russia** by 129 tU but decreased in **Ukraine** by 58 tU.

In 2014, uranium production in **Russia** amounted to 2 991 tU, of which 1 970 tU were produced using conventional underground mining methods and 1 021 tU were produced using the in situ leach method.

Uranium production in Russia is carried out by three mining centres owned by Atomredmetzoloto Uranium Holding (ARMZ): the Priargunsky Mining-Chemical Production Association (PMCPA), Dalur mine and Khiagda mine. The PMCPA remains the key uranium mining centre in Russia. The Priargunsky facility is implementing a set of activities focused on optimisation and modernisation of operating mines and on completion of the construction of mine No. 8. In 2014, the Priargunsky prepared a new concept for the development of the Argunskoe and Zherlovoye deposits, which will be the basis in the future for a new mine No. 6 feasibility study.

In **Ukraine**, there are three production centres: Ingulskiy mine, Smolinskiy mine and the Novokonstantinovskiy mine, which are all underground mining operations in metasomatite deposits. A fourth underground mine, the Severinsky mine (metasomatite-type deposit), is planned for 2020 and an ISL facility, the Safonovski mine (sandstone-type deposit), is planned for 2017.

The three producing countries in **Africa**, **Namibia**, **Niger** and **South Africa** were joined by **Malawi** in 2009 when production commenced at the Kayelekera mine. African production decreased from 10 631 tU in 2012 to 8 238 tU in 2014. The decline was a result of decreased production in all four producing countries because of market conditions and in some cases, because of security and political issues. After a test pilot mining phase, the Trekkopje mine in Namibia was put on care and maintenance in 2013 because of market conditions. A further decline is expected for 2015 as the Kayalakera mine in Malawi was shut down in 2014 and is now on care and maintenance. The Imouraren mine in Niger, which is being developed by Areva, was originally scheduled to begin production in 2012, but has been delayed as a result of unfavourable market conditions. A significant potential production gain in Africa will be from the new Husab mine in Namibia. Currently, the Husab mine is expected to become operational by the end of 2016. Possible production in **Botswana**, **Tanzania** and **Zambia,** and several projects under investigation in **South Africa**, could also contribute to regional production increases in the future should market conditions and security conditions improve.

Increases in production in the **Middle East**, **Central** and **South Asia** continued into 2014 with a total of 25 922 tU produced. This was driven mainly by **Kazakhstan,** where production increased from 21 240 tU in 2012 to 22 513 tU in 2013, and 22 781 tU in 2014. It is now by far the largest uranium-producing country in the world, producing 41% of the world's total in 2014. Uranium was mined using the in situ acid leaching method at the Kanzhugan, Moinkum, Akdala, Uvanas, Mynkuduk, Inkai, Budenovskoye, North and South Karamurun, Irkol, Zarechnoye, Semizbay and Northern Kharasan deposits. As of 1 January 2015, the total capacity of uranium production centres in Kazakhstan is 24 000 tU/yr.

India and **Pakistan** do not report production figures, but their combined total is estimated to be about 396 tU in 2014, only a minor drop since the estimated 409 tU in 2012. **Uzbekistan** did not report production for this edition, and the NEA/IAEA estimates that production increased somewhat to 2 700 tU in 2014. **Iran** continues to produce small amounts of uranium from its Gachin deposit and plans to commence production from its Saghand facility in the future. At present the development of mines No. 1 and 2 is being carried out in the Saghand ore field. **Jordan** continues to develop resources with the aim of producing uranium, but there are currently no firm plans for production.

China, the only producing country in **East Asia**, reported a small but steady increase in production from 1 450 tU in 2012 to 1 500 tU in 2013 and 1 550 tU in 2014 with six production centres in operation. Production is spread between granite-hosted, sandstone-hosted and volcanic-hosted deposits, with granite-related sources slightly higher than the others.

Australia is the only producing country in the **Pacific** region. Production decreased dramatically from 7 009 tU in 2012 to 6 432 tU in 2013, and further decreased to 4 975 tU in 2014. The Four Mile mine started production in 2014 with uranium processed at the Beverley plant. However, this new start-up was not enough to offset the decreases in production for this reporting period. Decreases were a result of completion of the Ranger 3 pit in December 2012, and though stockpiled ore was still being processed, the failure of a leach tank late in 2013 at the Ranger mine stopped operations several months. Further decreases were a result of production halting at the Honeymoon mine in 2013 and the Beverley/Beverly North mines in 2014.

Ownership

Table 1.22 shows the ownership of uranium production in 2014 in the 21 producing countries. Domestic mining companies controlled about 58.6% of 2014 production, which is only slightly lower than the 59.2% reported for 2012. Domestic government participation increased from 38.6% in 2012 to 43% in 2014. Non-domestic mining companies controlled about the same amount of production as in 2012, that is just over 40%. However, for this reporting period, the percentage of control (i.e. government vs. private) in this category, for both Australia and the United States, is not known as this data was not reported because of confidentiality issues.

Table 1.22. Ownership of uranium production based on 2014 output

Country	Domestic mining companies				Non-domestic mining companies				Total
	Government-owned		Privately owned		Government-owned		Privately owned		
	tU	%	tU	%	tU	%	tU	%	tU
Australia	0	0	1 339	26.9	NC	NC	NC	NC	4 976
Brazil	55	100	0	0	0	0	0	0	55
Canada	0	0	6 829	74.7	2 286	25	21	0.2	9 136
China	1 550	100	0	0	0	0	0	0	1 550
Czech Republic	154	100	0	0	0	0	0	0	154
France	3	100	0	0	0	0	0	0	3
Germany	33	100	0	0	0	0	0	0	33
Hungary	2	100	0	0	0	0	0	0	2
India*	385	100	0	0	0	0	0	0	385
Iran	11	100	0	0	0	0	0	0	11
Kazakhstan	13 601	60	0	0	6 445	28	2 735	12	22 781
Malawi	55	15	0	0	0	0	314	85	369
Namibia*	39	1.2	0	0	327	10.07	2 880	88.73	3 246
Niger*	1 392	34.31	0	0	2 290	56.45	375	9.24	4 057
Pakistan*	45	100	0	0	0	0	0	0	45
Romania*	80	100	0	0	0	0	0	0	80
Russia	2 991	100	0	0	0	0	0	0	2 991
South Africa	0	0	566	100	0	0	0	0	566
Ukraine	954	100	0	0	0	0	0	0	954
United States	0	0	NC	NC	0	0	NC	NC	1 881
Uzbekistan*	2 400	100	0	0	0	0	0	0	2 400
Total	**23 750**	**43**	**8 734**	**16**	**11 348**	**20**	**6 325**	**13**	**55 675**

* NEA/IAEA estimate.

NC = Data not available for reasons of confidentiality.

Employment

Although the data are incomplete, Table 1.23 shows that employment levels at existing uranium production centres declined by 10.7% from 2012 to 2013, then rebounded somewhat and increased by 3.1% from 2013 to 2014, but then declined again by 3.9% in 2015. However, if future production expansions and restarting of mines currently on care in maintenance in countries such as Australia, Canada, India, Kazakhstan, Namibia, Niger and Russia are successfully completed, employment will increase in the longer term. Table 1.24 provides employment directly related to uranium production (excluding head office, R&D, pre-development activities, etc.), in selected countries.

Table 1.23. Employment in existing production centres of listed countries

(person-years)

Country	2008	2009	2010	2011	2012	2013	2014	2015 (expected)
Argentina	133	133	133	128*	78	78	85	82
Australia[(a)]	4 787	3 830	4 813	4 888	5 574	5 620	5 800	6 000
Brazil	640	620	620	620	620	620	620	590
Canada[(b)]	1 984	2 205	2 399	2 060	2 109	2 148	2 874	2 900
China	7 450	7 500	7 560	7 650	7 560	7 650	7 660	7 670
Czech Republic	2 287	2 248	2 164	2 118	2 126	2 110	2 072	2 106
Germany[(c)]	1 770	1 638	1 489	1 452	1 372	1 204	1 147	1 062
India	4 634	4 643	4 917	4 917	4 962	4 962	4 962	5 000
Iran	285	320	325	340	350	500	500	600
Kazakhstan	7 940	9 261	8 828	8 550	9 760	7 682	7 728	8 010
Malawi	1 250	1 033	1 036	766	759	N/A	N/A	N/A
Namibia	>2 543	>2 781	2 554	1 886	2 786	N/A	N/A	N/A
Niger	2 156	2 764	2 915	2 915	2 915	N/A	N/A	N/A
Romania*	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Russia	12 870	9 975	8 989	9 028	9 526	10 164	8 790	7 125
South Africa	3 364	4 494	4 825	4 320	237	1 742	4 141	3 815
Spain[(c)]	43	43	25	24	23	23	23	N/A
Ukraine	4 260	4 350	4 310	4 470	4 350	4 480	4 500	4 500
United States	1 409	934	948	1 089	1 017	957	626	N/A
Uzbekistan	8 750	8 800	8 860	N/A	N/A	N/A	N/A	N/A
Total	**70 555**	**69 572**	**69 710**	**59 221**	**58 124**	**51 940**	**53 528**	**51 460**

* NEA/IAEA estimate; N/A = Data not available; (a) Olympic Dam does not differentiate between copper, uranium, silver and gold production; Employment has been estimated for uranium-related activities; (b) Employment at mine sites only; (c) Employment related to decommissioning and rehabilitation.

Table 1.24. Employment directly related to uranium production

Country	2012		2013		2014	
	Production employment (person-years)	Production (tU)	Production employment (person-years)	Production (tU)	Production employment (person-years)	Production (tU)
Australia[(a)]	3 720	7 009	3 750	6 432	3 870	4 976
Brazil	340	326	340	192	340	55
Canada[(b)]	1 361	8 998	1 406	9 332	1 829	9 136
China	6 860	1 450	6 950	1 500	6 960	1 550
Czech Republic	1 147	228	1 137	215	1 105	154
Iran	150	24	145	8	135	11
Kazakhstan	5 809	21 240	6 874	22 513	6 915	22 781
Namibia*	2 628	4 653	1 583	4 264	1 853	3 246
Niger*	N/A	4 822	N/A	4 528	N/A	4 057
Russia	5 810	2 862	7 180	3 135	6 126	2 991
South Africa	182	467	175	531	406	566
Ukraine	1 450	1 012	1 590	926	1 610	954
United States	856	1 595	808	1 792	540	1 881

* NEA/IAEA estimate; (a) Olympic Dam does not differentiate between copper, uranium, silver and gold production. Employment has been estimated for uranium-related activities; (b) Employment at mine sites only.

Production methods

Historically, uranium production has been produced mainly using open-pit and underground mining techniques processed by conventional uranium milling. Other mining methods include in situ leaching (ISL, sometimes referred to as in situ recovery, or ISR); co-product or by-product recovery from copper, gold and phosphate operations; heap leaching and in-place leaching (also called stope or block leaching). Stope/block leaching involves the extraction of uranium from broken ore without removing it from an underground mine, whereas heap leaching involves the use of a leaching facility on the surface once the ore has been mined. Small amounts of uranium are also recovered from mine water treatment and environmental restoration activities.

Over the past two decades, ISL mining, which uses either acid or alkaline solutions to extract the uranium directly from the deposit, has become increasingly important. The uranium dissolving solutions are injected into and recovered from the ore-bearing zone using a system of wells. ISL technology is currently being used to extract uranium from sandstone deposits only and in recent years has become the dominant method of uranium production.

The distribution of production by type of mining or "material sources" for 2011 through 2015 is shown in Table 1.25. The category "other methods" includes recovery of uranium through treatment of mine waters as part of reclamation and decommissioning.

As can be seen in Table 1.25, ISL production has continued to dominate uranium production, largely because of the rapid growth of production in Kazakhstan along with other ISL projects in Australia, China, Russia and Uzbekistan. Note that not all countries report production by method, and for this reporting period, the United States, where the majority of production is by ISL, did not make this information available. World uranium production by ISL amounted to 50.8% of the total production in 2014 and a similar percentage of about 49% was estimated for 2015. The co-product/by-product method could increase in importance in coming years, if the planned expansion of Olympic Dam proceeds.

Table 1.25. Percentage distribution of world production by production method

Production method	2011	2012	2013	2014	2015 (expected)
Open-pit mining	17.6	21.1	19.5	14.0	13.1
Underground mining	28.6	25.9	26.5	27.3	30.2
In situ leaching	44.5	45.2	46.7	50.8	48.7
In-place leaching	7.1	-	-	-	-
Co-product/by-product	1.5	6.6	6.8	7.3	7.4
Heap leaching	0.7	0.4	0.3	0.5	0.6
Other	-	0.9	0.1	0.1	0.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Projected production capabilities

To assist in developing projections of future uranium availability, member countries were asked to provide projections of *production capability* through 2035. Table 1.26 shows the projections for *existing and committed production centres* (A-II columns) and for *existing, committed*, *planned and prospective production centres* (B-II columns) in the <USD 130/kgU category through 2035 for all countries that either are currently producing uranium or have plans and the potential to do so in the future. Note that both the A-II and B-II scenarios are supported by currently identified local RAR and IR in the <USD 130/kgU category, with the exception of Pakistan.

Table 1.26. World uranium production capability to 2035

(in tonnes U/year, from RAR and inferred resources recoverable at costs up to USD 130/kgU)

Country	2015		2020		2025		2030		2035	
	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II
Argentina	0	0	150	100	150*	100*	150*	100*	150*	100*
Australia	5 640	5 640	6 000	9 000	8 000	14 000	10 000	19 000	10 000	24 000
Brazil	340	340	640	640	640	1 600	1 000*	1 300	1 000*	1 300
Botswana*	0	0	0	0	0	0	0	1 350	0	1 350
Canada	18 700	18 700	12 330	18 850	12 330	18 850	12 330	18 850	12 330	18 850
China*	1 600	1 600	1 600	1 600	1 600	1 600	1 800	1 800	1 800	2 300
Czech Republic	150	150	50	50	50	50	50	50	30	30
Finland**	0	0	0	350	0	350	0	350	0	350
Greenland**	0	0	0	0	0	500	0	500	0	500
India*	385	385	740	800	800	800	800	800	800	1 200
Iran	35	0	90	120	70*	70*	70*	70*	70*	70*
Kazakhstan	25 000	25 000	25 000	25 000	19 000	20 000	14 000	15 000	8 000	9 000
Malawi*	0	0	0	0	0	1 460	0	1 460	0	1 460
Mauritania*	0	0	0	0	0	400	0	400	0	400
Mongolia*	0	0	0	0	150	150	150	150	150	1 000
Namibia*	3 000	3 000	8 700	8 700	7 700	7 700	10 400	10 400	12 400	12 400
Niger*	4 200	4 200	5 000	5 000	5 000	5 000	5 000	6 000	5 000	7 500
Pakistan*	45	45	45	45	45	45	45	45	45	45
Romania*	50	50	50	50	50	50	50	100	50	400
Russia	3 010	3 010	3 060	3 060	5 430	5 430	5 280	9 610	5 280*	8 000*
South Africa	385	800	950	1 300	1 160	3 000	1 180	2 800	1 090	2 500
Sweden	0	0	0	0	0	0	0	0	0	1 000
Tanzania*	0	0	0	0	0	2 000	0	2 000	0	3 000
Turkey	0	0	0	0	300	300	300	300	300	300
Ukraine	1 050	1 050	2 000	2 100	2 000	5 800	1 700	5 800	1 700*	3 800*
United States*	1 250	1 250	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Uzbekistan*	2 400	2 400	2 700	2 700	3 000	3 000	3 000	3 000	3 000	3 000
Zambia*	0	0	0	0	0	0	0	650	0	650
Total	**67 240**	**67 620**	**71 105**	**81 465**	**69 475**	**94 255**	**69 305**	**103 885**	**65 195**	**106 505**

A-II = Production capability of existing and committed centres supported by RAR and inferred resources recoverable at <USD 130/kgU.

B-II = Production capability of existing, committed, planned and prospective centres supported by RAR and inferred resources recoverable at <USD 130/kgU.

* NEA/IAEA estimate.

** By-product production.

Several current or potential uranium-producing countries including Botswana, China, India, Malawi, Mauritania, Mongolia, Namibia, Niger, Pakistan, Romania, Tanzania, the United States, Uzbekistan and Zambia did not report, or only partially reported, projected production capabilities to 2035. In some countries, the NEA/IAEA suggested updates to the submitted data in order to take into account recent and important changes since the cut-off date for submission of data. As a result, estimates of production capability for many countries were developed by the NEA/IAEA using data submitted for past Red Books, company reports and other public data.

The reported production capability of existing and committed production centres in the A-II category for 2015 is about 67 240 tU. For comparison, the estimated 2013 production capability totalled 74 310 tU. However, actual 2013 production amounted to 59 445 tU, or about 80% of stated production capability. In 2011, production amounted to 54 740 tU, or about 75% of stated production capability, 76% in 2007, 84% in 2005 and 75% in 2003, demonstrating that full capability is rarely, if ever, achieved. Total production capability for 2015, including planned and prospective centres (category B-II), amounts to 67 620 tU, about 9% lower than the 2013 B-II total capability of 74 410 tU. In 2011 and 2007, production amounted to 73% of total B-II capability, 81% in 2005 and 74% in 2003.

Since 2003, expansion in production capability was being driven by generally higher uranium prices, and production had correspondingly increased during the same period, although not as rapidly as the projected production capability. However, along with a decrease in uranium prices during this reporting period, production has also decreased, as did the growth in production capacities. In addition, turning stated production capability into production takes time, expertise and investment, and can be confounded by unexpected geopolitical events, legal issues and technical challenges.

The influence of the Fukushima Daiichi accident and its impact on nuclear development and in turn uranium prices is still apparent and slowed the rate of increase in production capabilities during this reporting period. Furthermore, a delay in the expansion of the Olympic Dam project in Australia, announced in August 2012, for which there is still no recent update, makes the timing of the additional production from this project uncertain. In addition, several projects have been put on hold in Australia (Honeymoon), in Malawi (Kayelakera) and in Namibia (Trekkopje mine). In the short term, expansion will come mainly from development of ISL projects in Kazakhstan and to a lesser extent in China, production from the Cigar Lake mine in Canada, potential production from the Husab mine in Namibia and eventually, in the longer term, from the Imouraren mine in Niger.

The current (2015) projections show a marked decrease in production capacity compared to the projections made for the same year in the last Red Book (decreases of 18 555 tU and 30 750 tU in the A-II and B-II categories, respectively), as developments are being brought in line with the slowdown in nuclear generation capacity growth since the Fukushima Daiichi accident (see Table 1.26). The projections to 2020 are also much lower for the same reasons. In the longer-term, growth prospects for nuclear power have also likely been affected, but to what degree it is not certain as projections of this nature over the long term are subject to numerous factors. As a result of adjustments to recent events, and the depressed uranium market, the revised figures on production capability to 2035 have decreased overall from the projections in the 2014 Red Book.

As currently projected, production capability of existing and committed production centres is expected to reach over 71 105 tU/yr in 2020, declining thereafter somewhat to about 69 475 tU in 2025, then decreasing up to 69 305 tU in 2030 and decreasing again to 65 195 tU in 2035. Total potential production capability (including planned and prospective production centres, category B-II) is only expected to rise to 94 255 tU/yr by 2025, followed by a slow increase to around 103 885 tU/yr and 106 505 tU/yr in 2030 and 2035, respectively. Although the total potential production capabilities are much lower than projected in the last Red Book, the current projections indicate a steady growth in production capability.

Recent, planned, committed mines and expansions

Several new mines began operations during this reporting period. Pilot production at the Honeymoon ISL mine commenced in September 2011, and commissioning of the plant continued through 2012. However, because of market conditions, production at Honeymoon ceased in November 2013 and the project is now on care and maintenance. The Tummalapalle mine in India began production in 2012, and several ISL mines in the United States started production in 2013-2015 (Lost Creek, Nichols Ranch and Ross). Production at the world's highest-grade uranium mine, Cigar Lake, commenced in 2014 with the first commercial production in 2015. In Australia, Four Mile ISL mine started production in 2014. In October, Khorasan-U LLP, Kazakhstan, completed test production and started commercial production at the deposit, Northern Kharasan (site Kharasan-1). There were a few mine expansions during this period – two in Kazakhstan and three in Uzbekistan (note that the latter is an NEA/IAEA estimate as Uzbekistan did not report to the Red Book for this edition). Iran also reports a committed production centre at Ardakan but no further information is available about whether production actually began in 2015. Table 1.27 summarises these recent developments, adding some detail to the global capacity expansions outlined in Table 1.26. Committed production centres (C) are those that are either under construction or are firmly committed for construction, whereas planned production centres (P) are those where feasibility studies are either completed or under way, but for which construction commitments have not yet been made. Expansions (Exp) are planned capacity increases at existing sites (E).

There are some additions to the existing and committed production capacities until 2020, with production increases projected mainly in Namibia (Husab mine is expected to become fully operational in 2016). Other additions to the existing and committed production capacities through 2035 are projected in Australia, Brazil, China, India, Russia, South Africa and Ukraine. Planned and prospective production capability is predicted to gradually ramp up through 2025 and may continue through 2035 with the main increases coming primarily from the planned expansion of the Olympic Dam deposit in Australia. Other increases are also projected from Botswana, China, Greenland, Mongolia, Namibia, Niger, South Africa, Russia, Tanzania and potentially Ukraine. Production in countries such as Canada, and Uzbekistan are projected to remain relatively constant, with only minor increases or decreases. Kazakhstan, on the other hand, has a long-term forecast for production to start decreasing around 2025.

Total production capacity could increase by more than 39 000 tU by 2035 (see Table 1.27). It is important to note, however, that many of these projected increases in production capacity will likely only go forward with strengthening market conditions. Increased mining costs and development of new exploitation technologies, combined with risks of producing in jurisdictions that have not previously hosted uranium mining, mean that strong market conditions will be needed to secure the required investment to develop these mines.

In addition, several prospective production centres were noted in national reports and company reports for which a projected start-up date, and in some cases mine capacities, have not yet been determined (see Table 1.28). While there is greater uncertainty surrounding the development of these sites, these potential capacity additions underscore the availability of uranium deposits of commercial interest. Once again, it must be noted that strengthened market conditions will be necessary before mine developments will proceed. Additionally, since these sites span several stages of approvals, licensing and feasibility assessments, it can reasonably be expected that at least some will take a number of years to be brought into production.

Table 1.27. Recent, planned, committed mines and expansions

(in year of estimated first production and tonnes U per year estimated production capacity)

Country	Production centre	2014	2015	2016	2017	2018	2019	2020	2021	2022	2024	2025
Argentina	Cerro Solo					P (200)						
Australia	Olympic Dam(1)											
	Beverley/Four Mile(2)											
	Wiluna				P (850)							
Brazil	Lagoa Real/Caetité (Cachoeira)(3)						E (340)					
	Santa Quitéria**							P (970)				
	Engenho(4)			C (300)								
Canada	Cigar Lake	E (6 900)										
Finland	Talvivaara(5)											
India	Gogi							P (130)				
	Lambapur-Peddagattu										P (130)	
	Tummalapalle(6)											
	KPM									P (340)		
Iran	Ardakan		C (50)									
Kazakhstan	Inkai 3									Exp (2 000)		
	Zhalpak							C (500)				
	Moikum site 3								Exp (250)			
Mongolia	Emeelt Mines					P (N/A)						
	Gurvansaikhan					P (N/A)						
	Coge-Gobi						P (N/A)					
Namibia*	Husab			C (5 700)								
	Langer Heinrich(7)											
	Trekkopje(8)											
Niger*	Madaouela											P (1 000)
	Imouraren(9)											
South Africa	Beaufort West					P (1 036)						
	Springbok Flats							P (600)				
Ukraine	Safonovskiy				C (150)							
	Severinskiy							P (1 200)				
United States	Ross(10)		E (850)									
	Nichols Ranch/Hank	E (770)										
	Lost Creek(11)											
Uzbekistan*	Alendy, Aulbek,		P (1 000)									
	North Kanimekh											

E = existing; C = committed; P = planned; Exp = expansion.

* NEA/IAEA estimate; ** Phosphate uranium project.

(1) BHP Billiton reported in late 2014 that a pre-feasibility study will be conducted regarding an expansion of the Olympic Dam project. Proposed trials of heap leach technology should assist the company in assessing less capital-intensive mineral processing technology for ore mined underground; (2) Approval has been granted to extend the capacity of the Beverley plant to produce 1 270 tU/yr (+ 420 tU) when the company decides it is commercially viable to do so. Production from Beverley ceased in early 2014. Four Mile started production in 2014 with uranium processed at the Beverley plant. (3) The open pit was totally mined in 2014. The underground part of Cachoeira mine is expected to start the development works by 2017 and the production in 2019. (4) Ore treated at Caetité mill. The mill capacity expansion to 670 tU/y is in progress. (5) Nickel by-product. Capacity: 350 tU/yr. Starting date: N/A. (6) Started production in 2012. Capacity: 220 tU/yr. Expansion announced but date unknown. (7) Extension Stage 4 + 1 800 tU/yr; date of expansion unknown. (8) Project stopped in 2012. Care and maintenance. Restart: Unknown. (9) Planned, on hold until market conditions improve. Planned capacity 5 000 tU/yr. Date of first production: Unknown. (10) Production began in late 2015; therefore it is not listed in existing mines in country report. (11) Production started in 2013. Capacity: 770 tU/yr. KPM = Kylleng-Pyndengsohiong Mawthabah.

Table 1.28. Prospective mines (estimated production capacity in tU/yr)*

Country	Production centre
Australia	Kintyre (2 300 tU/yr)
	Yeelirrie (3 000 tU/yr)
Botswana	Letlhakane (1 350 tU/yr)
Canada	Kiggavik (3 000 tU/yr)
	Michelin (2 200 tU/yr)
	Midwest (2 300 tU/yr)
	Millenium (2 750 tU/yr)
Greenland	Kvanefjeld (500 tU/yr)
Malawi	Kanyika**
Mauritania	Reguibat (400 tU/yr)
Namibia	Etango (3 000 tU/yr)
	Norasa (2 000 tU/yr)
Niger	Dasa (770 tU/yr)
Russia	Elkon (5 000 tU/yr) in 2025-2030
	Gornoe (300 tU/yr)
Spain	Retortillo/Alameda (1 030 tU/yr)
Sweden	Häggån (3 000 tU/yr)
Tanzania	Mkuju River (3 000 tU/yr)
Turkey	Temrezli (385 tU/yr)
United States	Roca Honda
	Church Rock-Mancos
	Dewey-Burdock
	Slick Rock
	Mount Taylor
Zambia	Lumwana (650 tU/yr)
	Mutanga (575 tU/yr)

* As noted in country reports or from public data, but in several cases start-up dates and capacity unknown.

** Niobium mine with uranium as by-product.

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Chapter 2. Uranium demand

This chapter summarises the current status and projected growth in world nuclear electricity generating capacity and commercial *reactor-related uranium requirements*. Relationships between uranium supply and demand are analysed and important developments related to the world uranium market are described. The data for 2015 and beyond are estimates and actual figures may differ.

Nuclear generating capacity and reactor-related uranium requirements

World

On 1 January 2015, a total of 437 commercial nuclear reactors were connected to the grid in 30 countries and 70 reactors were under construction (a total of about 68.5 GWe net).[1] During 2013 and 2014, ten reactors were connected to the grid and seven reactors were permanently shut down. Table 2.1 and Figures 2.1 and 2.2 summarise the status of the world's nuclear power plants (NPPs) as of 1 January 2015. The global NPP fleet generated a total of about 2 262 TWh of electricity in 2013 and about 2 432 TWh in 2014 (see Table 2.2).

World annual uranium requirements amounted to 56 585 tU as of 1 January 2015.

OECD

As of 1 January 2015, the 324 reactors connected to the grid in 18 OECD countries constituted about 81% of the world's nuclear electricity generating capacity. A total of 16 reactors were under construction. During 2013 and 2014, no reactors were connected to the grid and seven reactors were permanently shut down in the United States and Japan. However, 35 reactors were considered firmly committed to construction, including the first units in Turkey. On the other hand, some reactors are planned to be retired from service by 2020, reducing OECD nuclear generating capacity. Included are two closures in Germany, as part of the plan to phase out nuclear power by the end of 2022, along with one ageing reactor in the United Kingdom, as well as potential reactors in the United States.

In Japan, all the operational reactors were offline throughout 2014. By the end of 2014, however, the Nuclear Regulation Authority of Japan had determined that four reactors had met the strengthened safety requirements developed in response to the accident at the Fukushima Daiichi nuclear power plant, indicating that a return to operation of at least some reactors in the country can be expected. Despite the Fukushima Daiichi accident, a number of OECD member countries, namely the Czech Republic, Finland, Hungary, the Slovak Republic, Korea and the United Kingdom, remain committed to maintaining or increasing nuclear generating capacity in their energy mix. In North America, some new build construction plans made significant progress while others were put on hold, at least temporarily.

The OECD reactor-related uranium requirements were 42 195 tU as of 1 January 2015.

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[1] Figures include the reactors operating and under construction in Chinese Taipei.

Table 2.1. Nuclear data summary

(as of 1 January 2015)

Country	Operating reactors	Generating capacity (GWe net)	2014 uranium requirements (tU)	Reactors under construction	Reactors started up during 2013 and 2014	Reactors shut down during 2013 and 2014	Reactors using MOX
Argentina(a)	2	0.9	120	1	1	0	0
Armenia	1	0.4	65	0	0	0	0
Belarus	0	0.0	0	2	0	0	0
Belgium	7	5.9	870	0	0	0	0
Brazil	2	1.9	400	1	0	0	0
Bulgaria	2	1.9	300*	0	0	0	0
Canada	19	13.4	1 800	0	0	0	0
China(b)	23	20.3	4 200	26	6	0	0
Czech Republic	6	3.9	680	0	0	0	0
Finland	4	2.8	425	1	0	0	0
France	58	63.2	8 000	1	0	0	22
Germany	9	12.0	2 000	0	0	0	6(c)
Hungary	4	1.9	215	0	0	0	0
India	21	5.3	850*	6	1	0	1
Iran	1	0.9	160	0	0	0	0
Japan	48	42.4	370	2	0	2	N/A
Korea	23	20.7	4 200	5	0	0	0
Mexico	2	1.4	190	0	0	0	0
Netherlands	1	0.5	60	0	0	0	1
Pakistan	3	0.7	110*	2	0	0	0
Romania	2	1.3	210*	0	0	0	0
Russia	33	25.2	4 400	9	1	0	0
Slovak Republic	4	1.8	360	2	0	0	0
Slovenia	1	0.7	150	0	0	0	0
South Africa	2	1.8	290	0	0	0	0
Spain	8	7.5	1 120	0	0	0	0
Sweden	10	9.5	1 430	0	0	0	0
Switzerland	5	3.3	250	0	0	0	0
United Arab Emirates	0	0.0	0	3	0	0	0
Ukraine	15	13.8	2 480	2	0	0	0
United Kingdom	16	9.2	1 500	0	0	0	0
United States	99	97.9	18 575	5	0	5	0
OECD	324	298.0	42 195	16	0	7	29
Total(b)	**437**	**377.4**	**56 585**	**70**	**9**	**7**	**30**

* NEA/IAEA estimate.

(a) Atucha II reactor was not considered for the 2014 generating capacity as the official operating licence was not released in the year.

(b) The following data for Chinese Taipei are included in the world total but not in the total for China: six NPPs in operation, 5.0 GWe net; 800 tU as 2014 uranium requirements; two reactors under construction; none started up or shut down during 2013 and 2014.

(c) All nine operating reactors are licensed to use MOX, but only six used MOX in 2014.

MOX not included in uranium requirement figures.

Source: i) Government-supplied responses to a questionnaire; ii) NEA *Nuclear Energy Data 2015* for OECD countries; and iii) IAEA *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (IAEA, 2015a) for non-OECD countries.

Figure 2.1. World installed nuclear capacity: 377.4 GWe net

(as of 1 January 2015)

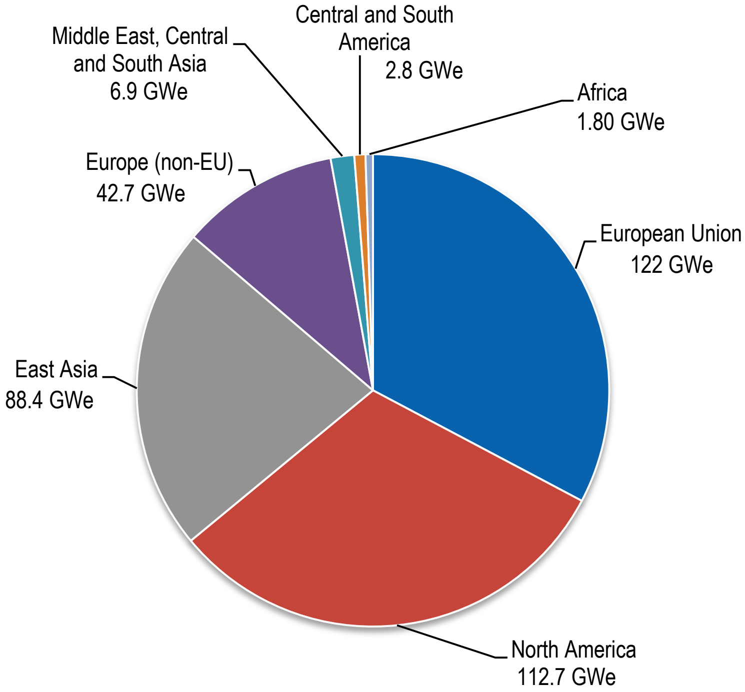

Figure 2.2. World uranium requirements: 56 585 tU

(as of 1 January 2015)

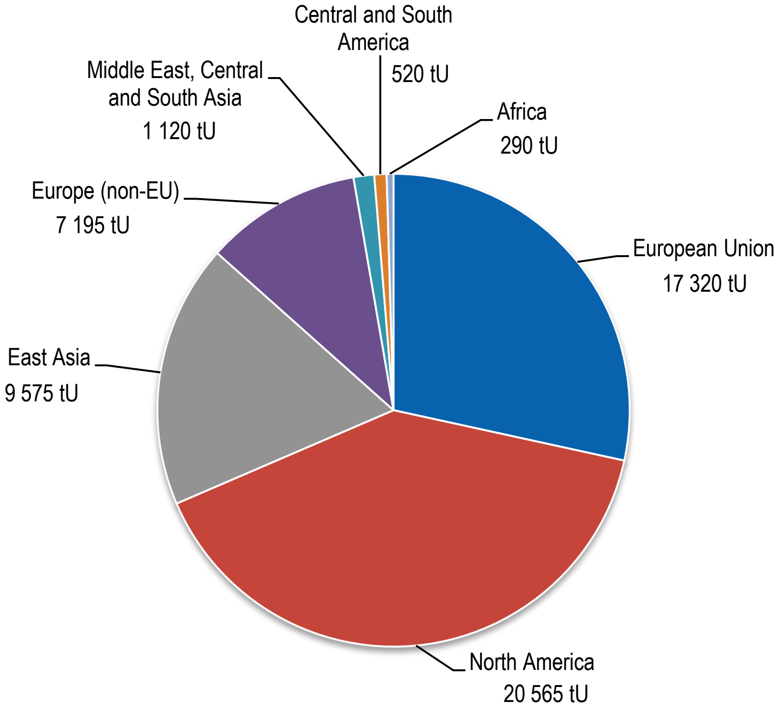

Table 2.2. Electricity generated at nuclear power plants

(TWh net)

Country	2011	2012	2013	2014
Argentina	5.9	5.9	5.7	5.3
Armenia	2.4	2.1	2.4	2.3
Belgium	45.9	40.0	41.0	32.0
Brazil	14.8	15.2	14.6	15.4
Bulgaria	15.3	14.9	13.3	15.0
Canada	88.3	91.0	97.0	100.9
China(a)	82.6	92.7	104.8	123.8
Czech Republic	26.7	28.6	29.0	28.6
Finland	22.3	22.1	22.6	22.2
France	405.0	421.0	403.7	415.9
Germany	102.0	94.5	92.1	91.8
Hungary	14.7	14.8	14.4	14.7
India	29.0	29.7	35.3	38.0
Iran	0.1	1.3	3.9	3.7
Japan	156.2	17.2	0.0	0.0
Korea	154.7	143.5	133.2	150.4
Lithuania	0.0	0.0	0.0	0.0
Mexico	9.3	8.4	11.4	9.3
Netherlands	3.9	3.9	2.7	3.5
Pakistan	3.8	5.3	4.4	4.6
Romania	10.8	10.6	10.7	10.8
Russia	162.0	166.3	172.2	180.5
Slovak Republic	14.3	14.4	14.7	14.5
Slovenia	5.9	5.2	5.0	6.0
South Africa	12.9	12.4	13.6	14.8
Spain	55.1	58.6	54.3	54.8
Sweden	58.0	61.2	63.6	62.2
Switzerland	25.7	24.4	24.8	26.4
Ukraine	84.9	84.9	83.2	88.6
United Kingdom	62.7	64.0	64.1	57.8
United States	790.0	769.0	789.0	797.0
OECD	2 040.7	1 881.8	1 862.6	1 888.0
Total(a)	**2 505.6**	**2 361.8**	**2 366.5**	**2 431.6**

(a) The following data for Chinese Taipei are included in the world total, but not in the total for China: 40.4 TWh in 2011, 38.7 TWh in 2012, 39.8 TWh in 2013 and 40.8 TWh in 2014.

Source: i) government-supplied responses to a questionnaire; ii) NEA *Nuclear Energy Data 2015* for OECD countries; and iii) IAEA *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (IAEA, 2015a) for non-OECD countries.

European Union

As of 1 January 2015, 131 nuclear reactors were operational in the European Union (EU) with a total installed generating capacity of 122 GWe (net). The operating NPPs produced about 27% of electricity in the EU in 2014.

Nuclear phase-out policies remain in place in Belgium and Germany. All reactors in Germany are now expected to be permanently shut down by the end of 2022. In Belgium, the current policy is to close all nuclear power plants by 2025. However, other countries in the EU remain committed to nuclear power and plan to add nuclear generating capacity in the coming years.

In response to the Fukushima Daiichi accident, stress tests were carried out on the entire EU reactor fleet as well as those in adjacent countries in order to assess safety and robustness of NPPs in case of extreme natural events. In this process, NPP operators conducted self-assessments that were later reviewed by national safety authorities and then by multinational teams in a peer review process.

In February 2015, the European Commission released a series of proposals that call for strengthening energy security and developing an energy union. The Energy Union proposals call for increased harmonisation of energy markets for the 28-nation group, but do not yet include enforceable legislation. However, eventually the proposals could lead to EU-wide rules that limit the powers of national regulators and enable a greater degree of energy transmission among different nations. The European Commission is seeking greater diversification and independence from Russia for the EU's natural gas market and also wants to modernise the electricity market. In addition, the European Commission seeks greater energy efficiency. Recently released proposals contain little mention of nuclear power but call for greater diversification of nuclear fuel supplies and also for a transition to a low-carbon society.

In **Belgium**, seven nuclear power plants provide about 50% of domestic electricity generation. However, concerns about security of electricity supply were heightened in late 2014 as a transformer fire forced an unplanned shutdown of the Tihange 3 reactor, at a time when the Doel 3 and Tihange 2 reactors were offline for further investigation by the regulator as a result of pressure vessel fault indications. The Tihange 3 reactor was returned to service within two weeks after repair. The Belgian Federal Agency for Nuclear Control (FANC) also approved the restart of Doel 3 and Tihange 2. In 2015, the Belgian government agreed to a ten-year extension of the operation of Doel 1 and 2 amid concerns about the security of energy supply.

In **Bulgaria**, following the closure of four older reactors by the end of 2006, only two units (about 0.95 GWe net each) remain operational at the Kozloduy NPP. These two units generated about 30% of the country's electricity in 2014. To compensate for the loss of nuclear generating capacity and to regain its position as a regional electricity exporter without increasing greenhouse gas emissions, the government of Bulgaria has plans to build new reactors. In 2008, work began at the Belene site on two VVER reactors supplied by Russia, but this project was abandoned. It was reported later that the government was considering the construction of a new plant at the Kozloduy site and supporting a project to extend the lifetime of the two existing reactors. The government continues to assess the situation for the new build. In 2015, the majority of the preliminary activities had been completed and the technical and economic analysis was finalised and approved. However, the lack of a strategic investor and a clear definitive financial framework are the major issues impeding the realisation of the project.

In the **Czech Republic**, a total of six reactors were operational on 1 January 2015, with an installed capacity of 3.9 GWe net. After the modernisation and power uprate programme for all reactors at the Dukovany NPP, an upgrade of the Temelin units began in 2013 and resulted in a capacity increase to 1 078 MWe gross for each block. In May 2015, the Czech government announced a national energy policy that favours an ambitious increase in nuclear power from its current 35% to about 50% by 2035 as a means to reduce carbon emissions. This will be achieved by the long-term operation of the existing Dukovany NPP (at least 50 years), construction of new nuclear units up to 2.5 GWe until 2035 and additional new units replacing the current ones after 2035. The Czech utility ČEZ is working on further development of both sites with potential construction of 1-2 new units at each site. The work consists of feasibility studies, geology and seismic research, environmental impact assessments and preparation of tender documentation. Since all alternatives on investment and delivery models are under consideration, new subsidiary companies responsible for new build were established.

In **Finland**, four units (two each at the Olkiluoto and Loviisa NPPs) with a total generating capacity of 2.8 GWe (net) were operational on 1 January 2015, providing about 34% of domestic electricity generation. Teollisuuden Voima Oyj (TVO), a non-listed public limited company, owns and operates the two plant units, Olkiluoto 1 and 2, and is building a new unit, Olkiluoto 3. Construction of the Olkiluoto 3 (EPR, about 1.6 GWe net) continues but may not be completed until the end of 2018. According to the climate and energy strategy adopted by Finland, nuclear power is an option, but the initiatives must come from industry. TVO filed a decision-in-principle (DIP) application for the construction of Olkiluoto 4 in 2008, and Fortum and Fennovoima applied for Loviisa 3 in 2009. The applications by TVO and Fennovoima were approved, whereas the application by Fortum was rejected. TVO's Olkiluoto 4 project proceeded to the bidding phase. However, in 2014 the government rejected TVO's application to extend the validity of the DIP and to set a new deadline to submit the construction licence application. In December 2013, Fennovoima signed a "turnkey" plant supply contract for an AES-2006-type VVER reactor with Rosatom Overseas. At the same time, an integrated fuel supply contract with TVEL to cover the first nine operating years was signed, together with a shareholders agreement to sell 34% of Fennovoima's shares to Rosatom Overseas. A preliminary safety assessment of the plant design was completed in 2014. Fennovoima submitted an application in June 2015 for a licence to construct the Hanhikivi 1 nuclear power plant and updated the application in August to document sufficient Finnish ownership of the project. According to Fennovoima, the electricity production will begin in 2024.

In **France**, 58 operational reactors generated 77% of domestically produced electricity in 2014. Construction of a new EPR at the Flamanville NPP began in late 2007 and the unit is scheduled to begin commercial operation by 2018. A national debate on the French energy transition was launched in late 2012 to address how energy efficiency can be improved, to define options for the future energy mix and how they can be achieved by 2025 while maintaining commitments to reduce greenhouse gas emissions. The government passed legislation in 2015 for the transition to a low-carbon economy, restricting nuclear power to its current level of capacity, with a goal of ultimately reducing the percentage of nuclear power to 50% by 2025 through increased deployment of renewable capacity. Construction of the Georges Besse II centrifuge uranium enrichment plant continued on Tricastin site, with a total target capacity of 7.5 million SWU by 2016. Commercial production began in 2011 and the energy intensive gaseous diffusion centrifuge plant (Eurodif) was closed at the end of June 2012 after 33 years of operation.

In **Germany**, nine reactors were operational on 1 January 2015, producing about 16% of domestic electricity generation in 2014. Changes to the Nuclear Power Act (NPA) in 2002 enshrined the nuclear phase-out in the German law and necessitated the early shutdown of two reactors. In December 2010, the NPA was amended to extend the operating lives of the existing reactors by an average of 12 years. However, following the Fukushima Daiichi accident, the German government decided to reassess the risks posed by nuclear energy. On 30 May 2011, the German Cabinet announced that it was accelerating the nuclear phase-out by permanently shutting down the seven oldest reactors, plus the Krümmel NPP. The remaining nine reactors are to be permanently shut down no later than the end of 2022 in the following order: Grafenrheinfeld by the end of 2015; Gundremmingen B by the end of 2017; Philippsburg 2 by the end of 2019; Grohnde, Gundremmingen C and Brokdorf by the end of 2021, and the three most recently built facilities – Isar 2, Emsland and Neckarwestheim – by the end of 2022. With reduced nuclear generating capacity, renewable energy sources are being added at a rapid rate, but it has also been necessary to increase the use of coal-fired plants, which in turn increases greenhouse gas emissions.

In **Hungary**, four operational VVER reactors at the Paks NPP (1.9 GWe net) accounted for over 51% electricity generation at the end of 2014. A programme of power uprates and service lifetime extension continued, with an important milestone achieved in November 2014 when a licence for extended operation (further 20 years) was issued for unit 2. In January 2014, Hungary signed an intergovernmental agreement with Russia. The agreement covers the design, construction and commissioning of two new nuclear units (1.2 GWe each), the supply of nuclear fuel and the return of the spent fuel to Russia. Rosatom, the Russian nuclear state authority, will be in charge of the implementation of the design and construction works. The financial contract was elaborated by the stakeholders and cover the state-loan and investment details. The contract was approved by the Parliament in July 2014, with the following conditions: 80% of the investment will be covered by a state-loan of EUR 10 billion to be provided by Russia, while 20% will be covered by Hungarian resources, due at the end of the project. In 2015, the EU launched an investigation into the 2014 procurement agreement for Rosatom to supply two new units for the Paks nuclear power plant.

In **Italy**, processes to bring about the removal of a 20-year ban on nuclear power and install up to 13 GWe of nuclear power generating capacity by 2030 came to an abrupt end in 2011 following the Fukushima Daiichi accident. Immediately after the accident, the government declared a one-year moratorium on nuclear development plans in order to reconsider the energy strategy following stress tests conducted by the European Commission (EC). However, results of a referendum in June 2011 firmly rejected the government’s proposed nuclear development plans. Italy is heavily reliant on imported fuels to meet over 85% of its energy needs, has high electricity prices and is subject to occasional electricity shortages. The referendum result does not, however, restrict ongoing work on the disposal of radioactive waste, including the development of a national repository.

In **Lithuania**, the Ignalina 2 reactor was shut down at the end of 2009 in accordance with agreements governing entry into the EU (Ignalina 1 had been shut down in 2004 for the same reason). The closure of these reactors significantly reduced domestic electricity generation. Following the election of a new coalition government in 2012, led by a party that had opposed the construction of the proposed Visaginas NPP on economic grounds, prospects for a new nuclear plant diminished. However, the new government has stated that such an important decision should be made only after detailed economic study and discussions have continued with the potential strategic investor, Hitachi-GE. A final investment decision on a proposal to build a 1.35 GWe advanced boiling water reactor, with Hitachi-GE holding a 20% share in the project (along with Lithuania 38%, Estonia 22% and Latvia 20%), is still expected. With no nuclear generating capacity, Lithuania relies heavily on imports, in particular natural gas from Russia.

In the **Netherlands**, the single operational reactor (0.5 GWe net) supplied 3.5% of domestically generated electricity in 2014. In 2011, the government issued a list of conditions that must be met to build a new NPP, including that the reactor design and safety levels meet the highest standards (e.g. withstanding an airplane crash) and that the plant owner be responsible for dealing with waste and decommissioning, as well as posting financial guarantees to do so. Companies had originally expressed an interest in building a new unit at the existing Borssele site, but in 2012 prospective investors Delta (in partnership with EDF) and RWE Group announced that such plans had been put on hold for at least a few years owing to the financial crisis, the size of the investment required, as well as current overcapacity in the electricity market.

In **Poland**, where coal-fired plants currently generate more than 90% of domestic electricity, the government continues to advance plans to construct about 6 GWe of new nuclear power generation in the next 20 years. A consortium led by state-owned Polska Grupa Energetyczna (PGE, the Polish Energy Group), the largest power supplier in the country, has been put in charge of organising the project. The legal framework for the development of nuclear power was established in 2011 and the Council of Ministers instructed the Ministry of Economy to prepare a new national strategy concerning radioactive waste and spent fuel management. In 2015, Poland's state PGE notified the Ministry of Economy that a contract for difference, similar to that adopted by the United Kingdom for Hinkley Point C, was the best way to encourage nuclear investment because of its capital-intensive nature. Poland's two new reactors are now planned to be online in 2029 and 2035.

In **Romania**, the two CANDU reactors at the Cernavoda NPP provided 18.4% of the electricity generated in the country in 2014. Facing the coming retirement of as much as one-third of non-nuclear electricity generating capacity, the government developed plans to expand nuclear generating capacity by adding two more units by 2035. A tender for the construction of Cernavoda units 3 and 4 (each with a capacity of 0.72 GWe) was launched. In June 2013, the government announced the partial privatisation of the state-owned nuclear power corporation, Societatea Nationala Nuclearelectrica. In 2015, China General Nuclear has been designated as the selected investor for the construction of the third and fourth CANDU units. A letter of intent has been signed. Nuclearelectrica has also announced plans to refurbish unit 1 of Cernavoda NPP in order to extend the lifetime operation.

In the **Slovak Republic**, a total of four reactors with a combined capacity of 1.8 GWe net were operational as of 1 January 2015. In 2014, the reactors provided 57% of the total electricity generated in the country. Fuel with higher enrichment (4.87% ^{235}U) has been used in the Mochovce reactors since 2011 and in the Bohunice units since 2012. The completion of the construction of two additional units at the Mochovce NPP has been delayed as a result of design safety improvements and technology updates. The new units are now expected to be in operation in late 2016 (unit 3) and 2017 (unit 4), respectively. When in operation, the new units will add 0.9 GWe of electrical generating capacity to the grid. Discussions with several NPP vendors were reportedly ongoing for the construction of a single large reactor at Bohunice. The government of the Slovak Republic supports the construction of NPPs as part of a plan to increase the security of energy supply.

In **Slovenia**, the single nuclear reactor in operation (Krško, 0.70 GWe) is jointly owned and operated with Croatia by Nuklearna Elektrana Krško (NEK). The Krško reactor began commercial operation in 1983 and was recently granted a 20-year lifetime extension to 2043. The single unit accounted for 37% of the electricity generated in Slovenia in 2014, although a proportion of this is exported to meet about 20% of Croatia's electricity requirements. The Slovenian government had been considering the construction of a second unit by 2025, subject to parliamentary approval and a possible referendum, but the plan was put on hold following the effects of the financial crisis.

In **Spain**, eight operational reactors provided about 20.4% of the total domestically generated electricity in 2014. The Spanish government supports a balanced electricity mix that takes into account all energy sources and available capacities. In addition, it notes that since nuclear energy contributes both to the diversification of energy supply and the reduction of greenhouse emissions, it cannot be disregarded when the reactors are in compliance with nuclear safety and radiological protection requirements enforced by the Nuclear Safety Council. Through 2010 and 2011, the Spanish government approved ten-year licence extensions for Ascó units 1 and 2, Almaraz units 1 and 2, Vandellós unit 2 and the Lone Cofrentes unit. In 2014, the Trillo NPP received its renewal for operation until 2024. In July 2013, the definitive shutdown of the Santa Maria de Garona NPP was declared by ministerial order. As this declaration was not motivated by safety reasons, in May 2014, the licence holder applied for a renewal of the operating licence until 2031. This renewal is subject to a favourable report by the Nuclear Safety Council.

In **Sweden**, ten operational reactors (a total of 9.5 GWe net) generated over 41% of domestic electricity supply in 2014. Following the Fukushima Daiichi accident, the government ordered a comprehensive review of the current reactor fleet ahead of the EU stress tests. Nationally owned Vattenfall, the largest Nordic utility, filed an application to build up to two reactors to replace its older units in 2012, at the same time noting that an investment decision would not be made for a number of years. In 2013, Vattenfall announced that it is planning to invest USD 2.4 billion between 2013 and 2017 to modernise and upgrade its five most recently built units (Ringhals 3, 4 and Forsmark 1-3) in order to continue operations for up to 60 years. The results of the election in September 2014 brought to an end the possibility of constructing replacement reactors at existing sites, when a new coalition government set up an energy commission to drive the country towards total reliance on renewable energy sources. Also, in response to the proposed 17% increase in taxes from 2015, the operators of the NPPs said that older plants may have to be shut down earlier than expected because the increased taxes, along with demanding and costly post-Fukushima safety upgrades, reduce profitability.

In the **United Kingdom**, 16 operational reactors with a combined capacity of 9.2 GWe (net) as of 1 January 2015 provided about 17% of total domestic electricity generation in 2014. The UK fleet is comparatively old and operators have stated that they expect up to 7.4 GWe of existing nuclear capacity to close by 2019, although lifetime extension plans could extend operations of some reactors until 2023. The government has taken a series of actions to encourage nuclear new build. Industry has announced ambitions of adding up to 16 GWe of new nuclear generating capacity by 2025. New nuclear investments are expected to be part of the total estimated expenditure of GBP 75 billion in new power generation capacity needed by 2020. Three consortia – NNB Generation Company, a joint venture led by EDF, Horizon Nuclear Power (Hitachi-GE) and NuGen (GDF Suez and Iberdrola) – are currently making preparations for the construction of new units. Interest by Chinese, Korean and Russian vendors has also been reported. Among the existing consortia, NNB GenCo has made the most progress, having received regulatory approval (a site licence, environmental permits and a generic design assessment of its EPR reactor design). The government has made clear that investments in new nuclear build will not be subsidised by government. It has, however, made changes to the energy market in order to encourage the installation of low-carbon energy sources such as nuclear power. One important part of the reformed energy market is long-term guaranteed prices for low-carbon power generation in order to reduce uncertainties associated with such investments. Negotiations between the NNB GenCo and the government over the guaranteed price (referred to as a contract for difference or "strike price") were finalised in October 2013, improving prospects of new build. In October 2014, the European Union decided that UK plans to support the construction and operation of the project were in line with EU state aid rules.

The reactor-related uranium requirements for the EU amounted to about 17 320 tU as of 1 January 2015.

North America

At the beginning of 2015, a total of 99 reactors were connected to the grid in the United States, 19 in Canada and 2 in Mexico. Abundant supplies of low-cost natural gas and competition from subsidised renewable energy sources currently limit prospects for growth in nuclear generating capacity in this region.

In **Canada**, nuclear energy provided about 17% of the country's electricity needs in 2014 (over 60% in Ontario) and should continue to play an important role in the future. Canada has a fleet of 22 CANDU PHWR reactors, of which 19 are currently in full commercial operation (18 in Ontario and 1 in New Brunswick). Bruce Power announced an agreement with the Independent Electricity System Operator to refurbish six of its eight reactors in Ontario at Bruce Generating Station, assuming all costs and overruns for guaranteed electricity prices. The agreement and resulting upgrades will allow the plants to operate until the 2060s. The provincial government of Ontario is also planning the refurbishment of four Darlington units, adding 25-30 years to their operational life.

In **Mexico**, the two units at Laguna Verde NPP (a total of 1.4 GWe net) typically provide about 4% of the electricity generated in the country. It was reported in 2012 that the Energy Minister supported the addition of two new units at Laguna Verde as part of the strategic energy plan to meet rising demand and reduce carbon emissions. Since the election of a new coalition government later that year, focus has shifted to liberalising the state-run oil industry. No plan to add additional nuclear generating capacity has been announced, although it has been reported that the government is still considering adding more units in the longer term.

In the **United States**, 99 reactors were operational on 1 January 2015, contributing about 20% of the total electricity generated in the country. The construction of two AP-1000 reactors began in early 2013, one each at Vogtle (Georgia) and Virgil C. Summer (South Carolina), the initial phase of a plan to have two reactors in operation at each site by 2020. The Tennessee Valley Authority (TVA) continues the work towards the completion of the Watts Bar 2 reactor, a construction project resumed in 2007 after being halted in 1988. In 2015, Watts Bar 2 reactor began loading fuel in preparation for start-up in early 2016. The US Nuclear Regulatory Commission (NRC) regulations do not limit the number of licence renewals and the industry is reportedly preparing applications for continued operation beyond 60 years. However, low natural gas prices and subsidised renewable generating sources led to announcements in 2013 of the closure of two reactors on economic grounds (Kewaunee in Wisconsin and Vermont Yankee in Vermont). Three other reactors were permanently shut down in 2013 owing to technical issues (San Onofre 2 and 3 in California and Crystal River 3 in Florida). In September 2015, the NRC renewed the operating licences of TVA's Sequoyah 1 and 2 units from 2020-2021 to 2040-2041, bringing the 20-year licence extensions total to 78, with 16 further units under review. The possibility of additional 20-year extensions, to a total of 80 years, is being discussed. However, Entergy announced in 2015 that it will shut down the Fitzpatrick and Pilgrim plants before the end of their licences. Exelon's plants in Illinois cleared capacity auctions through 2018, but their continued operation beyond that point remains uncertain.

Annual uranium requirements for North America were about 20 565 tU as of 1 January 2015.

East Asia

As of 1 January 2015, 94 reactors[2] were operational in East Asia (83.4 GWe net). In 2013 and 2014, six new reactors in China were connected to the grid and two reactors in Japan were definitively shut down. During these same two years, construction of a total of 4 reactors was initiated, bringing the regional total to 33 reactors under construction in East Asia as of 1 January 2015. Prospects for nuclear growth are greater there than in any other region of the world, principally driven by rapid growth underway in China. However, political developments and public dissent in Japan and Korea could limit somewhat the overall expected growth in the region.

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[2] There were also six NPPs in operation in Chinese Taipei (about 5.0 GWe net) and two plants under construction (about 2.6 GWe net).

In **China**, 23 operational reactors (20.3 GWe) provided about 2.4% of national electricity production in 2014 and a total of 26 reactors were under construction (about 25.7 GWe net) as of 1 January 2015. The government plans to add significant nuclear generating capacity in order to meet rising energy demand and limit greenhouse gas and other atmospheric emissions since poor air quality, mainly due to emissions from coal-fired plants, is a significant health issue. At the end of 2014, China's State Council approved the Energy Development Strategy Action Plan that confirms the target of 58 GWe of nuclear capacity in 2020. China is moving ahead with the planning and construction of new nuclear power plants and the development of its own Gen III technologies. China has also increased efforts to export these and other designs. Chinese companies signed contracts with Argentina and Romania to work towards the construction of heavy-water reactors in these two countries. Three new reactors were connected to the grid in China during 2014 (Ningde 2, Fuqing 1 and Fangjiashan 1). However, the year 2014 saw no construction starts in China. In March 2015, the government granted authorisation for units 5 and 6 at Hongyanhe, and China General Nuclear hopes to bring both units online by 2021. Hongyanhe 5 and 6 use China's indigenous ACPR-1000 design and together constitute the second phase of the Hongyanhe nuclear power plant. In May 2015, construction began for unit 5 at the Fuqing nuclear power plant, which uses the nation's indigenous Hualong 1 reactor design. The milestone marks the first time China has begun construction of a reactor that uses the Hualong 1 design, which was jointly developed by China National Nuclear Power Corporation and China General Nuclear Power Group. China has full intellectual property rights to Hualong 1, which opens up the possibility of reactor export to other countries (e.g. Pakistan and Argentina).

In **Japan**, following the serious accident, four Fukushima Daiichi reactors (units 1-4) were permanently shut down and units 5 and 6 were taken out of service before being permanently retired in late 2013. The remaining 48 reactors in the country were progressively taken offline for mandatory maintenance outages. As of September 2013, the entire fleet was idled until permission to restart was granted in accordance with a new, more stringent regulatory regime. The Japanese Nuclear Regulation Authority was established as the new independent regulator, and new regulations for reactor restarts came into force in July 2013, leading a number of utilities to apply to restart reactors. With most NPPs out of service, Japanese utilities have been importing large amounts of oil and natural gas for electricity generation, driving electricity prices and greenhouse emissions upward. The initial government response after the accident included consideration of a complete exit from the nuclear power programme. Following the 2012 general election and the formation of a new government, however, a new energy plan was formulated in 2014. The energy plan outlined the importance of nuclear energy, provided safety could be assured, founded on energy security, and the economic and environmental benefits of the technology. Reactor restarts and rejuvenation of the industry is however proving to be challenging given the stringent new regulatory requirements and public resistance. Nevertheless, the finalisation in 2015 of a new long-term energy policy that envisions nuclear power representing 20-22% of total energy supply in 2030 represents an important step for a sustained nuclear comeback. In addition, the restart of Kyushu Electric Power Company's Sendai 1 and 2 reactors in August and October 2015 was a major achievement for the Japanese nuclear industry.

In **Korea**, 23 operational units produced about 30% of the total electricity generated in 2014. Construction of five reactors is underway. The government decided to shut down Kori 1, the first commercial NPP to start operation in 1978. Kori 1 will operate until June 2017. Wolseong 1, the first CANDU reactor in Korea, obtained a long-term operation grant for ten additional years from its expiration in 2012 to continue operation to 2022. Shin-Wolsong 2 began full power operations in July 2015. The Ministry of Trade, Industry and Energy announced its seventh "Basic Plan for Long-term Electricity Supply and Demand", covering the period until 2029, which calls for an increase of 16 nuclear reactors by 2029, reaching a total of 39 reactors. According to this plan, the Korean government will cancel the building of four coal-fired power plants and will boost its nuclear reactor fleet, looking to increase the share of nuclear energy up to 28.5% in power generation.

Although **Mongolia** does not currently have nuclear generating capacity, it has signalled its interest in the use of small and medium-sized reactors after signing an agreement with Russia on the exploration, extraction and processing of uranium resources.

The reactor-related uranium requirements for the East Asia region were 9 575 tU as of 1 January 2015.

Europe (non-EU)

As of 1 January 2015, 54 reactors were operational in 4 countries. This region is also undergoing strong growth with 13 reactors under construction. During 2013 and 2014, one new plant was connected to the grid in Russia, and construction was initiated on two reactors in Belarus. Several countries in this region continue to support nuclear power and overall growth in nuclear generating capacity is expected.

Albania had been considering the construction of new NPPs, but in 2012 it was reported that it had postponed its new build plans to consider all potential environmental impacts in light of the Fukushima Daiichi accident.

In **Armenia**, the single operational reactor (Armenia 2, 0.4 GWe) provided 30% of the electricity generated in the country in 2014. It was reported that following an intergovernmental agreement, Rosatom will finance the extended operation of the reactor. According to the Armenian energy sector development plan, construction of one new unit (1 GWe) is envisaged by 2026. The Ministry of Energy and Natural Resources released in 2011 an environmental assessment of the new build project.

In **Belarus**, a USD 10 billion agreement was signed with Atomstroyexport in 2012 to build the country's first NPP, consisting of two VVER-1200 reactors, with expected completion dates by 2020-2025. It was reported that Russia would extend a loan to Belarus for construction costs.

In **Russia**, 33 operational reactors (25.2 GWe net) provided about 17% of the total electricity generated in the country in 2014. Rostov unit 3 (1 GWe) was connected to the grid at the end of 2014, and it reached 100% of its capacity in mid-July 2015. The BN-800 sodium-cooled reactor at the Beloyarsk NPP was connected to the electric grid in December 2015. Following a safety review after the Fukushima Daiichi accident, the government continued with the implementation of a 2010 national energy strategy that envisioned the commissioning of a total of 26 new reactors along with the development and integration of fast neutron reactors to close the nuclear fuel cycle. In addition to an active domestic programme, the state-run energy company Rosatom is adding a portfolio of building contracts in several countries (e.g. Bangladesh, China, India, Turkey, Viet Nam) through active participation in numerous tenders for new build projects using its build, own, operate (BOO) model, supplemented by possibilities for loans to fund the projects, lifetime fuel supply and spent fuel take-back. A technological solution was developed to resolve graphite stack problems in RBMK reactors that could have led to the early closure of some units and to repairs for all of the 11 reactors of this type in operation. Plans to start the construction of three BN-1200 sodium fast neutron reactors by 2030 were announced.

In **Switzerland**, proposals to build three reactors to replace plants that have reached the end of their operational lifetime were abruptly terminated following the Fukushima Daiichi accident. The government suspended the approval process for replacement reactors and ordered a safety review of the existing five operational reactors. Later in the year, Cabinet proposed that all five existing reactors be shut down at the end of 50 years of operation (i.e. between 2019 and 2034). After a thorough review (EU stress tests plus its own test programme), the national safety authority concluded that since the cooling of the core and fuel rod storage pools would remain operational in the event of an earthquake followed by flooding, the power plants could remain in service. The five operating reactors in Switzerland typically produce about 35-40% of the electricity generated in the country. To ensure that Switzerland has a competitive and safe supply of electricity, a phased transformation of the energy system has been planned. A reduction of energy and electricity consumption, combined with an increased share of renewable energy sources and the introduction of combined heat and power fossil fuel plants is planned to fill the gap created by the phase-out of nuclear power. Modernisation and enlargement of the electricity grid is also considered necessary to accommodate increased input from variable renewable energy sources.

In **Turkey**, the government continues to advance its nuclear development programme as its fast growing economy faces rapidly escalating electricity demand. An intergovernmental agreement (IGA) signed with Russia for the construction of four VVER-1200 units at the Mediterranean Akkuyu site on the BOO model entered into force in July 2010. Under the terms of the IGA, Russia will retain the majority share of ownership of the power plant during the entire lifetime of operation and will provide fuel supply, take back spent fuel for reprocessing, train personnel and decommission the facility. The energy market regulator announced in June 2015 that it had granted a pre-licence to Akkuyu Nuclear to complete preparation for its first nuclear power plant. The regulatory authority will consider a final production licence once the preparation process is complete. In April 2015, Turkey's Parliament voted to ratify an agreement with Japan's government, along with a commercial agreement for the construction of a four-reactor nuclear power plant at the Sinop site, which could become the nation's second nuclear power plant. Under the agreement, four Mitsubishi and Areva ATMEA 1 reactors could be built with a combined capacity of approximately 4.4 GWe. The project is being developed by a consortium that includes Mitsubishi Heavy Industries, Itochu Corporation, GDF Suez, Areva, and the Turkish government-owned utility EÜAŞ. Now that Turkey's Parliament has approved the project, the consortium will move forward with a feasibility study.

In **Ukraine**, 15 reactors with a combined installed capacity of 13.8 GWe net were operational on 1 January 2015, producing 49% of the electricity generated in the country in 2014. The national energy programme foresees that nuclear energy will continue to generate 45% of total electricity production by 2030. Achieving this target will require a combination of lifetime extensions of existing reactors, the construction of 12 additional units (with 10 of these new units having a gross capacity of 1.5 GWe) and the decommissioning of 12 reactors at the end of their operational lifetime. Two reactors are under construction (Khmelnitski 3 and 4). Construction of these two reactors originally began in the mid-1980s, but was suspended in 1989. The agreement reportedly involved Russia providing finances for the design, construction and commissioning of the two reactors. However, work on the reactors has ceased and the Ukrainian government is preparing to cancel the construction contract. In 2013, the European Bank for Reconstruction and Development backed a EUR 300 million loan in support of a safety upgrade programme for all operating reactors in Ukraine. The total cost of the programme is estimated to amount to EUR 1.4 billion, to which Euratom will contribute EUR 300 million.

Reactor-related uranium requirements for the Europe (non-EU) region amount to about 7 195 tU as of 1 January 2015.

Middle East, Central and Southern Asia

As of 1 January 2015, 25 reactors were operational in this region and 11 were under construction. Growth in nuclear generating capacity in this region is expected in the coming years as governments continue to work towards implementing plans to meet rising electricity demand without increasing greenhouse gas emissions.

In **Bangladesh**, Cabinet ratified a deal with Rosatom in 2012 to build two 1 GWe reactors at the Rooppur site. Under the terms of the agreement, Russia will reportedly provide support for construction and infrastructure development, supply fuel for the entire lifetime of the reactors and take back spent fuel. Loans from Russia will also finance 90% of the estimated plant cost. Construction is expected to begin in 2017, with a target date of 2025-2030 for first electricity generation. Site works started in 2013.

In **India**, 21 reactors (5.3 GWe net) were operational on 1 January 2015, providing about 3.5% of domestic electricity generation in 2014. Agreements in 2008 that granted India the ability to import uranium and nuclear technology have resulted in improved reactor performance through adequate uranium supply. However, concerns about the nuclear liability legislation have slowed the development of agreements on imported technology. Construction of four pressurised heavy-water reactors (Kakrapar Atomic Power Project [KAPP] 3 and 4, 0.7 GWe and the Rajasthan Atomic Power Project [RAPP] 7 and 8, 0.7 GWe), one light-water reactor (Kudankulam nuclear power plant [KKNPP] 2, 1 GWe) and one prototype fast breeder (0.5 GWe) is in progress. According to the government, total nuclear power generating capacity is expected to grow to about 9.4 GWe by 2017 as projects under construction are progressively completed. In April 2015, India announced that it signed two agreements with Areva in support of the proposed Jaitapur nuclear power plant, where six EPRs could be built. Areva and Nuclear Power Corporation of India Ltd (NPCIL) signed a pre-engineering agreement that includes preparation of the EPR for licensing in India. Early in 2015, India began design work for an indigenous 0.9 GWe light-water reactor. Nuclear Power Corporation of India Ltd and the Bhabha Atomic Research Center are working together to develop light-water reactor technology.

In the **Islamic Republic of Iran**, commissioning of the Bushehr-1 reactor (about 0.9 GWe net) supplied by Atomstroyexport took place in 2011. The reactor reached full capacity in January 2013 and in September that year the two-year handover process from the Russian constructor to the Iranian customer began. The Iranian government plans to develop up to 8 GWe net of installed nuclear capacity by 2030 in order to reduce its reliance on fossil fuels, beginning with the installation of three more units at Bushehr. It has reportedly been in discussions with Russia to expand co-operation and engaged in identifying potential sites for additional reactors. In February 2013, the Atomic Energy Organisation of Iran announced that it had designated 16 new sites for NPPs in coastal areas of the Caspian Sea and the Persian Gulf, as well as in south-western and north-western regions of the country. It was reported in 2015 that China is also expected to construct two nuclear power plants in Iran.

In **Jordan**, a plan to construct two reactors to generate electricity and desalinate water, along with development of the country's uranium resources, has been moving forward since as early as 2004, driven by rising energy demand and the current need to import around 95% of its energy needs. The situation has worsened in recent years as natural gas supply has become less reliable owing to regional geopolitical turmoil. Nuclear co-operation agreements have been signed with several countries, including Argentina, Canada, France, Japan, Russia, the United Kingdom and the United States. In October 2013, Jordan announced that Russia would be the supplier of two nuclear units. Rosatom Overseas will contribute 49.9% of the project's cost (about USD 10 billion), with the state-owned Jordan Nuclear Power Co (JNPC) controlling 50.1%. The plant was to be provided on a BOO basis. In September 2015, Jordan Atomic Energy Commission (JAEC) reported that it was negotiating with China National Nuclear Corporation (CNNC) to finance not less than 50% of the construction project, though the main nuclear island would use Russian technology. JAEC suggested that a final split of share capital in the plant might be Jordan 35%, Russia 35% and China 30%. Rosatom will supply all the fuel and take back the used fuel.

As of 2015, **Kazakhstan** has no active nuclear power generation capacity. In 2013, it was reported that the political decision to install nuclear generating capacity had been taken and the most likely location for the facility is in the western region of Aktau on the Caspian coast, site of the past NPP operation between 1973 and 1999. In May 2014, Russia and Kazakhstan signed a preliminary co-operation agreement regarding the construction of a new nuclear power plant with a generating capacity of between 300 and 1 200 MWe.

In **Pakistan**, three reactors (0.69 GWe net) were operational on 1 January 2015, supplying 4.3% of domestic electricity production in 2014. The Chasnupp 2 reactor (0.3 GWe net), completed under an agreement with the CNNC and placed under IAEA safeguards, was added to the grid in 2011. In the face of severe power shortages, the government of Pakistan began construction of two additional units (Chasnupp 3 and 4, 0.3 GWe each) later in 2011 with financial and technical assistance from China. These two units are expected to be completed by 2020. As part of an effort to address chronic power shortages, a growing population and increasing electricity demand, the government established the Energy Security Action Plan with a target to install additional nuclear generating capacity by 2030. In mid-2013, it was reported that the government had signed contracts for the construction of two ACP-1000 reactors supplied by the CNNC to be built at the coastal Karachi site. This contract has been challenged as lying outside norms established by the Nuclear Suppliers Group, but China declared that the arrangement is for peaceful purposes and within the IAEA safeguard regime. In April 2015, China Energy Engineering Group Co. (CEEC) won the tender for civil engineering construction and installation work for the conventional island of the plant. In the light of its inability to buy uranium on the open market, Pakistan has agreed that China will provide the lifetime fuel supply for the reactors (60 years). The Pakistan Nuclear Regulatory Authority has received the safety analysis of China's ACP-1000 reactor from CNNC and is expected to take at least a year to complete the review before granting a construction licence.

In the **United Arab Emirates**, a consortium from Korea led by the Korea Electric Power Company (KEPCO) won a contract in 2009 to build four APR-1400 reactors (a total of 5.4 GWe net). The contract reportedly includes provisions that require the KEPCO consortium to hold an equity interest in the facility, assist in the design, operation and maintenance of the reactors, provide training and education, as well as initial fuel loads for all four units. Construction of the first and second units (Barakah 1, 2) officially began in 2012 and 2013, respectively. Work is reportedly on track for the completion of Barakah 1 in 2017, with the other three reactors scheduled to be completed in successive years. Emirates Nuclear Energy Corporation (ENEC) has stated in January 2015 that construction remains on schedule for the country's nuclear power programme. Unit 1 at Barakah is now more than 60% complete. ENEC also stated that it completed construction on the concrete dome for the reactor containment building of Barakah 1. When all units are in operation, the Barakah NPP is expected to produce about 25% of national electricity requirements. Increasing energy demand, combined with policies to reduce greenhouse gas emissions and domestic consumption of natural gas in order to maintain the inflow of foreign capital through exports, were central considerations in the government's decision to develop the Barakah NPP.

In 2012, it was reported that **Saudi Arabia** planned to build as many as 16 reactors with 22 GWe installed capacity by 2030 in order to meet rising electricity demand and reduce oil exports. In early 2013, the government endorsed a nuclear energy pact signed in 2011 with France to contribute to the development of technical skills and personnel development, as well as the use and transfer of knowledge of the peaceful uses of nuclear energy. In January 2015, it was reported that the nation's plans to develop nuclear energy will take longer than previously expected. The government and other stakeholders have revised their outlook with the expectation that the planned nuclear capacity will come online by 2040.

Other countries in the region, currently without NPPs, have been considering the development of such facilities, including **Bahrain**, **Iraq**, **Israel**, **Kuwait**, **Oman**, **Qatar** and **Yemen**.

Reactor-related uranium requirements for the Middle East, Central and Southern Asia region were about 1 120 tU as of 1 January 2015.

Central and South America

As of 1 January 2015, a total of five reactors were operational in two countries and two reactors were under construction. Governments in Argentina and Brazil continue to support nuclear power, suggesting growth in nuclear generating capacity in the long term, despite other countries in the region reportedly turning away from plans to install nuclear generating capacity following the Fukushima Daiichi accident.

In **Argentina**, three reactors were operational on 1 January 2015, accounting for 4.1% of domestic electricity production in 2014. In 2006, the state generating company Nucleoeléctrica Argentina restarted construction of Atucha 2 (0.75 GWe net), a Siemens heavy-water reactor design unique to Argentina. The unit began generating electricity at the end of 2014. In addition, the CNEA is completing the development and construction of the CAREM-25 (25 MWe), a small locally designed power reactor, and is planning to build other larger units by 2032. Argentina's government is also considering the initiation of construction of the fourth nuclear power plant (PHWR-type reactors) by 2020-2022. Two other reactors (PWR-type) are planned to start operations by 2024-2028. High-level agreements were signed by the government with China and Russia for the construction of new reactors in Argentina. In support of the national nuclear development plan, initiatives are underway to extend the life of Embalse and Atucha 1 reactors.

In **Brazil**, two reactors (Angra 1 and 2, 0.5 GWe net and 1.3 GWe net, respectively) were operational on 1 January 2015, providing about 3% of the electricity generated in the country in 2014. Construction of the Angra-3 reactor (1.2 GWe net) was restarted in 2010. Work on this reactor originally began in 1984, but was suspended in 1986. The national long-term electricity supply plan includes a total of 4 GWe nuclear generating capacity installed by 2030 in order to help meet rising energy demand. In 2013, it was announced that USD 150 million would be invested in strengthening safety measures at the two existing units in a programme referred to as the Fukushima Response Plan.

Other countries in the region, currently without NPPs, have been considering the development of such facilities, including **Bolivia**, **Chile**, **Cuba**, **Uruguay** and **Venezuela**. Given the risk of strong seismic events in **Chile**, the government is reconsidering nuclear development plans while observing the response of the Japanese authorities to the Fukushima Daiichi accident. **Venezuela** has also put its nuclear development plans on hold. Legislation in **Uruguay** promotes development of renewable energy sources, for the time being putting nuclear development plans on hold.

The uranium requirements for Central and South America amount to about 520 tU as of 1 January 2015.

Africa

Nuclear capacity remained constant in Africa with the region's only two operational reactors located in South Africa. Government plans to increase nuclear generating capacity are projected to drive growth in this region, but no construction activities have been initiated. Although several countries are considering adding NPPs to the generation mix to help meet rising electricity demand, development of the required infrastructure and human resources could delay these ambitions.

In **South Africa**, two operational units (a total of 1.8 GWe net) accounted for about 5% of the total electricity generated in the country in 2014. Coal-fired plants dominate current electricity generation, accounting for about 90% of generating capacity. In order to meet electricity demand, avoid additional power shortages and reduce carbon emissions, South Africa solicited bids for a fleet of up to 12 reactors in 2007, but the process was put on hold owing to the financial crisis. In 2010, the South African government approved the Integrated Resources Plan that sees nuclear generating capacity increasing from 1.8 GWe today to 9.6 GWe by 2030, with the first units online by 2023. In 2013, the government signed an agreement with the EU to co-operate in the supply of nuclear and non-nuclear materials, equipment and technologies associated with civil nuclear power. South Africa currently plans to build six new nuclear plants by 2030 at an estimated cost of between USD 32 billion and USD 80 billion. In 2015, it was reported that the country is planning for a 9.6 GWe nuclear fleet expansion, with reactors from Rosatom and Westinghouse being considered.

Although no other countries in Africa have NPPs at this time, several have expressed interest in developing nuclear power for electricity generation and desalination in recent years, including **Algeria**, **Egypt**, **Ghana**, **Kenya**, **Morocco**, **Namibia**, **Niger**, **Nigeria**, **Tunisia** and **Uganda**. Both **Egypt** and **Nigeria** reaffirmed plans to install nuclear generating capacity in the long term after the Fukushima Daiichi accident. In 2012, a commission to co-ordinate and promote the development of nuclear energy in Africa established by the African Union became fully operational. South Africa has agreed to host the African Commission on Nuclear Energy (Afcone) in Pretoria.

Annual reactor-related uranium requirements for Africa amounted to about 290 tU as of 1 January 2015.

South-eastern Asia

No reactors were operational in this region at the end of 2014, but several countries are considering nuclear development plans, suggesting growth in nuclear generating capacity in the longer term as the region continues to experience strong economic growth. Concerns about climate change, security of energy supply and energy mix diversification along with volatile fossil fuel prices are driving nuclear development policies, but political support has generally been weak (except in Viet Nam) owing to public safety and cost concerns. Moreover, public confidence in nuclear power has been undermined by the Fukushima Daiichi accident.

In **Malaysia**, since the decision to develop a national nuclear policy in 2008, the government established the Malaysian Nuclear Power Corporation in late 2011 to plan and co-ordinate the implementation of a nuclear energy development programme. Driven by an emerging gap in electricity production and the need to diversify the energy mix, a target of 2 GWe of nuclear generating capacity was adopted, with the first unit to be operational by 2021. However, it was reported that the programme had fallen behind schedule as a result of public distrust following the Fukushima Daiichi accident. Nevertheless, work continues through efforts to promote public acceptance, adopt the necessary regulations, sign required international treaties and obtain low-cost financing.

In **Thailand**, the revision of the National Energy Policy Council scaled back the planned contribution from nuclear energy from 10% to 5% and set back the schedule for the installation of the first unit from 2020 to 2028. The postponements were implemented in order to ensure safety and improve public understanding of nuclear energy. Currently, Thailand relies on natural gas to generate over 70% of its electricity. Domestic fossil fuel energy reserves are in decline and electricity demand is expected to double by 2024. The Thailand Power Development Plan of 2010 called for the installation of a total of 5 GWe of nuclear generating capacity.

In **Viet Nam**, as a result of increasing electricity demand that already requires rationing, and with further shortages forecast by 2020, along with a reliance on hydro with little prospect for expansion and a shortage of fossil fuels, the government has established a master plan with a goal of nuclear power supplying as much as 25% of domestic electricity production by 2050. The first step in achieving this goal was made when the Ministry of Industry and Trade signed an agreement with Atomstroyexport in 2010 to construct the country's first NPP. This agreement covers two VVERs (1.0 GWe each) to be built at PhuocDinh in the NinhThuan province on a turnkey basis, the first of which is expected to be operational by 2030. A second agreement has reportedly been signed with a Japanese consortium for two units at VinhHai in the NinhThuan province, including finance and insurance for up to 85% of total costs. The potential bottleneck of an insufficient number of qualified personnel to operate and regulate the industry is being addressed with a USD 140 million budget for training, initially in Russia and Japan. In August 2013, it was announced that construction of a centre for nuclear science technology would be undertaken, funded by loans of up to USD 500 million from Russia to further accelerate training. The government has also launched an information campaign to better inform the public on nuclear power. In July 2015, Rosatom and Electricity of Vietnam signed a framework agreement for the construction of unit 1 at the proposed Ninh Thuan nuclear power plant. A total of four 1.2 GWe AES-2006 (VVER-1200) reactors are planned at the Ninh Thuan site. Russia has agreed to loan Viet Nam USD 8 billion to finance the project. In addition, Russia will supply all fuel required and will take back spent fuel.

The governments of **Indonesia**, the **Philippines** and **Singapore** have considered the use of nuclear power to help meet rising electricity demand despite recurring large-scale natural hazards.

Pacific

This region has no commercial nuclear capacity at present. Current policy prohibits the development of commercial nuclear energy in **Australia**. However, a new interest in nuclear power was prompted by the South Australian premier in February 2015 when it was announced that a Royal Commission would investigate South Australia's future role in the nuclear fuel cycle. The government of **New Zealand** also has a policy prohibiting the development of nuclear power but is reported to be considering options for future electricity supply in light of greenhouse gas reduction targets and declining supplies of natural gas.

Projected nuclear power capacity and related uranium requirements to 2035

Factors affecting capacity and uranium requirements

Reactor-related requirements for uranium over the short term are fundamentally determined by installed nuclear capacity, or more specifically by the number of kilowatt-hours of electricity generated in operating NPPs. Since the majority of the anticipated near-term capacity is already in operation or under construction, short-term requirements can be projected with greater certainty. However, both short-term and long-term requirements are much more challenging to project following the accident at the Fukushima Daiichi NPP.

Uranium demand is also directly influenced by changes in the performance of installed NPPs and fuel cycle facilities, even if the installed base capacity remains the same. Energy availability and capacity factors have increased to over 80% in the period 2000-2010 (IAEA, 2014). Increased availability tends to increase uranium requirements, but unexpected events in recent years have disrupted the trend of increasing availability factors. The world average availability factor declined to 78.7% in 2011 and further to 73.9% in the period 2012-2014 (IAEA, 2015b) following the Fukushima Daiichi accident that led to the Japanese nuclear fleet being taken offline pending safety checks. These reactors will not be restarted until applications from utilities are reviewed in light of new, more stringent safety requirements administered by the Japanese Nuclear Regulation Authority (NRA), a new independent regulatory body created in 2012. Once restarts are approved by the Japanese NRA, consent will also have to be received from local and national governments. Sendai 1 and 2 became the first two reactors to restart in Japan in 2015 under the new regulatory regime.

Other factors that affect uranium requirements include fuel cycle length, burn-up, improved fuel design, as well as strategies employed to optimise the relationship between the price of natural uranium and enrichment services[3]. Generally, increased uranium prices have provided an incentive for utilities to reduce uranium requirements by specifying lower tails assays at enrichment facilities, to the extent possible, in contracts and the ability of the enrichment facilities. Overcapacity in the enrichment market since the Fukushima Daiichi accident has provided incentive to operators to "underfeed" enrichment facilities by extracting more ^{235}U from the uranium feedstock. This reduces the amount of uranium required to produce contracted quantities of enriched uranium and, in turn, creates a stockpile of uranium. In recognition of these recent market trends, uranium requirements for the operational lifetime of projected new reactors in this publication have been reduced from 175 tU/GWe/yr, assuming a tails assay of 0.30% (2012 edition), to 160 tU/GWe/yr, assuming a tails assay of 0.25% (including first core requirements over the lifetime of the reactor). In the absence of data provided by governments, this uranium requirement factor has been applied in this edition of the Red Book.

Enrichment providers have indicated that they are considering re-enrichment of depleted uranium tails in modern centrifuge facilities as an economic means of creating additional fissile material suitable for use in civil nuclear reactors. In addition, technological development of laser enrichment led to an agreement in 2013 between the US Department of Energy (DOE) and Global Laser Enrichment to further develop the technology using a portion of the US inventory of high assay uranium tails (about 115 000 tonnes). Successful deployment of laser enrichment to re-enrich depleted uranium tails could bring a significant source of secondary supply to the uranium market in the mid-term, although technological hurdles remain to be overcome before commercial deployment can be achieved. Meanwhile, in 2015, Global Laser Enrichment announced plans to slow development of its laser enrichment technology owing to poor market conditions.

The combined impact of strategies to optimise reactor operation and fuel costs, as well as unanticipated reactor closures and the idling of reactors in Japan, are evident in the uranium requirements data collected for this edition, since global requirements have decreased from 60 715 in 2013 to 56 585 tU as of 1 January 2015. Uranium requirements (defined in the Red Book as anticipated acquisitions, not necessarily consumption) are, however, expected to increase in the coming years as the significant amount of capacity currently under construction comes online, particularly in Asia.

The strong performance and economic competitiveness of existing plants, chiefly because of low operating, maintenance and fuel costs, has made retention and improvement of existing plants desirable in many countries. This has resulted in a trend to keep existing plants operating as long as this can be achieved safely and upgrading existing generating capacity where possible. This strategy has been undertaken in the United States, and other countries have or are planning to upgrade their generating

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[3] A reduction of the enrichment tails assay from 0.3 to 0.25% ^{235}U would, all other factors being equal, reduce uranium demand by about 9.5% and increase enrichment demand by about 11%. The tails assay selected by the enrichment provider is dependent on many factors, including the ratio between natural uranium and enrichment prices.

capacities and/or extend the lives of existing NPPs (e.g. Canada, Hungary, Mexico, the Netherlands, the Slovak Republic and Russia). Competition from subsidised renewable energy sources and low natural gas prices as a result of technological advances in shale gas recovery have nevertheless recently rendered some plants uneconomic in liberalised energy markets in the United States, leading to shut downs before the end of the originally planned operational lifetime (e.g. Kewaunee and Vermont Yankee). Regulatory responses to the Fukushima Daiichi accident have also increased operating costs that may affect the competitiveness of other reactors, in particular the smaller, single units operating in liberalised markets in the United States.

Installation of new nuclear capacity will increase uranium requirements, particularly since first load fuel requirements are roughly some 60% higher than reloads for plants in operation, providing that new build capacity outweighs retirements. A wide range of factors must be taken into consideration before any new significant building programmes are undertaken. These factors include projected electricity demand, security and cost of fuel supplies, the cost of financing these capital-intensive projects, the competitiveness of nuclear power compared to other generation technologies and environmental considerations, such as greenhouse gas emission reduction targets. Proposed waste management strategies and non-proliferation concerns stemming from the relationship between the civil and military nuclear fuel cycles also must be addressed. Following the Fukushima Daiichi accident, public acceptance of the safety of nuclear energy will require greater attention and this remains a pivotal issue in the yet to be determined role that nuclear power will play in the coming years in Japan.

Declining electricity demand in several developed countries, the low cost of natural gas in the United States, competition from subsidised renewable energy sources in Europe and the United States and the challenge of raising the significant investment required for capital-intensive projects with lengthy regulatory approval and construction times like NPPs, has made nuclear power development generally more challenging, particularly in liberalised energy markets.

However, despite these challenges and the reaction of a few countries to back away from nuclear power following the Fukushima Daiichi accident (i.e. the strengthening of nuclear phase-out programmes in Belgium and Germany and the decision to not proceed with nuclear power development in Italy for at least five years following a national referendum), many countries have decided that, on balance, objective analysis of these factors supports development of nuclear power. This is particularly so in countries with growing air pollution issues like China and India where coal-fired generation presently provides the majority of electricity. Significant nuclear build programmes are underway in China and are continuing in India. Although the impacts of the global financial crisis have slowed the implementation of ambitious new build plans in some countries (e.g. South Africa), several other nations remain committed to long-term growth in nuclear generating capacity. Smaller scale programmes to increase nuclear generating capacity are underway in the Czech Republic and Finland, for example, while Poland continues to work towards construction of its first reactors. In the United States, despite the unexpected closure of five reactors, construction activities are underway on five reactors.

The 2015 *World Energy Outlook* (IEA, 2015) notes that global energy demand is set to grow by 32% from 2013 to 2040 in the central scenario (New Policies Scenario), driven primarily by India, China, Africa, the Middle East and Southeast Asia. Non-OECD countries account together for all the increase in global energy demand, as demographic and structural economic trends, allied with greater efficiency, reduce collective consumption in OECD countries. Declines are led by the EU, Japan and the United States (IEA, 2015). The success of policy measures proposed to reduce emissions in the face of rising demand hinges on the transition from fossil-fuelled to low-carbon generation sources. In the IEA New Policies Scenario, primary energy demand for all fuels will grow through to 2040. Of this growth, renewables account for 34%, natural gas for 31%, nuclear energy for 13%, oil for 12% and coal for 10%. Despite some positive signs that a low-carbon transition is underway, energy-related CO_2 emissions are projected in the New Policies Scenario to be 16% higher by 2040.

The extent to which nuclear energy is seen as beneficial in meeting greenhouse gas reduction targets could have an effect on the role that nuclear energy plays in meeting future electricity demand.

Projections to 2035[4]

Forecasts of installed capacity and uranium requirements, although uncertain because of the above-mentioned factors, continue to point to long-term growth. Installed nuclear capacity is projected to increase from about 377 GWe net at the beginning of 2015 to between about 418 GWe (low case) and 683 GWe (high case) by the year 2035. The low case[5] represents growth of about 11% from 2014 nuclear generating capacity, while the high case represents an increase of about 81% (see Table 2.3 and Figure 2.3). By 2020, low and high case scenario projections see increases of 5% and 20% respectively, indicating that significant expansion activities are already underway in several countries.

However, these projections are subject to uncertainty following the Fukushima Daiichi accident, since the role that nuclear power will play in the future generation mix in some countries has not yet been determined and China did not report official targets for nuclear power capacity beyond 2020 for this edition.

Although the low case installed nuclear capacity projection to 2025 has decreased by 8% compared to the last edition of this publication in 2014, the projection to 2035 increased slightly (4%). The low case scenario incorporates the current policy of the French government to reduce nuclear generation share of electricity production, strengthened phase-out policies in Belgium and Germany and reduced expectations of capacity additions or delays in nuclear projects in several countries (e.g. India, Korea, Romania, Sweden, Turkey and the United States). In Japan, installed nuclear capacity is projected to decline from 42.4 GWe in 2014 to about 7.6 GWe by 2035 as reactors are permanently shut down owing to a range of factors including location near active faults, technology, age and local political resistance.

The high case projection to 2025 has also declined by 10% compared to projections made in 2014, as policies concerning climate change mitigation are still unclear and financing is uncertain. Expectations of nuclear capacity additions in a number of countries (e.g. Argentina, Armenia, Brazil, the Czech Republic, Korea, Italy, Turkey, Ukraine, the United Kingdom and the United States) have been delayed or reduced. New safety requirements have in general strengthened the robustness of responses to extreme events and the costs of implementing these measures could reduce the competitiveness of nuclear power in some liberalised markets. However, the high case projection to 2035 increased slightly (about 4%) compared to the 2014 scenario, mainly because of higher nuclear capacity growth expectations for China by 2035. The high case

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[4] Projections of nuclear capacity and reactor-related uranium requirements are based on official responses from member countries to questionnaires circulated by the NEA/IAEA. For countries that did not provide this information, the NEA/IAEA relied on data from NEA *Nuclear Energy Data*, and projections established by an expert group (IAEA/NEA) and published in the IAEA *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050*. Because of the uncertainty in nuclear programmes in the years 2015 onward, high and low values are provided.

[5] The low case forecast assumes current market and technology trends continue with few additional changes in policies and regulations affecting nuclear power and includes implementation of phase-out or reduced nuclear generation policies. The high case assumes that current rates of economic and electricity demand growth continue. It also assumes changes in country policies towards the mitigation of climate change.

projection for Japan sees installed capacity staying about the same, as several reactors remain in service and ageing units are replaced by new reactors.

Nuclear capacity projections vary considerably from region to region. The East Asia region is projected to experience the largest increase that could result in the installation of between 48 GWe and 166 GWe of new capacity in the low and high cases, respectively, by the year 2035, representing increases of about 54% and 188% over 2014 capacity. While representing significant regional capacity increases, it is important to note that while the projections are based on recently revised nuclear development plans in Korea, China's new build programme beyond 2020 has yet to be clarified, in particular with respect to inland power plants. The regional projection also estimates that installed (not necessarily in operation) nuclear generating capacity in Japan by 2035 will be reduced by either 82% or will decrease slightly by about 2% from 2014 installed capacity in the low and high cases, respectively. Should either of these projections prove incorrect, significant regional and global capacity adjustments could result.

Nuclear capacity in non-EU member countries on the European continent is also projected to increase considerably, with between 21 and 45 GWe of capacity additions projected by 2035 (increases of about 49% and 105% over 2014 capacity, respectively). Other regions projected to experience significant nuclear capacity growth include the Middle East, Central and Southern Asia and South-eastern Asia regions, with more modest growth projected in Africa and the Central and South American regions.

For North America, the low case projection sees nuclear generating capacity remaining about the same by 2035 and an increase of 11% in the high case, depending largely on future electricity demand, lifetime extension of existing reactors and government policies with respect to greenhouse gas emissions. In the EU, nuclear capacity in 2035 is either projected to decrease by 48% in the low case scenario or increase by 2% in the high case. The low case projection includes the implementation of phase-out or reduced nuclear generation policies, continued subsidisation of intermittent renewable energy sources and weak growth in electricity demand. In the high case, phase-out policies are maintained, but plans for the installation of additional nuclear generation capacity are assumed to be successfully realised in the Czech Republic, Finland, Hungary, Romania, Poland and the United Kingdom.

World reactor-related uranium requirements by the year 2035 (assuming a tails assay of 0.25%) are projected to increase to a total of between 66 995 tU/yr in the low case and 104 740 tU/yr in the high case, representing increases of about 18% and 85%, respectively, compared with 2014 requirements (see Table 2.4 and Figure 2.4). As a result of a combination of reductions in installed nuclear capacity projections and the use of a lower uranium requirements figure in cases where governments do not provide this information (160 tU/GWe/yr compared to 175 and 163 tU/GWe/yr in previous editions), projected uranium requirements to 2035 have declined by 7% in the low case and 14% in the high case, compared to the last edition of this publication in 2014.

As in the case of nuclear capacity, uranium requirements vary considerably from region to region, reflecting projected capacity increases and possible inventory building. Annual uranium requirements are projected to be largest in the East Asia region, where increased installed nuclear generating capacity (particularly in China and Korea) drives significant growth in uranium needs. In contrast to steadily increasing uranium requirements in the rest of the world, annual requirements in the EU are either projected to decline by about 46% (low case) or increase by 12% (high case) by 2035, compared to 2014 requirements. Projected North American uranium requirements vary from a decline of 11% (low case) to almost 4% (high case) by 2035.

Table 2.3. Installed nuclear generating capacity to 2035

(MWe net, as of 1 January 2015)

Country	2013	2014	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Algeria	0	0	0	0	0	0	0	0	0	600*	0	600*
Argentina(b)	935	935	1 025	1 025	1 450	1 450	3 450	3 590	3 690	4 660	4 750	5 720
Armenia	375	375	375	375	375	375	375	375	1 000	1 000	1 000	1 000
Bangladesh*	0	0	0	0	0	0	0	0	0	1 000	0	1 000
Belarus*	0	0	0	0	1 109	1 109	2 218	2 218	2 218	2 218	2 218	2 218
Belgium+	5 927	5 927	3 000	5 000	3 000	5 000	0	0	0	0	0	0
Brazil	1 875	1 875	1 875	1 875	3 120	3 120	3 120	3 120	3 120	5 120	3 120	7 485*
Bulgaria*	1 900	1 900	1 900	1 900	1 900	1 900	1 900	1 900	1 900	2 900	950	2 900
Canada	13 350	13 400	13 500	13 500	9 900	13 800*	10 200	12 920*	11 100	14 070*	11 100	12 520*
China(a)	15 980*	20 305	23 025*	29 675*	40 000	58 000	58 725*	74 725*	78 825*	118 525*	91 340*	158 355*
Czech Republic	3 830	3 940	3 960	3 965	3 965	3 970	3 965	3 970	3 965	3 970	6 150	6 250
Egypt*	0	0	0	0	0	0	0	0	0	1 000	0	1 000
Finland	2 760	2 760	2 760	2 760	4 380	4 380	5 580	7 390	5 080	6 890	4 580	6 390
France	63 200	63 200	63 200	63 200	61 000	63 200	37 000	63 200	37 000	63 200	37 000	63 200
Germany	12 070	12 070	12 100	12 100	8 100	8 100	0	0	0	0	0	0
Hungary	1 890	1 890	1 890	1 890	2 000	2 000	2 000	3 200	2 000	4 400	1 000	3 400
India	4 780	5 308*	6 258*	7 480	10 080	11 480	11 181*	25 000	16 411*	27 558*	18 209*	36 711*
Indonesia*	0	0	0	0	0	0	0	0	0	1 000	0	2 000
Iran	915	915	915	915	915	915	2 815	5 075	6 975	7 925	1 915*	4 245*
Italy*	0	0	0	0	0	0	0	0	0	0	0	0
Japan*	42 400	42 400	40 290	40 290	25 340	42 890	20 390	42 890	15 250	42 890	7 590	41 330
Jordan*	0	0	0	0	0	0	0	1 000	1 000	2 000	1 000	2 000
Kazakhstan*	0	0	0	0	0	0	0	0	600	1 200	600	1 200
Korea*	20 700	20 700	23 057	23 057	26 511	27 087	31 234	32 467	35 734	39 391	37 573	43 234
Lithuania*	0	0	0	0	0	0	0	0	0	1 500	0	1 500
Malaysia*	0	0	0	0	0	0	0	0	0	1 000	0	1 000
Mexico	1 400	1 400	1 400	1 634	1 620	1 634	1 620	1 634	1 620	1 634	1 620	1 634

See notes on page 98.

Table 2.3. Installed nuclear generating capacity to 2035 *(cont'd)*

(MWe net, as of 1 January 2015)

Country	2013	2014	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Netherlands+	500	500	400	500	400	500	400	500	400	500	0	0
Pakistan*	690	690	690	690	900	1 290	1 200	2 200	1 200	3 200	1 200	3 200
Poland	0	0	0	0	0	0	1 000	1 650	3 000	4 000	6 500	7 500
Romania*	1 300	1 300	1 300	1 300	1 300	1 300	1 300	2 000	2 000	2 700	2 000	2 700
Russia	25 200	25 200	27 200	27 200	31 600	31 600	32 500	35 000	32 500	41 400	32 000	42 700
Saudi Arabia*	0	0	0	0	0	0	0	0	0	1 400	0	2 800
Slovak Republic	1 814	1 814	1 814	1 814	2 729	2 815	2 815	2 918	2 815	2 918	2 815	2 918
Slovenia	681	692	688	698	688	698	688	698	688	698	688	698
South Africa	1 840	1 840	1 840	1 840	1 840	1 840	1 840	7 200	1 840	9 600	1 840	9 600
Spain	7 069	7 069	7 069	7 069	7 069	7 069	7 121*	7 321*	7 121*	7 321*	2 048*	7 321*
Sweden+	9 500	9 500	9 500	9 500*	9 670*	10 000	6 874*	9 670*	4 828*	7 800	200*	7 800*
Switzerland	3 300	3 300	3 300	3 300*	3 000	3 300*	3 000	2 600*	3 000	2 230*	0*	2 230*
Thailand	0	0	0	0	0	0	0	0	0	0	0	1 000
Turkey	0	0	0	0	0*	0*	0*	5 840	2 280*	9 280	2 280*	9 280
Ukraine	13 800	13 800	13 800	13 800	15 800	17 900	16 500	20 200	18 800	26 200	26 000	30 500
United Arab Emirates*	0	0	0	0	2 690	5 380	5 380	5 380	5 380	5 380	5 380	5 380
United Kingdom+	9 400	9 400	8 900	8 900	8 900	8 900	4 700	9 980*	1 200	11 600*	0	12 200*
United States	99 200	97 900	99 600	99 600	101 400	101 400	101 400	101 600	101 400	104 500	101 400	110 400
Viet Nam*	0	0	0	0	0	0	0	1 000	2 000	5 000	2 000	6 000
OECD total	**298 994**	**297 865**	**296 428**	**298 777**	**279 672**	**306 743**	**239 987**	**310 448**	**238 481**	**327 292**	**222 544**	**338 305**
World total(a)	**373 616**	**377 342**	**381 665**	**391 884**	**396 576**	**452 135**	**382 493**	**508 165**	**417 942**	**611 712**	**418 068**	**682 753**

* NEA/IAEA estimate based on data established by a group of experts (IAEA/NEA) and published in IAEA, 2015a.

+ Data from the 2015 edition of NEA *Nuclear Energy Data*.

(a) The following data for Chinese Taipei are included in the world total but not in the totals for China: 5 032 MWe in 2013, 2014 and 2015, respectively; 3 824 and 7 732 net for the low and high cases in 2020; 0 and 7 732 MWe net for the low and high cases in 2025; 0 and 10 332 MWe net for the low and high cases in 2030; 0 and 11 632 for the low and high cases in 2035, respectively.

(b) MWe gross converted to net by the NEA/IAEA.

Table 2.4. Annual reactor-related uranium requirements to 2035

(tonnes U, rounded to nearest five tonnes)

Country	2013	2014	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Algeria*	0	0	0	0	0	0	0	0	0	100*	0	100*
Argentina	120	120	140	140	225	225	510	545	520	755	915	950
Armenia	65	65	65	65	65	65	65	65	155	155	155	155
Bangladesh*	0	0	0	0	0	0	0	0	0	160	0	160
Belarus*	0	0	0	0	175	175	350	350	350	350	350	350
Belgium	805	870	1 030	1 030	1 055	1 055	0	0	0	0	0	0
Brazil	400	400	400	400	550	550	550	550	550	1 000	550	1 200*
Bulgaria*	300	300	300	300	300	300	300	300	300	460	150	460
Canada	1 750	1 800	1 875	1 875*	1 550	2 205*	1 600	2 070*	1 700	2 250*	1 700	2 005*
China(a)	2 560*	4 200	3 685*	4 750*	6 400*	9 860	9 390*	11 950*	12 300	16 200	14 400	20 500
Czech Republic	630	680	660	660	680	685	680	685	680	690	1 080	1 110
Egypt*	0	0	0	0	0	0	0	0	0	160	0	160
Finland	570	425	440	480	700	1 360	700	1 050	520	850	520	1 070
France	8 000	8 000	8 000	9 000	8 000	9 000	5 000	9 000	5 000	9 000	5 000	9 000
Germany	2 000	2 000	2 000	2 000	1 200	1 200	0	0	0	00	0	0
Hungary	370	215	470	470	390	390	390	1 060	390	1 030	200	840
India	1 400	850*	1 000*	1 690	1 800	2 050	1 790*	4 400	2 625*	4 410*	2 915*	5 875*
Indonesia*	0	0	0	0	0	0	0	0	0	160	0	320
Iran	160	160	160	160	160	160	490	910	1 230	1 390	310*	680*
Italy*	0	0	0	0	0	0	0	0	0	0	0	0
Japan*	1 460^{+}	370^{+}	6 445*	6 445*	4 050*	6 860*	3 260*	6 860*	2 440*	6 860*	1 215*	6 610*
Jordan*	0	0	0	0	0	0	0	160	160	320	160	320
Kazakhstan*	0	0	0	0	0	0	0	0	100	190	100	190
Korea^{+}	4 200	4 200	3 690*	3 690*	4 240*	4 330*	5 000*	5 195*	5 715*	6 300*	6 010*	6 915*
Lithuania*	0	0	0	0	0	0	0	0	0	240	0	240
Malaysia*	0	0	0	0	0	0	0	0	0	160	0	160
Mexico	385	190	190	260*	390	260*	390	260*	390	260*	390	260*

See notes on page 100.

Table 2.4. Annual reactor-related uranium requirements to 2035 *(cont'd)*

(tonnes U, rounded to nearest five tonnes)

Country	2013	2014	2015		2020		2025		2030		2035	
			Low	High	Low	High	Low	High	Low	High	Low	High
Netherlands+	60	60	60	60	60	60	60	60	60	60	0	0
Pakistan*	110	110	110	110	140	210	190	350	190	510	190	510
Poland	0	0	0	0	0	0	160	260	480	640	1 040	1 200
Romania*	210	210	210	210	210	210	210	320	320	430	320	430
Russia	4 400	4 400	4 700	4 700	5 500	5 500	5 700	6 100	5 700	7 200	5 600	7 400
Saudi Arabia*	0	0	0	0	0	0	0	220	0	440	0	440
Slovak Republic	350	360	365	365	480	480	490	530	490	530	490	530
Slovenia	150	150	120	180	120	180	120	180	120	180	120	180
South Africa	290	290	290	290	290	290	290	1 150	290	1 540	290	1 540
Spain	1 185	1 120	1 200	1 400	1 150	1 250	1 150	1 250	1 135*	1 170*	320*	1 170*
Sweden	1 410+	1 430+	1 520*	1 520*	1 550*	1 600*	1 100*	1 550*	770*	1 250*	30*	1 250*
Switzerland	360	250	230	230	330	365	320	460	320	460	0*	355
Thailand	0	0	0	0	0	0	0	0	0	0	0	160
Turkey*	0	0	0	0	0	0	0	935	365	1 485	365	1 485
Ukraine	2 480	2 480	2 480	2 480	3 020	3 600	3 020	3 660	3 600	4 800	4 800	5 300
United Arab Emirates*	0	0	0	0	430	860	860	860	860	860	860	860
United Kingdom+	1 480	1 510	1 390	1 700	1 080	1 320	770	1 600*	305	1 860*	0	1 950*
United States	22 250	18 575	18 540	18 540	19 080	19 080	16 130	16 130	16 130	16 530	16 130	17 530
Viet Nam*	0	0	0	0	0	0	0	160	320	800	320	960
OECD total	**47 415**	**42 195**	**48 225**	**49 905**	**46 105**	**51 680**	**37 320**	**49 135**	**37 010**	**51 405**	**34 610**	**53 460**
World total	**60 715**	**56 585**	**62 570**	**66 005**	**65 975**	**76 965**	**61 035**	**82 195**	**66 580**	**95 630**	**66 995**	**104 740**

* NEA/IAEA estimate.

\+ Data from the 2015 edition of NEA *Nuclear Energy Data*.

(a) The following data for Chinese Taipei are included in the world total but not in the totals for China: 805 tU in 2013, 2014 and 2015; 605 tU and 1 230 tU in the low and high cases in 2020; 0 tU/yr and 1 230 tU in the low and high cases in 2025; 0 tU and 1 650 tU in the low and high cases in 2030; 0 tU and 1 860 tU in the low and high cases in 2035, respectively.

Figure 2.3. Projected installed nuclear capacity to 2035

(low and high projections)

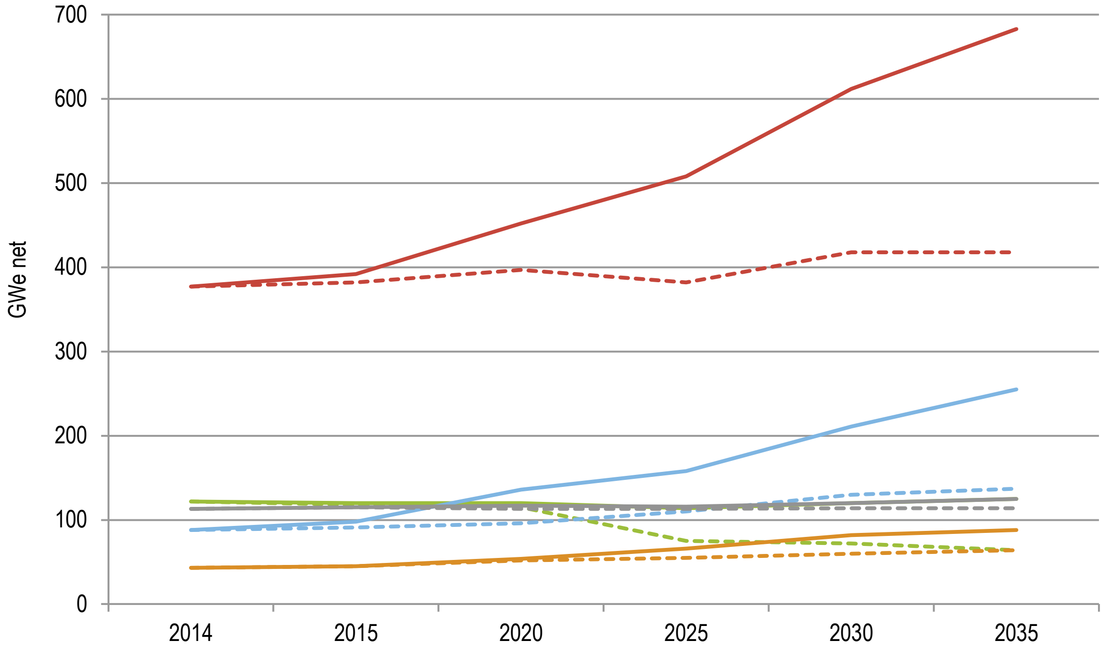
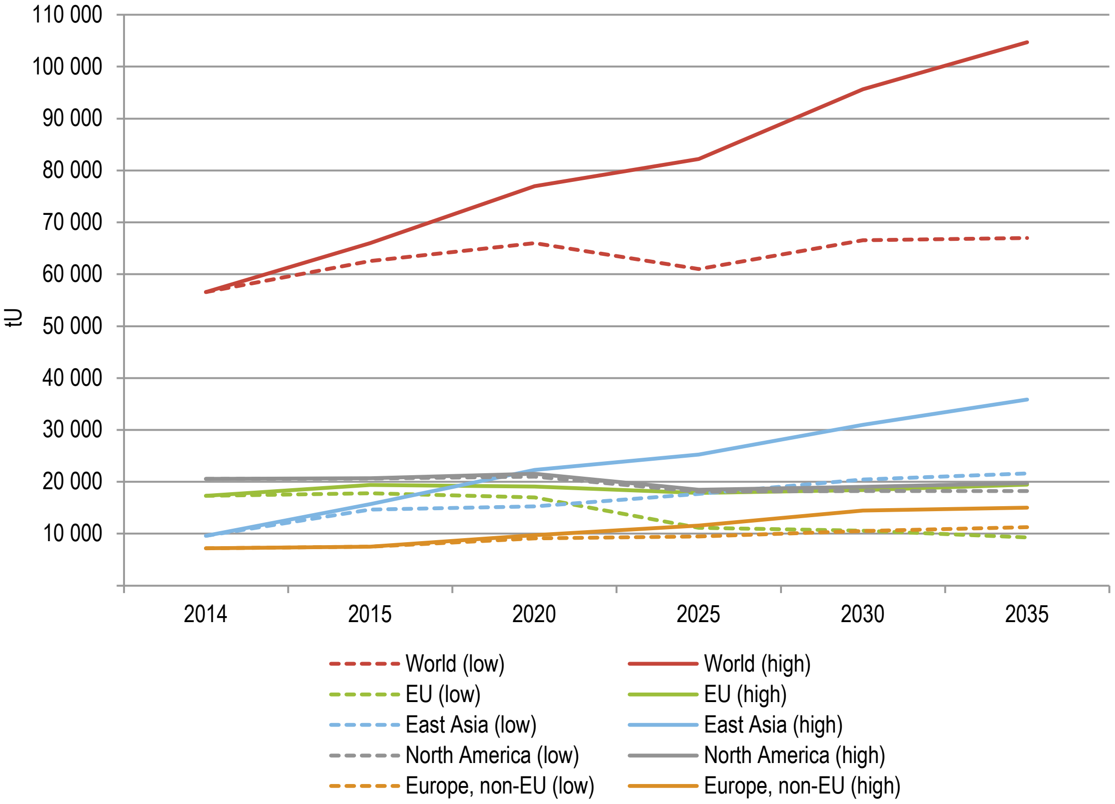


Figure 2.4. Annual reactor uranium requirements to 2035

(low and high projections)



Uranium supply and demand relationships

Uranium supply has been adequate to meet demand for decades, and there have been no supply shortages since the last edition of this report. However, a number of different sources of supply are required to meet demand. The largest is the primary production of uranium that, over the last years, has satisfied as much as 50 to 99% of world requirements. The remainder has been provided or derived from secondary sources including stockpiles of natural and enriched uranium, blending down weapons-grade uranium, reprocessing of spent fuel, underfeeding and uranium produced by the re-enrichment of depleted tails.

Primary sources of uranium supply

Uranium was produced in 21 countries in 2014, with total global production amounting to 55 975 tU (representing a decrease of about 6% from 2013 and 2012). Of these 21 producing countries, three reported limited production through mine remediation efforts only (France, Germany and Hungary). Kazakhstan surpassed Canada in 2009 to become the world's largest producer and remained in this position through 2014, continuing its run of production increases of 7% over the past two years, albeit levelling off from the more significant increases of 65% and 27% in 2009 and 2010, respectively. Production in Kazakhstan increased by 4% in 2015 to 23 800 tU. The top 5 producing countries in 2014 (Kazakhstan, Canada, Australia, Niger and Namibia) accounted for 79% of world production and 11 countries – Kazakhstan, Canada, Australia, Niger, Namibia, Russia, Uzbekistan, the United States, China, Ukraine and South Africa – accounted for almost 98% of global mine production.

Of the 30 countries currently using uranium in commercial NPPs, only Canada and South Africa produced enough uranium in 2014 to meet domestic requirements (see Figure 2.5), thereby creating an uneven distribution between producing and consuming countries. All other countries with nuclear power must make use of imported uranium or secondary sources and, as a result, the international trade of uranium is a necessary and established aspect of the uranium market. Given the uneven geographical distribution between producers and consumers, the safe and secure shipment of nuclear fuel will need to continue without unnecessary delays and impediments. Difficulties that some producing countries, in particular Australia, have encountered with respect to international shipping requirements and transfers to international ports have therefore always been a matter of some concern. However, efforts to objectively inform port authorities on the real risks involved, and better recognition of the long-standing record of successful shipments of these materials, have helped avoid unnecessary delays.

Because of the current availability of secondary supplies, primary uranium production volumes have been significantly below world uranium requirements for some time. However, this has changed in recent years as production has increased and requirements have declined. In 2014, world uranium production (55 975 tU) provided about 99% of world reactor requirements (56 585 tU). In OECD countries, the gap between production and requirements has changed little as both have declined in the past two years. In 2014, production of 16 185 tU provided 38% of requirements (42 195 tU; Figure 2.6). Remaining reactor requirements were met by imports and secondary sources.

Secondary sources of uranium supply

Uranium is unique among energy fuel resources in that historically, a significant portion of demand has been supplied by secondary sources rather than direct mine output. These secondary sources include: stocks and inventories of natural and enriched uranium, both civilian and military in origin; nuclear fuel from the reprocessing of spent reactor fuels and from surplus military plutonium; underfeeding; and uranium produced by the re-enrichment of depleted uranium tails.

Figure 2.5. Uranium production and reactor-related requirements for major producing and consuming countries

(data as of 1 January 2015)

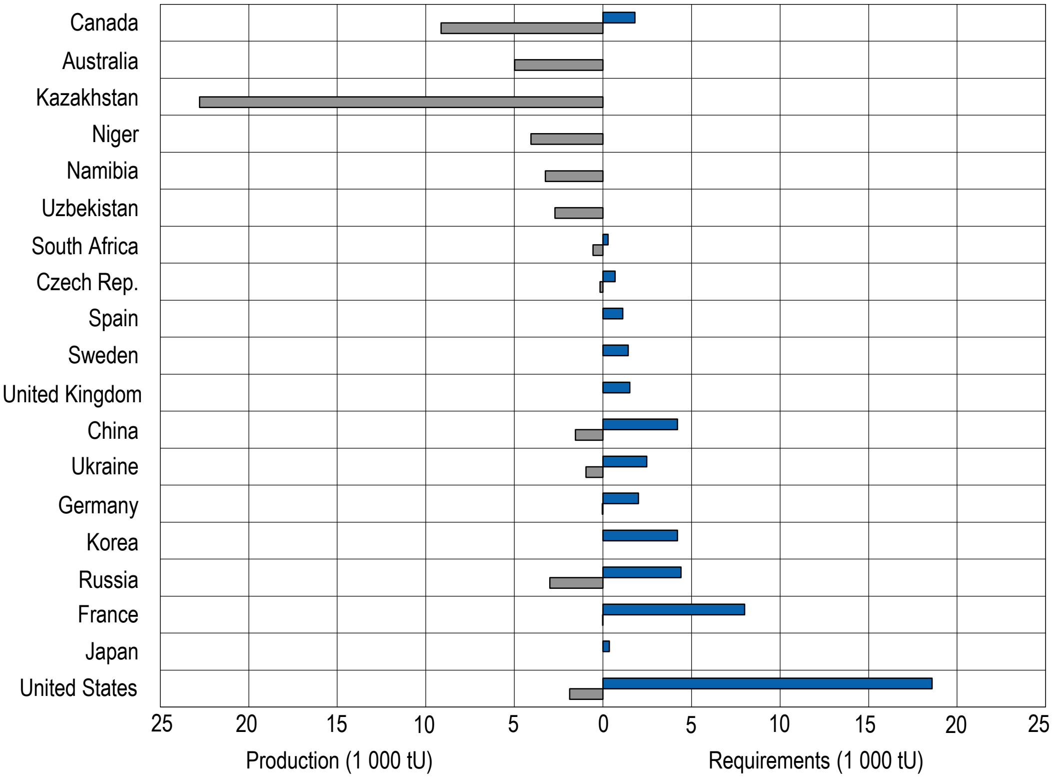
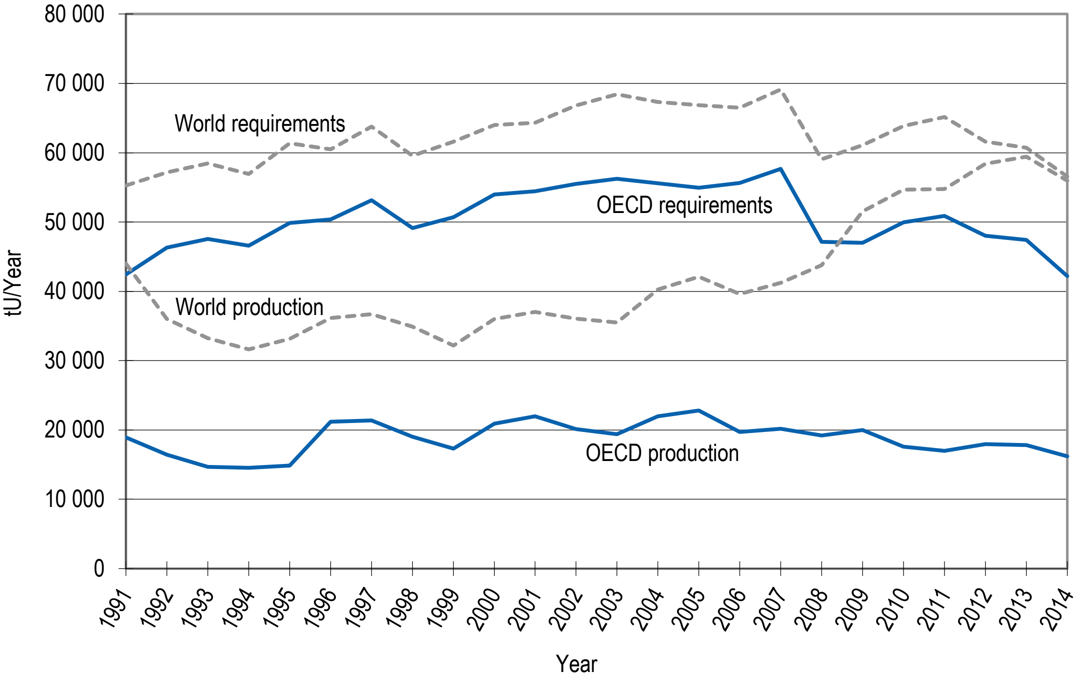


Figure 2.6. OECD and world uranium production and requirements

(data as of 1 January 2015)

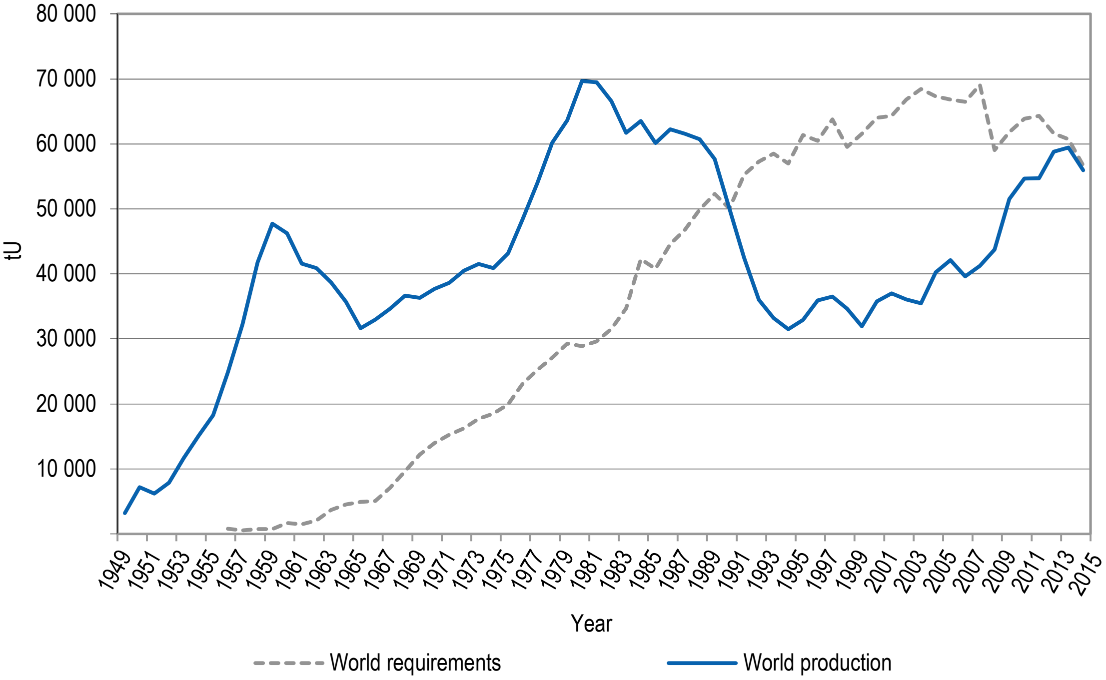


Natural and enriched uranium stocks and inventories

From the beginning of commercial exploitation of nuclear power in the late 1950s to 1990, uranium production consistently exceeded commercial requirements (see Figure 2.7). This was mainly the consequence of a lower than projected growth rate of nuclear generating capacity combined with high levels of production for strategic purposes. This period of over production created a stockpile of uranium potentially available for use in commercial power plants. After 1990, production fell well below demand as secondary supplies fed the market. However, this gap has closed in the last two years as mine production is increasing and uranium requirements are declining, at least temporarily. The decline in requirements in 2008 was likely related to utilities specifying lower tails assays at enrichment facilities and a reduced number of reactors being refuelled. Since 2008, requirements increased slightly before declining again the last few years owing to unplanned reactor closures in Germany and Japan following the Fukushima Daiichi accident. Uranium production since 2007 has generally increased and has closed the gap between production and reactor requirements.

Figure 2.7. Annual uranium production and requirements*

(1949-2015)



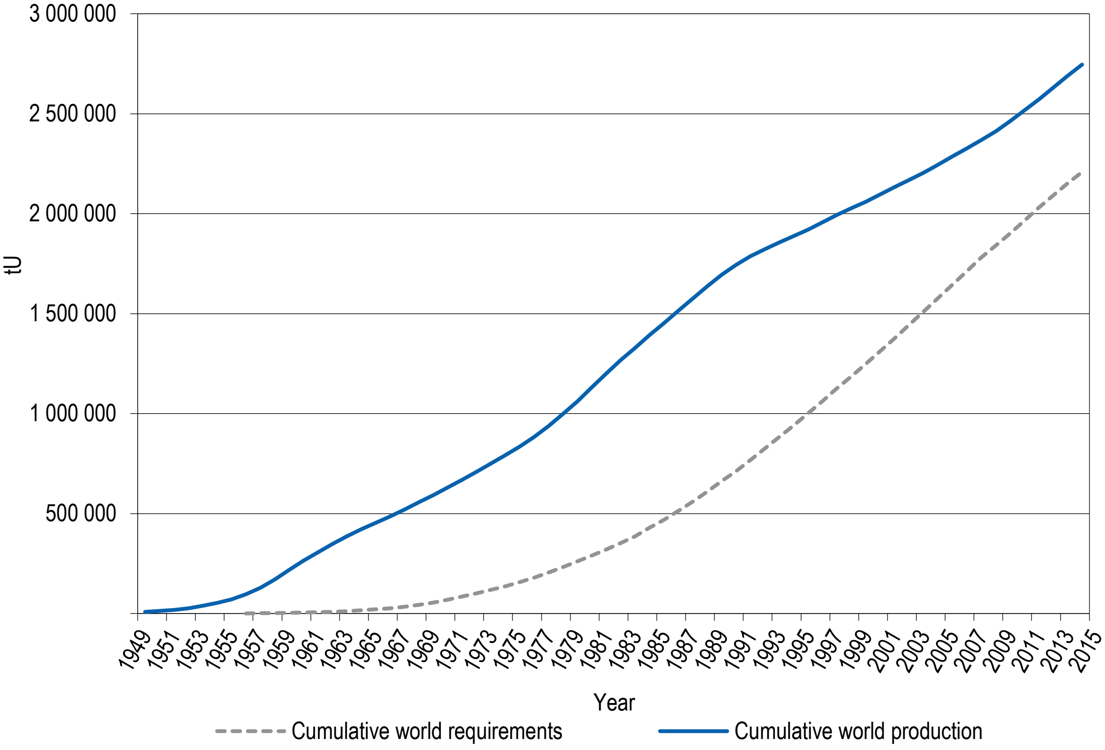
* Data as of 1 January 2015.

Following the political and economic reorganisation in Eastern Europe and the former Soviet Union in the early 1990s, steps have been taken to move towards the development of an integrated global commercial market. More uranium is now available from the former Soviet Union, most notably from Kazakhstan, but also from Russia and Uzbekistan, as is more information on the production and use of uranium in these countries. Despite these developments and more information on the amount of uranium held in inventory by utilities, producers and governments, uncertainties remain regarding the size of these inventories, as well as the availability of uranium from other potential secondary supply sources. These latter uncertainties, combined with uncertainty about the desired levels of commercial inventories, continues to influence the uranium market.

Data from past editions of this publication, along with information provided by member states, give a rough indication of the possible maximum upper level of the potential inventories commercially available. Cumulative production through 2015 is estimated to have amounted to over 2 750 000 tU, whereas cumulative reactor requirements through 2015 amounted to about 2 210 000 tU. This leaves an estimated remaining stock of roughly 540 000 tU; a rough estimate of the upper limit of what could potentially become available to the commercial sector (see Figure 2.8). This base of already mined uranium has essentially been distributed into two sectors, with the majority used and/or reserved for the military and the remainder used or stockpiled by the civilian sector. However, since the end of the Cold War, increasing amounts of uranium, previously reserved for strategic purposes, have been released to the commercial sector.

Figure 2.8. Cumulative uranium production and requirements*

(1949-2015)



* Data as of 1 January 2015.

Civilian inventories include strategic stocks, pipeline inventory and commercial stocks available to the market. In recent years, material held by financial investors has been a part of the inventory, although reports indicate that the major investment banks are in the process of exiting commodity markets because of declining demand and increased regulation. Utilities are believed to hold the majority of commercial stocks because many have policies that require them to carry the equivalent of one to two years of natural uranium requirements. Despite the importance of this secondary source of uranium, information about the size of these stocks is limited because few countries are able or willing, because of confidentiality concerns, to provide detailed information on stockpiles held by producers, consumers or governments (see Table 2.5).

Table 2.5. Uranium stocks in countries responding to the 2015 questionnaire

(tonnes natural U equivalent as of 1 January 2015)

Country	Natural uranium	Enriched uranium
Argentina[a]	N/A	N/A
Australia[b]	N/A	N/A
Belgium	N/A	N/A
Brazil	0	0
Bulgaria[c]	0	81
Canada[b]	N/A	0
China	N/A	N/A
Czech Republic[d]	<250	N/A
Finland[e]	N/A	N/A
France[f]	N/A	N/A
Germany	N/A	N/A
Hungary[g]	8	0
India	N/A	N/A
Iran	N/A	N/A
Japan	N/A	N/A
Kazakhstan	N/A	N/A
Korea[c, h]	2 000	6 000
Mexico	N/A	N/A
Mongolia	0	0
Netherlands	N/A	N/A
Niger	0	0
Poland	0	0
Portugal	168	0
Russia	N/A	N/A
Slovak Republic	0	228
South Africa	N/A	N/A
Spain[i]	N/A	608
Switzerland[c, j]	1 543	673
Turkey	2	0
Ukraine	0	0
United Kingdom	N/A	N/A
United States[k]	36 584	26 463
Viet Nam	0	0
Total	**>40 555**	**>34 053**

(a) Commercial data are not available. A minimum of two years' inventory is required for the plant's operator.

(b) Government stocks are zero in all categories. Commercial data are not available.

(c) Data from the 2014 edition of the Red Book.

(d) ČEZ maintains strategic and working inventories in various forms, including fuel assemblies, amounting to about two years of requirements. Data reported for uranium stocks in the table include only producer stocks.

(e) The nuclear power utilities maintain reserves of fuel assemblies sufficient for 7-12 months of use.

(f) A minimum strategic inventory, amounting to a few years of forward fuel requirements, is maintained by EDF.

(g) Inventory from mine water treatment only.

(h) A strategic inventory is maintained along with about one year of forward consumption in pipeline inventory.

(i) Regulations require a strategic inventory of at least 611 tU be maintained jointly by nuclear utilities.

(j) Utilities also hold 48 t (U equivalent) of reprocessed uranium.

(k) Natural uranium hexafluoride (UF_6) and enriched uranium in fuel assemblies held in storage prior to loading in the reactor is not included. Government stocks also include 30 000 t (U equivalent) of depleted uranium. Data from producers (7 141 tU) is also not included.

Nonetheless, available data suggest that industry has been increasing inventories in recent years. In the United States, 2014 year-end total commercial uranium inventories (natural and enriched uranium equivalent held by producers and utilities) amounted to 51 778 tU, an increase of almost 12% compared to 2012 levels of 46 438 tU. As of 1 January 2015, the total inventories (including government, producer and utility stocks) in the United States were 100 108 tU. Uranium inventories held by EU utilities at the end of 2014 totalled 52 898 tU, enough for an average of three years' fuel supply, a slight increase of 1% since the end of 2012 and 15% since the end of 2009 (ESA, 2015). These data from the two largest regions of nuclear power generation suggest that global commercial inventories have been increasing.

Uranium requirements are growing rapidly in East Asia (in particular in China where 26 reactors were under construction at the end of 2014). By the early 2020s, demand in this region is expected to surpass both that of North America and the EU. Questionnaire responses received during the compilation of this volume revealed little about national inventory policies in the East Asia region. However, based on import statistics, it is estimated that China has accumulated an inventory of over 75 000 tU at the end of 2014, in anticipation of increasing uranium requirements due to the significant number of reactors under construction and planned.

The World Nuclear Association (WNA) reports that questionnaire responses from industry show a clear build-up of utility inventory since 2003, mainly in East Asia. At the end of 2014, global commercial inventories totalled 143 000 tU, an increase of 23 000 tU since 2010. The WNA (2015) considers this build-up to be a response to the Fukushima Daiichi accident (since reactors have been laid up in Japan pending restart and fuel deliveries have continued), as are lower uranium prices since the accident.

In recent years, commercial entities other than utilities have been holding quantities of uranium for investment purposes. Although commercially confidential, variable and largely dependent on uranium price dynamics, the US Energy Information Administration notes that US-based traders and brokers held about 2 230 tU at the end of 2014 (EIA, 2015). Financial investors also hold a certain amount of uranium inventory. Uranium Participation Corporation (UPC), for example, held about 5 400 tU as U_3O_8 and UF_6 at the end of 2015 (company website). Some banks have also purchased uranium stocks (e.g. Macquarie, Deutsche Bank). However, because of stricter regulations related to the commodities activities, some banks have withdrawn from the uranium market. Efforts by governments and international agencies have also resulted in actions to create nuclear fuel banks – another form of inventory. These efforts are discussed below.

In July 2013, the US DOE outlined to Congress its plan to manage its excess uranium inventory in various forms that amounts to between 46 000 and 56 000 tNatU (tonnes of natural uranium equivalent; DOE, 2013). It identifies uranium inventories that have entered the commercial uranium market since the issuance of the last plan in 2008, as well as transactions that are ongoing or being considered through 2018. A DOE Secretarial Determination must be made every two years in advance of sales or transfers in order to provide assurance that the transactions will not have an adverse material impact on the domestic uranium mining, conversion or enrichment industries.

In the calendar year 2015, the DOE Secretarial Determination authorised the transfer of up to 2 000 tU to DOE contractors for clean-up services at the Portsmouth gaseous diffusion plant and up to 500 tNatU to the National Nuclear Security Administration (NNSA) for blending down HEU to low-enriched uranium (LEU). Other transactions involved the transfer of up to 9 082 t of depleted uranium (DU) to Energy Northwest in 2012 and 2013, the majority of which would be enriched for use in the company's power reactor and the remainder sold to TVA as part of a commercial transaction to support future power generation and tritium production from 2013 through 2030.

Also of note is the approximately 123 000 t of the total DOE inventory of 510 000 t DU believed to have economic value for enrichment (referred to as high assay tails).

Transfers to Energy Northwest have reduced this high assay tails total to around 114 000 t DU, half of which are located at the Paducah gaseous diffusion enrichment facility. Operations at Paducah, a DOE facility leased to United States Enrichment Corporation (USEC), were brought to an end in May 2013. Ahead of the closure, the DOE issued a request for expressions of interest for the DU inventory and in late 2013 selected a proposal by GE-Hitachi Global Laser Enrichment to build and operate a tails processing plant using Silex laser enrichment technology. However, in 2015, GE-Hitachi Global Laser Enrichment announced plans to slow development of its laser enrichment technology owing to poor market conditions.

Large stocks of uranium, previously dedicated to the military in both the United States and Russia, have become available for commercial applications, bringing a significant secondary source of uranium to the market. Despite the programmes outlined below, the remaining inventory of HEU and natural uranium held in various forms by the military is significant, although official figures on strategic inventories are not available. If additional disarmament initiatives are undertaken to further reduce strategic inventories, several years of global supply of NatU for commercial applications could be made available.

- HEU from Russia

Russia and the United States signed a 20-year, government-to-government agreement in February 1993 for the conversion of 500 t of Russian HEU from nuclear warheads to LEU suitable for use as nuclear fuel (referred to as the Megatons to Megawatts agreement). USEC, the United States executive agent for this agreement, purchased the enrichment component of the LEU, about 5.5 million SWU per year from Techsnabexport (TENEX) of Russia. Under a separate agreement, the natural uranium feed component of the HEU purchase agreement was sold under a commercial arrangement between three western corporations (Cameco, Areva and Nukem) and TENEX. Deliveries under this government-to-government agreement were finalised at the end of 2013.

Imports of uranium from Russia outside of these agreements have been limited by the Agreement Suspending the Antidumping Duty Investigation on Uranium from Russia signed between the US Department of Commerce (DOC) and the Ministry of Atomic Energy of Russia in 1992. However, a 2008 amendment to the suspension agreement allows small quantities of Russian LEU to enter the United States beginning in 2011 and much higher sales of Russian uranium products directly to US utility companies under quota from 2014 to 2020. In addition, Russian-origin fuel supply to new reactors will be quota-free. Since the signing of this amendment, agreements for nuclear fuel supply deliveries have been signed by US utilities and Russia, including a contract between USEC and TENEX in March 2011 for the ten-year supply of LEU through to 2022. By mid-2012, it was reported that TENEX had signed 13 commercial contracts with 10 US utilities, representing more than 50% of the permitted quota. In 2015, the LEU supplied amounted to about one-half the level supplied in the past under the HEU purchase agreement. However, quantities supplied under these new arrangements will come from Russia's commercial enrichment activities as opposed to blending down excess Russian weapons material.

- HEU from the United States

In 1995, the United States declared 200 t of fissile material, about 175 t of which is HEU, as surplus to defence needs and committed to its disposition. The preferred option for the disposition of this material is blending down HEU to LEU suitable for fuel in research and commercial reactors. The remainder that is not suitable for such uses would be blended down and disposed of as low-level radioactive waste (DOE, 1996). As of 2007, approximately 100 of the 175 t HEU had been blended down, another 10 t HEU was in the blending down process and about 18 t HEU was considered unsuitable for use as nuclear fuel (DOE, 2007).

In 2001, the DOE and TVA signed an interagency agreement, whereby TVA committed to utilising LEU derived from blending down about 33 t of US surplus HEU for the production of "off-spec" LEU fuel (termed blended low-enriched uranium – BLEU). This fuel is considered "off-spec" because it contains ^{234}U and ^{236}U in excess of the specifications established for commercial nuclear fuel. In 2004, this agreement was modified to increase the total to 39 t of HEU and an additional 5.6 t of HEU was added to the programme in 2008.

From 1999 to 2000, four BLEU fuel assemblies loaded in the Sequoyah NPP successfully demonstrated the use of "off-spec" LEU. Since 2005, BLEU has been used in TVA's Browns Ferry and Sequoyah reactors, and TVA plans to continue to use BLEU in these reactors until 2016 since it has proven to be a reliable source of lower cost fuel (TVA, 2011).

In 2005, an additional 200 t HEU was declared as surplus, the majority of which was designated for use in naval propulsion and with a portion to be blended down to LEU fuel for use in power or research reactors (DOE, 2007). DOE proposed to allocate about 61 t HEU for BLEU production over the next few decades, with the LEU gradually being made available to power reactors over a 25-year period. TVA subsequently prepared an environmental assessment for the acquisition of an additional 28 t of HEU for blending down to LEU in order to meet Browns Ferry and Sequoyah fuel requirements from 2016 through 2022 (TVA, 2011). By October 2010, 22.8 t HEU had been blended down, creating 312 t of LEU.

Also in 2005, the DOE announced its intention to set aside 17.4 t of HEU to be blended down to LEU fuel and held in reserve to address any disruptions in domestic or foreign nuclear fuel supply. In August 2011, the DOE announced that the American Assured Nuclear Fuel Supply had been established to secure sufficient LEU for six reloads of an average 1 000 MWe reactor (230 t LEU), derived from blending down this HEU. The remaining 60 t LEU produced from blending down the 17.4 t HEU is expected to be sold on the market to pay for processing costs.

In December 2008, the DOE excess uranium inventory included 67.6 t of HEU that was declared unallocated (not presently obligated or approved for a specific purpose or programme). The disposition plan for this material noted that the HEU will be made available gradually over several decades at a rate controlled by weapons dismantlement initiatives and the rejection of material from naval reactors (DOE, 2008).

As of 1 January 2013, the DOE reported that it held 11.4 t of surplus HEU remaining in the active disposition programme and approximately 18 t of unallocated surplus HEU, (DOE, 2013). These amounts reflect the material blended down since 2008, the allocation of 5 t HEU to the BLEU programme and the reallocation of significant quantities of surplus HEU to activities not expected to impact uranium markets (i.e. research reactor and naval fuel requirements).

As of June 2015, the US DOE reported 15 t of unallocated HEU. Blending down of this material is expected to continue over the next decade.

Nuclear fuel produced by reprocessing spent reactor fuels and surplus weapons-related plutonium

The constituents of spent fuel from NPPs are a potentially substantial source of fissile material that could displace primary uranium production. When spent fuel is discharged from a commercial reactor, it is potentially recyclable since about 96% of the original fissionable material remains, along with the plutonium created during the fission process. The recycled plutonium can be reused in reactors licensed to use MOX. The uranium recovered through reprocessing of spent fuel, known as reprocessed uranium (RepU), is not routinely recycled; rather, it is stored for future reuse.

The use of MOX has not yet significantly altered world uranium demand because only a relatively small number of reactors are using this type of fuel. Moreover, the number of recycles possible using current reprocessing and reactor technology is limited by the build-up of plutonium isotopes that are not fissionable by the thermal neutron spectrum found in light-water reactors and by the build-up of undesirable elements, especially curium.

As of January 2015, there were 33 reactors, or about 8% of the world's operating fleet, licensed to use MOX fuel, including reactors in France, Germany, India and the Netherlands (see Table 2.1). Japan had planned to use MOX fuel in 16 to 18 reactors by 2015, but the status of this plan and the current MOX licensing situation is unknown. Reprocessing and MOX fuel fabrication facilities exist or are under construction in France, India, Japan, Russia, the United Kingdom and the United States.

Following on basic research and MOX fuel fabrication for experimental reactors by the Japan Atomic Energy Agency (JAEA), Japan Nuclear Fuel Ltd (JNFL) began testing plutonium separation at the Rokkasho reprocessing facility in 2006. Japanese utilities began using MOX initially in fuel manufactured overseas. The use of imported MOX fuel was to be followed by the use of MOX produced at JNFL's MOX fuel fabrication facility (JMOX) adjacent to the Rokkasho reprocessing plant. JMOX construction began in 2010. By mid-2010, three reactors in Japan had received fuel loads with MOX produced overseas, the last being reactor No. 3 at the Fukushima Daiichi NPP. Commercial operation of JMOX is expected to begin by 2019 (130 tHM/yr capacity). Japan's Agency for Natural Resources and Energy is trying to review the financial mechanism to fund reprocessing and MOX fuel production. A new legal entity will be put in place to collect fees from utilities.

Following the closure in 2003 of the Cadarache MOX fuel production plant in France and the MOX fuel plant in Belgium (Belgonucleaire) in 2006, the MELOX plant in Marcoule, France was licensed in 2007 to increase annual production from 145 tHM to 195 tHM of MOX fuel (corresponding to 1 560 tNatU). Annual MOX production in France varies below this licensed capacity, in accordance with contracted quantities. Most of the French MOX production is used to fuel French NPPs (a total of about 120 t/yr; 960 tNatU) and the remainder is delivered abroad under long-term contract arrangements.

The Euratom Supply Agency (ESA) reported that the use of MOX fuel in the EU increased by 23% in 2014 to 11 603 kg Pu from 9 410 kg Pu in 2011. Use of plutonium in MOX fuel reduced natural uranium requirements in the EU by an estimated 1 156 tU in 2014 and 1 047 tU in 2013. Since 1996, MOX fuel use in EU reactors has displaced a cumulative total of 20 956 tU through the use of 184.2 t of Pu (ESA, 2015). Since the great majority of world MOX use occurs in Western Europe, this figure provides a reasonable estimate of the impact of MOX use worldwide on uranium requirements during that period. Responses to the questionnaire provide some additional data on the production and use of MOX (see Table 2.6).

Uranium recovery through reprocessing of spent fuel, known as RepU, has been conducted in the past in several countries, including Belgium and Japan. It is now routinely undertaken only in France and Russia, principally because the production of RepU is a relatively costly endeavour, in part because of the requirement for dedicated conversion, enrichment and fabrication facilities. Available data indicate that it represents less than 1% of projected annual world requirements. Reprocessing could become a more significant source of nuclear fuel supply in the future if China successfully commercialises the process. It was reported that China planned to move beyond conducting research and development of reprocessing and recycling technologies to build and operate a large-scale commercial facility with a capacity of about 800 tHM/yr in order to achieve maximum utilisation of uranium resources, given the country's rapidly rising requirements. Since 2007, China and France have reportedly been discussing the possibility of France supplying a commercial scale recycling facility.

Table 2.6. MOX production and use

(tonnes of equivalent natural U)

Country	Pre-2012	2012	2013	2014	Total to 2014	2015 (expected)
MOX production						
Belgium	523	0	0	0	523	0
France	17 520*	1 200	992	1 072	20 784	1 200
Japan	684	0	0	0	684	N/A
United Kingdom	N/A	N/A	N/A	N/A	N/A	N/A
MOX use						
Belgium	520	0	0	0	520	0
France	N/A	880	880	880	N/A	880
Germany	6 730	100	N/A	N/A	N/A	N/A
Japan	912	0	0	0	912	0
Switzerland	1 407	N/A	N/A	N/A	N/A	N/A

N/A = Not available or not disclosed.

* Includes Cadarache historical production and Marcoule production adjustment.

Table 2.7. Reprocessed uranium production and use

(tonnes of equivalent natural U)

Country	Pre-2012	2012	2013	2014	Total to 2014	2015 (expected)
Production						
France(a)	15 900	1 000	1 000	1 000	18 900	1 000
Japan(b)	645	0	0	0	645	0
Russia	N/A	N/A	N/A	N/A	N/A	N/A
United Kingdom(c)	15 000	N/A	0	0	N/A	0
Use						
Belgium(d)	508	0	0	0	508	0
France(a)	4 700	600	600	0	5 900	0
Germany	N/A	N/A	N/A	N/A	N/A	N/A
Japan(b)	215	0	0	0	215	0
Switzerland(c)	3 180	291	266	266	4 003	266
United Kingdom(c)	1 500	0	0	0	1 500	0

N/A = Data not available.

(a) Cumulative in storage.

(b) For fiscal year.

(c) 2015 edition of *NEA Nuclear Energy Data*.

(d) From 1993 to 2002.

- MOX produced from surplus weapons-related plutonium

In September 2000, the United States and Russia signed the Plutonium Management and Disposition Agreement that committed each country to dispose of 34 t of surplus weapons-grade plutonium at a rate of at least 2 tonnes per year in each country, once production facilities are in place. Both countries agreed to dispose of the surplus plutonium by fabricating MOX fuel suitable for irradiation in commercial nuclear reactors that would convert the surplus plutonium into a form that cannot be readily used to make a nuclear weapon. In 2009, US President Obama and Russian President Medvedev signed a joint statement on nuclear co-operation in Moscow that reaffirmed this commitment. The 68 t of weapons-grade plutonium would displace about 14 000 to 16 000 tonnes of natural uranium over the life of the programme. This represents about 1% of world annual uranium requirements over this period.

In the United States, the MOX fuel is to be fabricated at the DOE's Savannah River complex in South Carolina. The DOE's National Nuclear Security Administration awarded a contract for construction of the Mixed Oxide Fuel Fabrication Facility (MFFF) at Savannah River in 2001 and construction was officially started in 2007. In late 2012, construction was reportedly 56% complete. In mid-2013, however, it was reported that the project had encountered technical difficulties and was running over budget. Recently, the project has seen progressive cuts to its funding as the DOE's National Nuclear Safety Administration embarked on a review of its plutonium disposition strategy.

The Russian MOX facility had reportedly been abandoned in favour of burning excess plutonium in fast breeder reactors (WNA, 2015). A MOX fuel fabrication facility established by Mining and Chemical Combine (MCC), a Rosatom subsidiary, was officially started in 2015. Russia has no commercial reactors using MOX fuel, but its BN-800 fast neutron reactor will use MOX fuel.

Uranium produced by re-enrichment of depleted uranium tails[6] *and uranium saved through underfeeding*

Depleted uranium stocks represent a significant source of uranium that could displace primary production. However, the re-enrichment of depleted uranium has been limited since it is only economic in centrifuge enrichment plants with spare capacity and low operating costs.

At the end of 2005, the inventory of depleted uranium was estimated to amount to about 1 600 000 tU and to be increasing by about 60 000 tU annually based on uranium requirements of 66 000 tU per annum (NEA, 2007). If this entire inventory was re-enriched to levels suitable for nuclear fuel, it would yield an estimated 450 000 tNatU, sufficient for about seven years of operation of the world's nuclear reactors at the 2006 uranium requirement levels.[7] Following the construction of new centrifuge enrichment facilities and declining demand since the Fukushima Daiichi accident, spare enrichment capacity is currently available, and it has been reported that tails assays are being driven downward at enrichment facilities to underfeed the centrifuge plants and create additional uranium inventory.

Deliveries of re-enriched tails from Russia had been an important source of uranium for the EU, representing 1 to 3.7% of the total natural uranium delivered annually to EU reactors between 2005 and 2009 (see Table 2.8). However, contracts with EU utilities came

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[6] Depleted uranium is the by-product of the enrichment process having less ^{235}U than natural uranium. Normally, depleted uranium tails contain between 0.25 and 0.35% ^{235}U compared with the 0.711% ^{235}U found in nature.

[7] This total assumes 1.6 million tU at 0.3% ^{235}U assay is re-enriched to produce 420 000 tU of equivalent natural uranium, leaving 1 080 000 tU of secondary tails with an assay of 0.14% ^{235}U.

to an end in 2010, and in 2011 Russia stopped the re-enrichment of depleted uranium tails. EU enrichers are now putting in place long-term strategies to manage enrichment tails remaining from enrichment activities, including deconversion of UF_6 to the more stable form U_3O_8. Currently, deconversion takes place in France, and Urenco UK is constructing a tails management facility.

Table 2.8. Russian supply of re-enriched tails to EU end users

Year	Re-enriched tail deliveries (tU)	Percentage of total natural uranium deliveries
2007	388	1.8
2008	688	3.7
2009	193	1.1
2010	0	0.0

Source: ESA *Annual Report*, 2011, 2012.

In the United States, the DOE and the Bonneville Power Administration initiated a pilot project to re-enrich 8 500 tonnes of the DOE's enrichment tails inventory. Between 2005 and 2006, this project produced approximately 1 940 tU equivalent for use between 2007 and 2015 at Northwest Energy's 1 190 MWe Columbia generating station in Washington State. In mid-2012, Northwest Energy and USEC, in conjunction with the DOE, developed a new plan to re-enrich a second portion of DOE's high assay tails. The resulting LEU is to be used to fuel Northwest Energy's Columbia generating station through 2028. Northwest Energy is also to provide some LEU created in this process to TVA starting in 2015.

Until 2009, a fraction of the depleted UF_6 flow generated through enrichment activities in France was sent to Russia for re-enrichment. This fraction was limited to materials with mining origins that would allow their transfer (in accordance with international and bilateral agreements dealing with the exchange of nuclear materials). The return flow was exclusively used to overfeed the enrichment plant in France (the Georges Besse gaseous diffusion plant run by the European Gaseous Diffusion Uranium Enrichment Consortium [EURODIF], an Areva subsidiary).

In addition, in 2008 and 2009, a few thousand tonnes of DU were removed from storage, converted to UF_6 and enriched to natural uranium grade at the Georges Besse gaseous diffusion plant, thanks to economic conditions (primarily high uranium spot prices at that time). Following the completion of additional centrifuge enrichment capacity sufficient to meet global demand, gaseous diffusion enrichment plants became uneconomic. The Georges Besse and Paducah plants were closed in 2012 and 2013, respectively.

As noted above, GE-Hitachi Global Laser Enrichment proposed to build and operate a tails processing plant using Silex laser enrichment technology at the closed Paducah gaseous diffusion enrichment plant. Successful development of laser enrichment could potentially result in an additional supply of uranium to the market in the longer term. However, GE-Hitachi Global Laser Enrichment recently announced plans to slow development of its laser technology because of poor market conditions. Some other commercial enrichment providers (e.g. Urenco) have indicated an interest in using centrifuge enrichment capacity for tails re-enrichment.

Additional information on the production and use of re-enriched tails is not readily available. However, the information provided in questionnaire responses (see Table 2.9) indicates that its use has been limited between 2012 and 2014.

Table 2.9. Re-enriched tails production and use

(tonnes of equivalent natural U)

Country	Pre-2012	2012	2013	2014	Total to 2014	2015 (expected)
Production						
France	N/A	N/A	N/A	N/A	N/A	N/A
United States	1 940	0	3 738	0	5 678	0
Use						
Belgium[(a)]	345	0	0	0	345	0
Finland	843	0	0	0	843	0
France	N/A	N/A	N/A	N/A	N/A	N/A
Sweden[(b)]	1 697	0	0	0	1 697	0
United States	1 567	0	373	0	1 940	0

N/A = Data not available.

(a) Purchased for subsequent re-enrichment.

(b) 2015 edition of *NEA Nuclear Energy Data*.

Underfeeding

The potential for **underfeeding** of enrichment plants is also a source of secondary supply, moreover one that has become more important in the last few years. Overcapacity in the enrichment market since the Fukushima Daiichi accident has provided incentive to operators to "underfeed" enrichment facilities by extracting more ^{235}U from the uranium feedstock. This reduces the amount of uranium required to produce contracted quantities of enriched uranium and, in turn, creates a stockpile of uranium that can be sold. It is estimated that global underfeeding and tails re-enrichment contribute up to 7 000 tU of supply per year (WNA, 2015).

In recent years, secondary supply has shown a downward trend resulting from the end of the "Megatons to Megawatt" agreement. However, the level of secondary supply is currently around 12 000 tU/yr and is likely to remain at over 10 000 tU/yr for the next two decades (WNA, 2015).

Uranium market developments

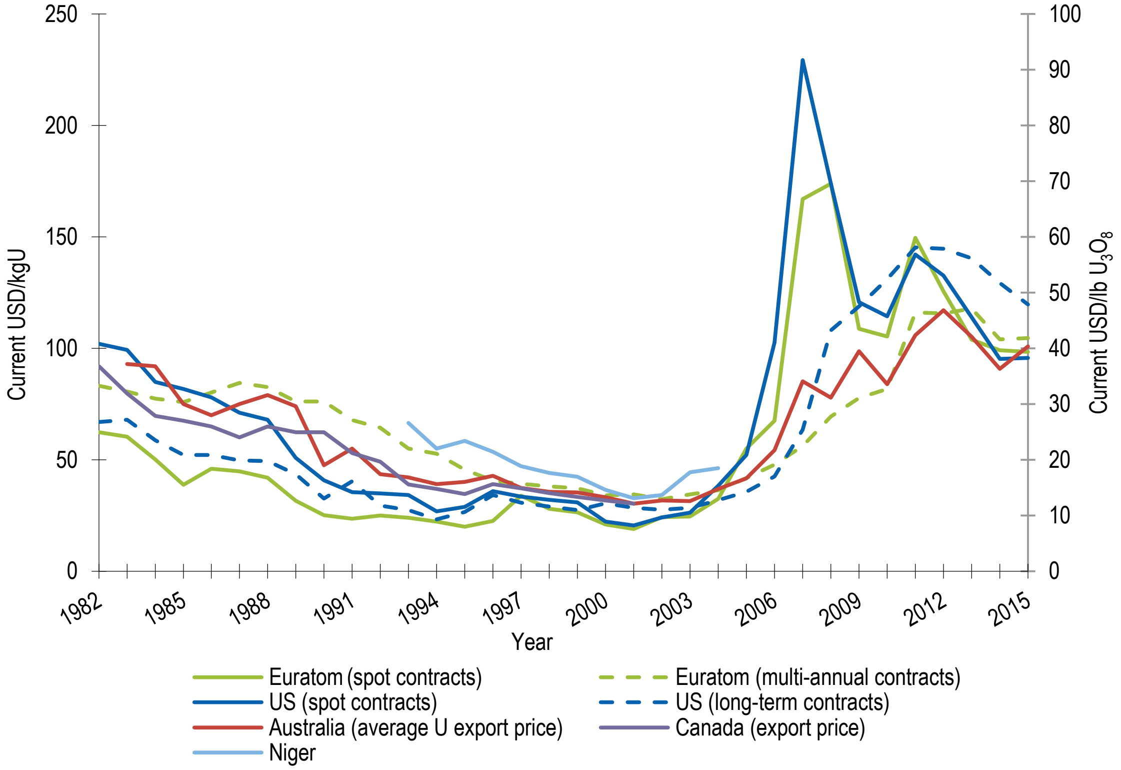
Uranium price developments

Some national and international authorities (Australia, the United States and Euratom), publish price indicators to illustrate uranium price trends for both long-term and short-term (spot price) contract arrangements. Australian data record average annual prices paid for exports, whereas Euratom (ESA) and US data show costs of uranium purchases in a particular year. Canada and Niger published export prices for some years, but neither continue to do so. Figure 2.9 displays this mix of annual prices reported for both short-term and longer-term purchases and exports.

The overproduction of uranium, which lasted through 1990 (see Figure 2.7), combined with the availability of secondary sources, resulted in uranium prices trending downward from the early 1980s through the mid-1990s, bringing about significantly reduced expenditures in many sectors of the world uranium industry, including exploration, production and production capability. The bankruptcy of an important uranium trading company resulted in a modest recovery in prices from late 1994 through mid-1996, but the regime of low prices returned shortly thereafter.

Beginning in 2002, uranium prices began to increase, eventually rising to levels not seen since the 1980s, then rising more rapidly through 2005 and 2006 with spot prices reaching a peak through 2007 and 2008, then falling off rapidly, recovering somewhat in 2011 and declining in 2012 (see Figures 2.9 and 2.10). In contrast, EU and US long-term price indices continued to rise until 2011 before levelling off in 2012 and then starting to decline until 2015. Fluctuations in these indicators do not rival the peak in spot market in 2007 and 2008 or the degree of declining prices since 2011 since they reflect contract arrangements made earlier under different price regimes. The Australia average export price has generally followed the trend of other long-term price indices, but with greater variation since it is a mix of spot and long-term contract prices. Depending on the nature of the purchases (long-term contracts versus spot market), the information available indicates that prices ranged between USD 96/kgU and USD 120/kgU (USD 37/lbU_3O_8 and USD 46/lbU_3O_8) in late 2015.

Figure 2.9. Uranium prices: 1982-2015



Source: Australia, Canada, ESA, Niger and the United States.

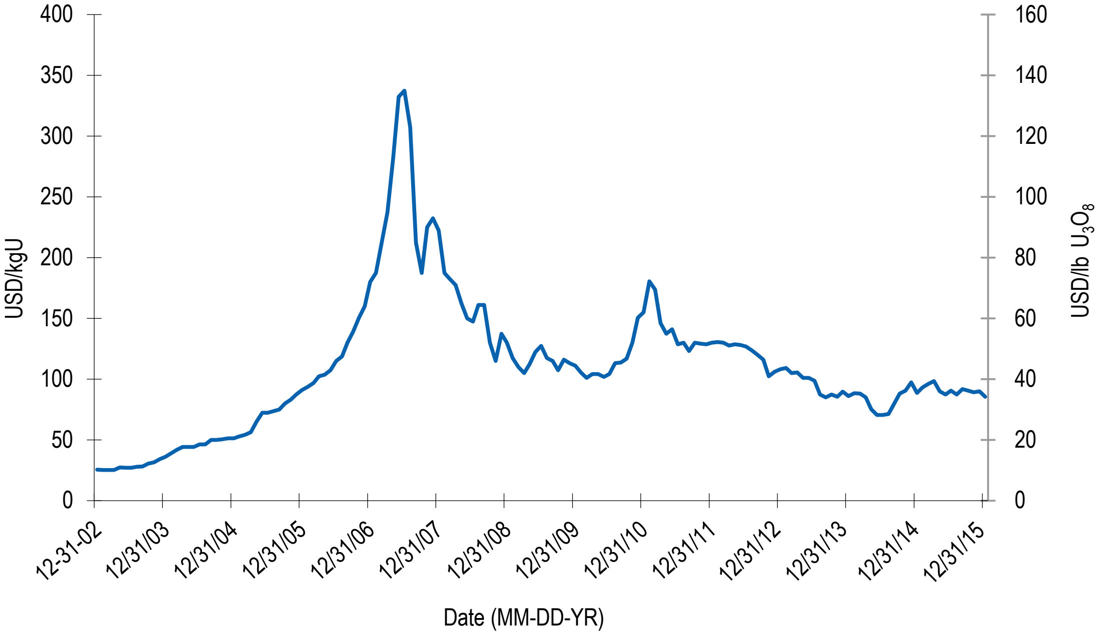
1. Euratom (ESA) prices refer to deliveries during that year under multi-annual contracts.
2. Beginning in 2002, Natural Resources Canada (NRCan) suspended publication of export prices pending policy review.

In addition to this information from government and international sources, spot price indicators for immediate or near-term delivery (less than one year) that typically amount to 15% to 25% of all annual uranium transactions, are provided by the industry trade press, such as TradeTech and the Ux Consulting Company LLC (UxC). While the trend of increasing prices outlined above is evident for spot market transactions since 2002, and in particular after 2004, the spot price shows more volatility than long-term price indicators since 2006 (see Figure 2.10). In June 2007, the spot market price reached as high as USD 136/lb U_3O_8 (USD 354/kgU) before declining to USD 40.50/lb U_3O_8 (USD 105/kgU) in February 2010. It recovered to USD 72.25/lb U_3O_8 (USD 188/kgU) at the end of January 2011, before declining to USD 34.20/lb U_3O_8 (USD 89/kgU) at the end of 2015 (see Figure 2.10).

A variety of factors have been advanced to account for the spot price dynamics between 2003 and 2015, including problems experienced in nuclear fuel cycle production centres that highlighted dependence on a few critical facilities in the supply chain, as well as changes in the value of the US dollar, the currency used in uranium transactions. In addition, the expected expansion of nuclear power generation in countries such as China, India and Russia, combined with the recognition by many governments of the role that nuclear energy can play in enhancing security of energy supply, contributed to the strengthening market through 2007. The influence of speculators in the market helped accelerate upward price movement at this time. The downturn in the spot price since June 2007 began with the reluctance on behalf of traditional buyers to purchase at such high prices and the global financial crisis that stimulated sales by distressed sellers needing to raise capital.

Figure 2.10. Uranium spot price dynamics

(NUEXCO exchange value trend, 2002-2015)



Source: Trade Tech (www.uranium.info).

In late 2007, the uranium spot price began a gradual decline that settled in the USD 40/lb U_3O_8 (USD 104/kgU) to USD 50/lb U_3O_8 (USD 130/kgU) range in 2009. Proposed US government inventory sales appeared to offset rising demand as government programmes in China and India to increase nuclear generating capacity began to be implemented. In the second half of 2010, the spot price began to rally once again on news that China was active in the long-term market, stimulating speculative activity on perceptions of tightening supply-demand. However, the Fukushima Daiichi accident precipitated an initial rapid decline in price that has continued more gradually through to the end of 2014. Reactor requirements dropped considerably, largely because reactors were shut down in Germany, Japan and the United States. Projects to increase uranium production, implemented before the accident, resulted in increasing production even as demand weakened and the market became saturated with supply, putting further downward pressure on prices through to the end of 2015. In addition, the excess uranium inventories and the decline in uranium needs as a result of the substitution of enrichment (underfeeding) contributed to the downdraught in uranium prices.

The uranium market was also impacted by macroeconomic trends. The strengthening of the US dollar in 2014, especially in relation to the currencies of major uranium producers (e.g. Canadian dollar, Kazakh tenge, Russian rouble and South African rand) contributed to the uranium price volatility. Non-US mining companies have benefited from USD appreciation against these currencies, as most of their operating costs, including labour, are in their domestic currencies. This allowed them to keep operating the mines despite falling uranium market prices, expressed in US dollars. The uranium market is also sensitive to the falling oil and natural gas prices. On the supply side, lower fuel costs mean savings for uranium producers. However, on the demand side, it can lead to premature shutdowns of operating nuclear reactors and a strong competition for potential new build.

Regarding the uranium market, evolution could be pushed further by developments on both the demand and supply side. Demand factors include Japanese restarts and successful global new builds. On the supply side, uranium production levelling off in the short term, as well as possible limitations on government inventories are viewed as critical considerations. When looking at the longer-term outlook, there is a general agreement that nuclear growth is likely to continue. Asia and the Middle East are the most critical markets for new reactors, and new uranium production will be needed in the coming decades. However, new uranium supply capacity would need the right price signals for producers to make investments.

Policy measures in the EU and uranium prices

Since its establishment in 1960 under the Euratom Treaty, the ESA has pursued a policy of diversification of sources of nuclear fuel supply in order to avoid overdependence on any single source. Within the European Union, all uranium purchase contracts by EU end users (i.e. nuclear utilities) must be approved by the ESA. Based on its contractual role and its close relations with industry, the ESA monitors the market with a particular focus on supplies of natural and enriched uranium to the EU. The ESA continues to stress the importance of maintaining an adequate level of strategic inventory and using market opportunities to increase inventories, where possible. It also recommends that utilities cover the majority of their needs under long-term contracts and continues with efforts to promote transparency and predictability in the market.

Nuclear materials for EU reactors came from diverse sources in 2014 (ESA, 2015). Kazakhstan-origin uranium supplied 26.7% of the natural uranium included in fuel loaded in the EU reactors, followed by Russia (18%), Niger (14.7%), Australia (13.5%) and Canada (12.6%). European uranium delivered to EU utilities originated in the Czech Republic and Romania, covering approximately 2.3% of the EU's total requirements. These deliveries were made under terms and conditions contained in a number of contracts of variable duration, with 96.5% of total deliveries covered under long-term contracts and 3.5% under spot market contracts. In 2014, the ESA processed a total of 81 contracts and amendments, of which 73% were new contracts.

Since uranium is sold mostly under long-term contracts and the terms are not made public, the ESA traditionally published two categories of natural uranium prices on an annual basis, i.e. multi-annual and spot, both being historical prices calculated over a period of many years. With at least some uranium market participants seeking greater price transparency, the ESA introduced a new natural uranium multi-annual contracts index price (MAC-3) in 2009. This index price, developed to better reflect short-term changes in uranium prices and to more closely track market trends, is a three-year moving average of prices paid under new multi-annual (long-term) contracts for uranium delivered to EU utilities in the reporting year.

In 2014, the MAC-3 average price index was EUR 93.68/kgU (USD 47.87/lbU_3O_8), an increase of 11% from 2013, and the multi-annual contract price decreased by 8% over the same period to EUR 78.31/kgU (USD 40.02/lbU_3O_8). The average spot price for deliveries in 2014 decreased by 5% from 2013 to EUR 74.65/kgU (USD 38.15/lbU_3O_8), (see Table 2.10). In 2014, spot price data and the multi-annual contract prices were widely distributed. On average, the multi-annual contracts which led to deliveries in 2014 had been signed 8 years earlier, in contrast to spot contract deliveries that are concluded over a maximum period of 12 months (ESA, 2015).

Since uranium is priced in US dollars, fluctuation of the EUR/USD exchange rate influences the level of the price indices calculated. In 2015, depreciation of the EUR/USD exchange rate resulted in an increase of ESA spot and long-term prices expressed in euros while the USD-denominated prices for the two indices did not change significantly. In addition, the MAC-3 price index fell substantially only when expressed in US dollars (see Table 2.10).

Table 2.10. ESA average natural uranium prices (2009-2015)

Year	Multi-annual contracts		Spot contracts		New multi-annual contracts (MAC-3)	
	EUR/kgU	*USD/lb U_3O_8*	*EUR/kgU*	*USD/lb U_3O_8*	*EUR/kgU*	*USD/lb U_3O_8*
2009	55.70	29.88	77.96	41.83	63.49	34.06
2010	61.68	31.45	79.48	40.53	78.12	39.83
2011	83.45	44.68	107.43	57.52	100.02	53.55
2012	90.03	44.49	97.80	48.33	103.42	51.11
2013	85.19	45.32	78.24	39.97	84.66	43.25
2014	78.31	40.02	74.65	38.15	93.68	47.87
2015	94.30	40.24	88.73	37.87	88.53	37.78

Source: ESA, 2015.

Supply and demand to 2035

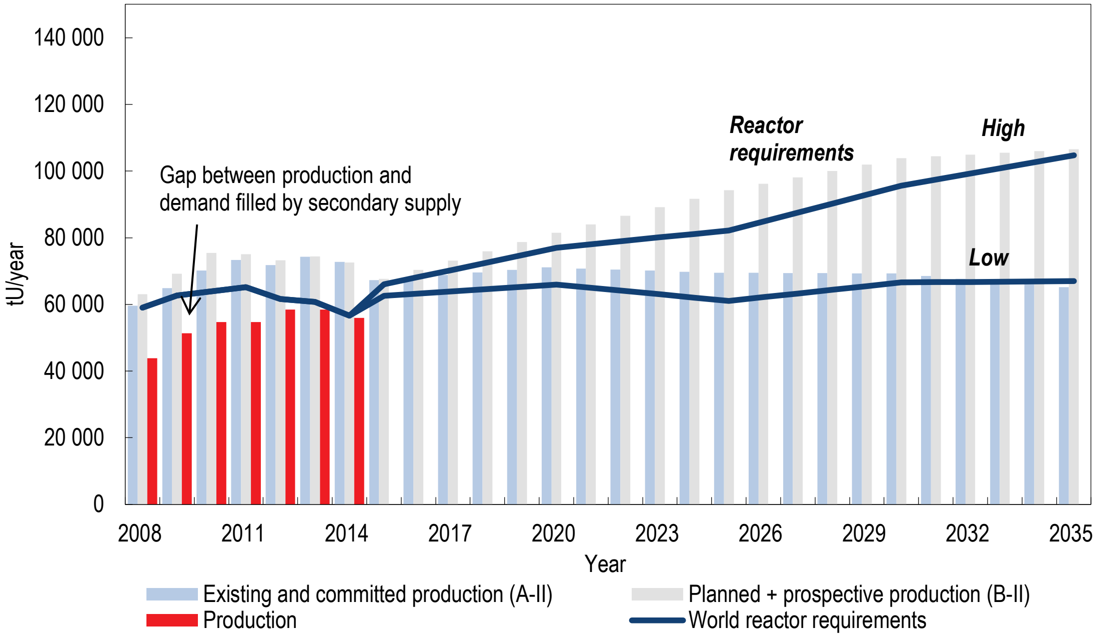
Market conditions are the primary driver of decisions to develop new or expand existing primary production centres. Market prices have generally increased since 2003, and even with declining prices since the onset of the financial crisis and following the Fukushima Daiichi accident, plans for increasing production capability continued through 2014. A number of countries, notably Australia, Brazil, Canada, Kazakhstan, Namibia, Niger and Russia, have plans for significant additions to future production capability. Some other countries, notably Botswana, Mongolia, Tanzania and Zambia, are working towards producing uranium in the near future. These developments are important as global demand is projected to increase in the longer term, and secondary sources are expected to decline somewhat in availability.

However, with rising mining and development costs and the long pause in nuclear development following the Fukushima Daiichi accident, along with the continuing decline of market prices through 2015, delays in some of the planned mine developments have been announced and more could follow should prices decline further. Uranium production has also slowed at a number of existing facilities because of poor market conditions. The most significant of these changes were the cessation of production at Kayelekera in Malawi, at Alta Mesa in the United States, at Honeymoon and Beverley/Beverley North in Australia and at Azelik mine in Niger. Meanwhile, the Willow Creek and Palangana mines in the United States are facing a situation where no new capital is being invested into developing new wellfields. A return to more favourable market conditions should see at least some of the delayed projects reactivated in order to ensure supply to a growing global nuclear fleet. Since several of these projects have advanced through regulatory and other development steps, the time required to bring these facilities into production should be reduced overall, and production will likely be able to respond more rapidly to increasing demand.

Despite some uncertainties and challenges in raising investment for mine development, producers have moved to increase production capability in recent years and governments are laying the groundwork (e.g. legislation and regulations) for mine development in countries that have not previously hosted uranium production. However, should uranium demand increase as projected, producers still face a number of significant and unpredictable issues in bringing new production facilities on stream, including geopolitical factors (e.g. from the moratorium on uranium mine development in the province of Quebec, Canada, to terrorist attacks and kidnappings in Niger), technical challenges and risks at some facilities (e.g. Cigar Lake, Canada), the development of more stringent regulatory requirements, heightened expectations of governments hosting uranium mining (e.g. increased taxes and contributions to regional socio-economic development) and generally increasing mining costs.

As reactor requirements are projected to rise through 2035, an expansion of production capability is also projected to occur (see Figure 2.11). As of 1 January 2015, these mining expansion plans, if successfully implemented, would cover high case demand requirements throughout this period, even without secondary supplies. The secondary supplies have met from 1% to 50% of annual requirements between 2000 and 2015 (see Figures 2.11 and 2.7). As noted above, secondary sources can be expected to continue to be a source of supply for some years to come, despite the end of the Russian-US programme to blend down HEU.

Figure 2.11. Projected world uranium production capability to 2035 compared with reactor requirements*



Source: Tables 1.26 and 2.4.

* Includes all existing, committed, planned and prospective production centres supported by reasonably assured resources and inferred resources recoverable at a cost of <USD 130/kgU. Does not include the secondary supply forecast.

If all existing and committed mines produce at or near stated production capability, high case demand is projected to be met through 2017 (without taking into account the secondary supplies estimated at over 10 000 tU/yr for the next two decades). If planned and perspective production capability is included, high case demand requirements are projected to be met through 2035. Planned capability from all existing and committed production centres is projected to satisfy low case requirements through 2033 and about 60% of high case requirements in 2035. With the inclusion of planned and prospective production centres, primary production capability would more than satisfy low case requirements through 2035. However, mine production is rarely more than 85% of mine production capability and, as noted above, several challenges will need to be overcome in order for all planned and prospective uranium projects to be successfully brought into production.

The total identified uranium resource base in 2015 is more than adequate to meet even optimistic (high case) projections of growth in nuclear generating capacity. Meeting high case demand requirements would consume less than 30% of the total 2015 identified resource base by 2035 (resources recoverable at a cost of <USD 130/kgU). With the appropriate market signals, as significant new nuclear generating capacity is added, additional resources of economic interest are likely to be identified with additional exploration effort.

However, it should be noted that production capability is not production. The gap between production and requirements from 2008 (and earlier) to 2014 has been met by drawing down secondary supplies. In 2014, producers almost closed the gap between world production and reactor requirements, albeit with requirements temporarily depressed owing to reactor closures and idling of reactors in Japan following the Fukushima Daiichi accident. Maintaining production at the level required to meet reactor requirements in the coming years, particularly in light of declining market prices for uranium through 2015 and 2016, will be a challenge.

World production has never exceeded 89% of reported production capability (NEA, 2006) and since 2003 has varied between 70% and 84% of full production capability. In addition, delays in the establishment of new production centres can reasonably be expected, especially in the prevailing risk-averse investment environment. As always, technical and geopolitical challenges in the operating and developing mine and mill facilities will need to be effectively dealt with. These factors can be expected to reduce and/or delay development of planned and prospective centres. Hence, even though the industry has responded vigorously to the market signal of generally higher prices since 2003, compared to the previous 20 years, additional primary production will likely be required. After 2015, secondary sources of uranium are generally expected to decline somewhat in availability and reactor requirements will have to be increasingly met by primary production. Therefore, despite the significant additions to production capability reported here, bringing facilities into production in a timely fashion remains important. To do so, strong uranium market conditions will be fundamental to bringing the required investment to the industry.

A key uncertainty of the uranium market continues to be the availability of secondary sources, particularly the level of stocks available and the length of time remaining until those stocks are exhausted. Information on secondary sources of uranium, especially inventory levels, is in general not publicly available. However, the possibility that at least a portion of the potentially large inventory (including from the military) continues to make its way to the market after 2015 cannot be discounted. These uncertainties complicate investment decisions on new production capability.

It is clear that the generally stronger market of recent years (2003-2011), compared to the last two decades of the 20th century has driven exploration activity that has built up an important uranium resources base. However, history shows that periods of low prices for uranium and reliance on secondary supplies have had dramatic impacts on the industry in terms of consolidation of producers and significant reductions in primary production capability. Given the extent of known uranium resources, the challenge in the coming years is likely to be less one of adequacy of resources than adequacy of production capacity development resulting from poor market conditions.

The long-term perspective

Uranium demand is fundamentally driven by the number of operating reactors, which ultimately is driven by the demand for electricity. The role that nuclear energy will play in helping meet projected electricity demand will depend on government policy decisions affecting nuclear development and how effectively a number of factors discussed earlier are addressed (e.g. economics, safety, security of energy supply, waste disposal, environmental considerations). Public acceptance of the technology in some countries in the wake of the Fukushima Daiichi accident remains an issue that needs to be addressed.

The International Energy Agency (IEA) and the Nuclear Energy Agency (NEA) have noted that if governments follow the current path of current energy policy, severe climate change impacts can be expected, and greenhouse gas emissions from electricity production are at the heart of this issue (IEA, 2015; NEA, 2015a). Although energy efficiency policies are gaining momentum, and growth in renewable energy sources is continuing, economic implementation of carbon capture and storage has yet to be achieved. In setting a goal of stopping growth in emissions by 2020, several policy measures have been proposed: implementation of select energy efficiency policies, limiting the use of inefficient coal power plants, reducing methane emissions from upstream oil and gas facilities, phasing out fossil fuel subsidies and increasing investment in renewable energy technologies (IEA, 2015). The 2015 *World Energy Outlook* notes that global energy demand is set to grow by 32% from 2013 to 2040 in the central scenario (New Policies Scenario), driven primarily by India, China, Africa, the Middle East and Southeast Asia. Non-OECD countries account for all the increase in global energy demand, as demographic and structural economic trends, allied with greater efficiency, reduce collective consumption in OECD countries. Declines are led by the EU, Japan and the United States (IEA, 2015). The success of policy measures proposed to reduce emissions in the face of rising demand hinges on the transition from fossil-fuel to low-carbon generation sources. In the IEA New Policies Scenario, primary energy demand for all fuels grows through to 2040. Of this growth, renewables account for 34%, natural gas for 31%, nuclear for 13%, oil for 12% and coal for 10%. Despite some positive signs that a low-carbon transition is underway, energy-related CO_2 emissions are projected in the New Policies Scenario to be 16% higher by 2040.

The expansion of nuclear power is mainly policy driven and can be limited by public opposition and long permitting processes. Nuclear power plants also face challenges due to their large upfront capital costs and complex project management requirements (IEA/NEA, 2015). However, nuclear energy can play a key role in decarbonising electricity systems by providing a stable source of low-carbon baseload electricity. Recognising the security of supply, reliability and predictability that nuclear power offers, and promoting incentives for all types of low-carbon electricity production, are key conditions for a faster deployment of nuclear power.

Several alternative uses of nuclear energy also have the potential to increase nuclear power installation worldwide, including desalination and heat production for industrial and residential purposes. The prospect of using nuclear energy for desalination on a large-scale is attractive since desalination is an energy intensive process that can make use of either the heat from a nuclear reactor and/or the electricity produced (NEA, 2008). About one-third of the world population lives in water stressed areas, mostly in Sub-Saharan Africa, the Middle East and South Asia, and with climate change, access to fresh water could become increasingly challenging (IAEA, 2013). In recent years, several governments have been actively evaluating the possibility of using nuclear energy for desalination (e.g. China, Jordan, Libya and Qatar), building on experience gained through the operation of integrated nuclear desalination plants in India, Japan and Kazakhstan. Global installed desalination capacity has more than doubled between 2004 and 2014, with the majority operating on fossil fuels.

Cogeneration, combining industrial heat applications with electricity generation, is not a new concept; some of the first civilian reactors in the world were used to supply heat as well as electricity. District heating using heat generated in reactors has been used in some countries for decades. Industrial process heating has also been used and potential for further development exists, but the extent to which reactors will be used for such applications will depend on the economics of heat transport, international pressure to reduce CO_2 emissions and national desires to reduce dependence on imported fossil fuels, as well as competition with alternative heat or combined heat and power (CHP) technologies (NEA, 2008). Participants at a workshop held in 2013 to identify technical and economic challenges to increased usage concluded that there is a proven record of operating non-electric applications of nuclear energy in the field of district heating and desalination and other areas, and although feasibility studies, lab-scale or prototype testing have been undertaken, significant industrial experience is lacking. It was also noted that since the public and decision makers are not sufficiently aware of the potential of non-electric applications of nuclear energy, better communication practices should be developed (NEA/IAEA, 2013).

Energy use for transport, which is projected to continue to grow rapidly over the coming decades, is also a major source of greenhouse gas emissions. Both electric and hydrogen-fuelled vehicles are seen as potential replacements for those powered by fossil fuels. Nuclear energy offers baseload electricity production that could be used to power electric vehicles; it also has the potential of producing hydrogen on a massive scale that could make this alternate energy carrier available with significantly less greenhouse gas emissions compared to current methods of hydrogen production (IAEA, 2013).

Small modular reactors (SMRs), with capacities generally in the range 30-300 MWe, could be suitable for areas with small electrical grids and for deployment in remote locations. SMRs offer smaller upfront investment costs and reduced financial risks compared to larger reactors typically being built today (1 000-1 700 MWe) and may be deployed as alternatives to larger nuclear power plants where such plants cannot be built, or to fossil-fired plants of similar sizes. The technical feasibility, the economic aspects and the factors affecting the competitiveness of SMRs are described in a recent NEA report (NEA, 2011). A number of SMR designs are under development (e.g. SMART, mPower and NuScale), others are undergoing licensing and examples are under construction in Argentina (CAREM) and in Russia (KLT-40s). The US DOE began a cost sharing programme in 2012 under a licensing technical support programme that has provided funding to NuScale and to B&W mPower (DOE, 2012). Only the NuScale partnership is active today.

Multilateral fuel cycle initiatives also have the potential to impact uranium demand. Driven by rising energy needs, non-proliferation and waste concerns, governments and the IAEA have made a number of proposals aimed at strengthening non-proliferation by establishing multilateral enrichment and fuel supply centres.

In December 2010, the first LEU reserve was inaugurated in Russia at the International Uranium Enrichment Centre in Angarsk under IAEA auspices. This LEU reserve is comprised of 120 t LEU in the form of UF_6 enriched to 2%-4.95% ^{235}U. Under IAEA safeguards, the reserve will be made available to IAEA member states (in good standing) whose supplies of LEU are disrupted for reasons unrelated to technical or commercial issues. It is to be made available for nuclear power generation at market prices, and the proceeds are to be used to replenish the LEU stock. Russia is covering the cost of LEU storage, maintenance, safety, security and safeguards. The LEU reserve is not intended to distort the functioning of the commercial market, but rather to reinforce existing market mechanisms of member states.

Also in December 2010, the IAEA Board of Governors authorised the IAEA Director-General to establish a LEU bank (owned and operated by the IAEA) to serve as a supply of last resort for nuclear power generation. The IAEA reserve, expected to be about half the size of the Russian LEU reserve, is to be a backup mechanism to the commercial market in the event that an eligible member state's supply of LEU is disrupted and cannot be restored by commercial means. The plan is to have sufficient LEU in the bank to meet the fuel fabrication needs for three 1 000 MWe light-water reactor reloads. Donors have pledged about USD 125 million and EUR 25 million to cover the estimated initial operational expenses, and the purchase and delivery of the LEU to a host state or states. In May 2015, Kazakhstan signed a draft agreement with the IAEA to host the IAEA LEU bank at the Ulba Metalurgical Plant.

In March 2011, the IAEA approved a proposal for nuclear fuel assurance led by the United Kingdom, co-sponsored by the member states of the EU, Russia and the United States. This initiative is designed to ensure that a commercial contract for nuclear fuel is not interrupted for non-commercial reasons. Although no stockpile of fuel is involved, contractual agreements between supplier and recipient states are proposed. As a response to this initiative, Germany proposed the establishment of a multilateral uranium enrichment plant administered by the IAEA, referred to as the Multilateral Enrichment Sanctuary Project (MESP). The proposal foresees the construction of one or more enrichment facilities under the exclusive supervision of the IAEA. The MESP is designed to allow independent access to nuclear fuel cycle services, complementing other proposals on assurances of supply of nuclear fuel.

In August 2011, the DOE announced that the American Assured Nuclear Fuel Supply Programme had been established to secure 230 t LEU, sufficient for six reloads of an average 1 000 MWe reactor, derived from the downblending of the 17.4 t HEU. The fuel will be available for use in civilian reactors by nations that are not pursuing uranium enrichment and reprocessing technologies. Qualifying countries will have access to the fuel at the current market price only in the event of an emergency that disrupts the normal flow of fuel supply.

Technological developments also promise to be a factor in defining the long-term future of nuclear energy and uranium demand. Advancements in reactor and fuel cycle technology are not only aimed at addressing economic, safety, security, non-proliferation and waste concerns, but also at increasing the efficiency of uranium resource use. The introduction and use of advanced reactor designs would also permit the use of other materials as nuclear fuel, such as uranium-238 and thorium, thereby expanding the available resource base. Fast neutron reactors are being developed to make more efficient use of the energy contained in uranium.

Many national and several major international programmes are working to develop advanced technologies, for example the Generation IV International Forum (GIF) and the IAEA International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). GIF gathers Argentina, Brazil, Canada, China, France, Japan, Korea, Russia, South Africa, Switzerland, the United Kingdom, the United States and Euratom, and more recently Australia. Since its launch in 2000, GIF has been working to carry out the research and development needed to establish the feasibility and performance capabilities of the next generation (Gen IV) reactor designs. These designs have stated objectives of safety, economics, sustainability and non-proliferation. In 2002, GIF reviewed 130 proposals and selected 6 nuclear energy system concepts to be the focus of continued collaborative research and development. These concepts are the sodium-cooled fast reactor, the very-high-temperature reactor, the supercritical-water-cooled reactor, the lead-cooled fast reactor, the gas-cooled fast reactor and the molten salt reactor. In 2014, the *Technology Roadmap* was updated, taking into account plans to accelerate the development of some technologies by deploying prototypes and demonstrators within the next decade. The two systems that are the focus of the most active research efforts are the sodium-cooled fast reactor and the very-high-temperature reactor. China has begun construction of a prototype high-temperature reactor while France and Russia are developing advanced sodium fast reactor designs for near-term demonstration. A prototype lead fast reactor is also expected to be built in Russia in the 2020 time frame. Many of the Gen IV concepts also have the potential to provide heat in addition to electricity, and therefore target other energy market sectors (such as hydrogen production).

Established in 2000, the objective of INPRO is to help to ensure that nuclear energy is available to contribute, in a sustainable manner, to energy needs in the 21st century. Many IAEA member states along with the European Commission are engaged in the INPRO project and several other member states or international organisations are observers in INPRO meetings. Holders and users of nuclear technology are being brought together to consider international and national actions that would produce the innovations required in nuclear reactors, fuel cycles or institutional approaches. INPRO assists member states in building national long-range nuclear energy strategies and making informed decisions on nuclear energy development and deployment. One INPRO initiative included a study of the potential role that thorium could play in supplementing the uranium-plutonium fuel cycle, concluding that sufficient knowledge and experience is available for the feasible implementation of a “once-through” thorium fuel cycle. Other initiatives included a study of the performance of passive safety systems in advanced water-cooled reactors, an investigation into load-following capabilities of innovative reactor designs, drivers and impediments for regional co-operation on nuclear energy systems and long-term prospects for nuclear energy following the Fukushima Daiichi accident.

In the long-term future, new reactor designs may bring fundamental changes in the nuclear fuel landscape.

Conclusion

As documented in this volume, sufficient uranium resources exist to support continued use of nuclear power and significant growth in nuclear capacity for electricity generation and other uses in the long term. Identified resources,[8] including reasonably assured resources and inferred resources, are sufficient for over 135 years, considering uranium requirements of about 56 600 tU (data as of 1 January 2015). If estimates of current rates of uranium consumption in power reactors[9] are used, the identified resource base would be sufficient for over 160 years of reactor supply. Exploitation of the entire conventional resource[10] base would increase this to well over 240 years, though uranium exploration and development, motivated by significantly increased demand and market prices, would be required to move these resources into more definitive categories.

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[8] Identified resources include all cost categories of reasonably assured resources and inferred resources for a total of about 7 642 000 tU (see Table 1.2).

[9] Uranium usage per TWh is taken from the NEA publication *Trends in the Nuclear Fuel Cycle: Economic, Environmental and Social Aspects* (NEA, 2002). It was used to define how much electricity could be generated for the given levels of uranium resources. Years of generation were then developed by factoring in the 2014 generation rate (2 432 TWh net, see Table 2.2) and rounding to the nearest five years.

[10] Total conventional resources include all cost categories of reasonably assured, inferred, prognosticated and speculative resources for a total of about 13 390 000 tU (see Tables 1.2 and 1.14). This total does not include secondary sources or unconventional resources, e.g. uranium from phosphate rocks.

The uranium resource base described in this document is more than adequate to meet projected growth requirements to 2035. Meeting projected low case requirements to 2035 would consume about 25% of the identified resources available at a cost of <USD 130/kgU and less than 20% of identified resources available at a cost of <USD 260/kgU. Meeting high case growth requirements to 2035 would consume about 30% of identified resources available at a cost of <USD 130/kgU and more than 20% of identified resources available at a cost of <USD 260/kgU. Given the limited maturity and geographical coverage of uranium exploration worldwide, there is considerable potential for the discovery of new resources of economic interest. As clearly demonstrated in the last few years, with appropriate market signals, new uranium resources can be readily identified and mined.

As noted in this report, there are also considerable unconventional resources, including phosphate deposits and black schists/shales that could be used to significantly lengthen the time that nuclear energy could supply energy demand using current technologies. However, more effort and investment would need to be devoted to better defining the extent of this potentially significant source of uranium and developing cost-effective extraction techniques.

Deployment of advanced reactor and fuel cycle technologies could also significantly add to world energy supply in the long term. Moving to advanced technology reactors and recycling fuel could increase the long-term availability of nuclear energy from hundreds to thousands of years. In addition, thorium, which is more abundant than uranium in the earth's crust, is also a potential source of nuclear fuel, if alternative fuel cycles are developed and successfully introduced in a cost-effective manner. Thorium-fuelled reactors have been demonstrated and operated commercially in the past.

Sufficient nuclear fuel resources exist to meet energy demands at current and increased demand well into the future. However, to reach their full potential, considerable exploration, research and investment will be required in order to develop new mining projects in a timely manner and to facilitate the deployment of promising technologies.

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Chapter 3. National reports on uranium exploration, resources, production, demand and the environment

Introduction

This chapter presents the national submissions on uranium exploration, resources and production. These reports have been provided by official government organisations (see Appendix 1) responsible for the control of nuclear raw materials in their respective countries, although the details are the responsibility of the individual organisations concerned. In countries where commercial companies are engaged in exploration, mining and production of uranium, the information is first submitted by these companies to the government of the host country and may then be transmitted to the NEA or the IAEA at the discretion of the government concerned. In certain cases, where an official national report was not submitted, and where it was deemed helpful for the reader, the NEA/IAEA has provided additional comments or estimates to complete this report. In such cases, "NEA/IAEA estimates" are clearly indicated.

It should be noted that exploration activities may be currently ongoing in a number of other countries that are not included in this report. In addition, uranium resources may have been identified in some of these countries. It is believed, however, that the total of these resources would not significantly affect the overall conclusions of this report. Nevertheless, the NEA and IAEA encourage the governments of these countries to submit an official response to the questionnaire for the next edition of the Red Book.

Finally, it should be noted that any map included herein is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Additional information on the world's uranium deposits is available in the IAEA online database *World Distribution of Uranium Deposits – UDEPO* (www-nfcis.iaea.org). UDEPO contains information on location, ranges of uranium tonnage and average grade, geological type, status, operating organisations (in case the deposit is being mined), and other technical and geological details about the deposits.

Thirty-seven member countries submitted a response to the questionnaire and the NEA/IAEA drafted twelve country reports. As a result, there are a total of 49 national reports in the following section.

Algeria

Uranium exploration and mine development

Historical review

Over the past 40 years, uranium exploration in Algeria, which began with the launching of the mineral prospecting programme in the Hoggar region, went through an initial phase (1969-1973) marked by a significant investment effort which led to the discovery of the first uranium deposits in the Hoggar Precambrian crystalline basement (Timgaouine-Abankor-Tinef).

These results, obtained through ground radiometric surveys and geological mapping, very swiftly identified the uranium mining potential of the Hoggar region which has highly promising geological and metallogenic properties.

The aerial magnetic and spectrometric survey of the entire national territory carried out in 1971 lent fresh direction and impetus to uranium exploration. The processing of the data collected in this survey identified potential regions for further uranium prospecting, including Eglab, Ouggarta and the Tin Serinine sedimentary basin (South Tassili; where the Tahaggart deposit was discovered), as well as individual sectors in Tamart-n-Iblis and Timouzeline.

While these developments were taking place, uranium prospecting entered into a new phase (1973-1981) primarily aimed and focused on the assessment of reserves and the exploitation of previously discovered deposits.

Despite a very sharp slowdown in prospecting activities in the following phase (1984-1997), the work undertaken in the immediate vicinity of the previously discovered deposits and in other promising regions revealed indications of uranium deposits and radiometric anomalies in the Amel and Tesnou zones situated in the north-west and north respectively of the Timgaouine region.

Surveys conducted in the Tin Seririne basin (Tassili south Hoggar) provided a basis on which to establish a geological map and revealed also the distribution of uranium-bearing minerals in Palaeozoic sedimentary formations.

Recent and ongoing uranium exploration and mine development activities

No uranium prospecting or mine development work was carried out between January 2013 and January 2015.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Reasonably assured resources in Algeria are of two geological categories: upper Proterozoic vein deposits in the western Hoggar and a deposit linked to the Precambrian basement and its Palaeozoic sedimentary unconformity in the central Hoggar. The first category includes vein deposits linked to the faults traversing the Pan-African batholith in the Timgaouine region, represented by the Timgaouine, Abankor and Tinef deposits of the south-west Ahaggar.

The second type is unconformity-related deposit represented by the Tahaggart, which is linked to the weathering profile (regolith) developed at the interface between the Pre-Cambrian basement and the Palaeozoic cover, and to the conglomerates at the base of the Palaeozoic sedimentary sequence in the Tin Seririne basin (south-east Hoggar).

It is worth noting that the uranium mineralisation discovered in the Ait Oklan-El Bema (north Hoggar) region have not been assessed in terms of uranium resources.

Undiscovered conventional resources (prognosticated and speculative resources)

Algeria does not report resources in any other category than RAR.

Uranium production

Historical review

Algeria does not produce uranium.

Regulatory regime

The protection of the environment in relation to mining activities is covered by the following legislation:

- Law No. 14-05 of 24 February 2014 on mining activities;
- Law No. 03-10 of 19 July 2003 on the protection of the environment for sustainable development.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

From a mining perspective, in a world market dominated in the short and medium term by a small number of producers, it is currently not economically feasible to exploit the uranium resources in Algeria.

Algeria's uranium resources can only be exploited in a sustainable manner as part of an integrated development of the nuclear sector and its main applications. The latter include in particular nuclear power generation and seawater desalination plants, together with applications in medicine, agriculture, water resources and industry.

With regard to the current situation in the global energy market, Algeria is working towards the integrated development of the uranium sector, ranging from exploration to production and encompassing research and development, training and long-term nuclear power generation prospects.

Gaining control over the uranium cycle and its applications would require the acquisition of technical expertise that can only be gained through ambitious research, development and training programmes. Through its nuclear research centres, Algeria currently has the appropriate tools in place to start work in the future, either alone or through bilateral or multilateral co-operation on these various research, development and training programmes.

It is in a spirit of openness and transparency that Algeria applied itself to the task of putting in place the most supportive and appropriate institutional and regulatory framework to provide a basis on which to pursue the energy development of the country, including a Mining Act, Electricity Act and Oil and Gas Act.

To straighten up the mining sector and boost research and mining exploration, the government resorted to the amendment of the Law 01-10 from 3 July 2001 by the enactment of Law 14-05 of 24 February 2014 of mining law.

This new law aims to create better conditions for the revival of the sector through adequate funding for research and exploration of new economically exploitable mining deposits.

Uranium stocks

None.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity				2 000
Granite-related				24 000
Total				**26 000**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	26 000
Total	**0**	**0**	**0**	**26 000**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	26 000
Total	**0**	**0**	**0**	**26 000**

* In situ resources.

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
0	0	Low	High	Low	High	Low	High	Low	High	Low	High
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Argentina

Uranium exploration and mine development

Historical review

Uranium exploration activities in Argentina began in 1951-1952, leading to the discovery of the Papagayos, Huemul, Don Otto and Los Berthos uranium deposits. During the late 1950s and the early 1960s, airborne surveys also led to the discovery of the Los Adobes sandstone deposits in Patagonia.

During the 1960s, the Schlagintweit and La Estela vein deposits were discovered and subsequently mined. During the 1970s, follow-up exploration in the vicinity of the previously discovered uranium occurrences in Patagonia led to the discovery of two new sandstone deposits: Cerro Condor and Cerro Solo. At the end of the 1980s, a nationwide exploration programme was undertaken to evaluate geological units with uranium potential.

The National Atomic Energy Commission (CNEA) selected the Cerro Solo sandstone-type uranium-molybdenum deposit to perform an assessment project in 1990, based on the deposit's promising grade. Mineralised layers are distributed in fluvial sandstone conglomerates belonging to the Cretaceous Chubut Group, at depths of 50 to 130 m.

An intensive exploration programme was developed in order to define the main morphological features of the orebodies and the mineralisation model, to update resource estimates and to select preliminary mining-milling methods in order to carry out an economic assessment of the project.

From 1990 to 1997, exploration was conducted in the vicinity of the Cerro Solo deposit (Chubut Province), where more than 56 000 m have been drilled to test the potential of favourable portions of the paleochannel structure. The results included the localisation and partial evaluation of specific mineralised bodies with a content of recoverable uranium resources estimated at 4 600 tU, taking into account reasonably assured resources and inferred resources.

These results allowed a pre-feasibility study on this U-Mo deposit. In consequence, CNEA developed a programme to complete a feasibility study of the Cerro Solo deposit, including exploration and evaluation of the surrounding areas.

Recent and ongoing uranium exploration and mine development activities

Government

As a consequence of the policy to reactivate the nuclear programme announced in August 2006 by the national government, active exploration/evaluation on the Cerro Solo ore deposits have been undertaken since 2007. From 2007 to 2014, a total of 44 469 m have been drilled into the main mineralised areas in the Pichiñán district, including 4 030 m of core which has been sampled for hydrometallurgical analyses. As of December 2012, the in situ identified uranium resources are 6 405 tU.

CNEA owns 64 exploration licences in Argentina, taking into account both requested and conceded exploration permits areas, statements of discovery and ore deposits. They are located within the provinces of Salta, Catamarca, La Rioja, San Juan, Mendoza, La Pampa, Río Negro, Chubut and Santa Cruz.

The most relevant uranium ore deposit in the assessment/exploration stage in Argentina is Cerro Solo, located in Chubut Province.

In order to have a better knowledge of the uranium resources located at Cerro Solo, exploration and assessment works have continued through drilling programmes. In 2013, in Sector B, 18 assessment drillings were carried out, totalling 2 329 m. In 2014, towards the west of Sector C and over the east border of Sector B, 7 drillings, for a total of 914 m, with core sample recovery were undertaken. Subsequently drilling was undertaken at La Volanta, located at the west of the aforementioned sectors, where a total of 1 666 m were drilled in ten exploration drill holes.

Within the period 2007-2014, a total of 36 931 m was drilled in 385 holes in the Cerro Solo Uranium District (former Pichiñán Este). It is worth mentioning that all drill holes were logged using caliper, long and short resistivity, spontaneous potential and gamma ray. Some tests were also performed with a sonic sonde and a recently acquired spectral gamma ray sonde.

To facilitate the proposed uranium concentrate production from mineralised sectors B and C of Cerro Solo deposit, data which includes topographic, mineralised-levels and geological-mining information in digital and analogical format, were transferred to the Raw Materials Production Management.

To define the hydrometallurgical extraction line of uranium and molybdenum mineral, laboratory-scale sample testing is nearly complete and further up-scale testing is being planned.

In situ uranium conventional resources (RAR and IR) estimated in sectors B and C of Cerro Solo deposit is 5 776 tU.

Other areas under study at Chubut Province are the Cuadrada Hill Uranium District, located in south-eastern part of the province, where at least four uranium mineralised areas were recognised. Three of them: Sierra Cuadrada, Sierra Cuadrada Sur and La Meseta are defined as “statements of discovery” (SD), which means that there is a legal document certifying the discovery of this new mine or mining area; and the last one is the Unión exploration area.

In the Cuadrada Hill Uranium District, a regional geological survey was carried out in an area of 4 000 ha with geological–radiometric data collection about three semi-regional profiles. Thereafter, four holes were drilled at SD Sierra Cuadrada (two) and Sierra Cuadrada Sur (two).

Two hundred kilometres north of the Cuadrada District, a discovery was made at the SD Mirasol Chico and El Cruce, where uranium ore is related to fluvial and lacustrine deposits of Cretaceous age. In the SD El Cruce, radiometric prospection works were followed by four drill holes with core sample recovery, resulting in 1 231 m (4 038 ft), and logged with downhole tools to obtain electric profiles. The core samples were used for lithological, chemical and radiometric determinations.

Finally, at SD Mirasol Chico the geological-topographic map was updated, covering an area of 2 000 ha (5 000 ac), in order to have a base map to locate the drillings in 2015. Also with this aim, some points of access were conditioned and some locations for drilling were built.

Regarding environmental preservation in the areas where exploration is conducted, monitoring networks are being implemented, adjusting the number of sampling points according to the knowledge and progress of the stage of the mining project.

From January 2012 to January 2015, the main activities at Cerro Solo ore deposit were related to environmental baseline studies and the development of hydrometallurgical tests. Among the first ones, hydrological, palaeontological, socio-economic studies, air quality, flora and fauna and pedological studies were finished. Others such as archaeological are currently being developed.

In the south of Argentina (Santa Cruz province), the main exploration works have focused on shallow low-grade uranium anomalies in six areas defined as a calcrete-type deposit, and within the Laguna Sirven area the focus is on defining the extension and continuity of uranium mineralisation to depths between 0.5 and 3 m.

At Laguna Sirven, laboratory hydrometallurgical tests have demonstrated that if the fine fraction can be separated (about 35% of the total volume) and concentrated, the original grade would be doubled.

In the Urcal and Urcuschun deposits, located in the Felipe Varela Department, La Rioja Province, uranium mineralisation is associated with limestone deposits from the Ordovician-aged San Juan Formation and is associated with chert and fault and fracture planes. It is also related to a sedimentary sequence from the Carbonic-Permian Paganzo group. Exploration activities included vertical and semi-regional detailed profile surveys, geological and topographic map updating, and old mining labour. Samples from mineralised zones have been taken in order to conduct metallogenic studies.

In a second stage, activities were focused on geophysical exploration by means of standard geoelectrical methods and through the implementation of the dipole-dipole method, assisted by an IAEA expert. Those works were the foundations for the design of the current drilling programme.

In the SD ALIPAN I, Velasco hill, La Rioja Province (defined as a granite-related U type, Perigranitic subtype deposit), systematic geochemical studies in new trenches were continued; two geological profile surveys with samples of water, rock and sediments were carried out, and geophysical exploration (audio-magnetotelluric and geoelectrical) to obtain structural and lithological information in depth was introduced. As a result, it was determined that the mineralised block occupies a “sloping” position towards the east over the oxidised sterile one.

For this area, there were 18 planned drillings, but only 3 of them have been executed (for a total of 885 m) as a result of anti-mining actions carried out by local authorities and non-governmental organisations since 2013.

Over the eastern side of Velasco hill, towards the north of SD ALIPAN I, a new area of exploration, called Lucero exploration area, is being studied. There, three zones with anomalies and evidence of surface uranium minerals were defined.

Gamma radiometric exploration airborne surveys have been carried out with CNEA’s equipment in four sites within the Córdoba hills, reintroducing the application of an exploration technique that was halted for decades.

In Vaquería hill, Salta province, and San Buenaventura hill, Catamarca province, an area of over 100 000 ha, which corresponds to 12 exploration areas, was liberated because it did not have the frequency and concentration of uranium mineralisation associated with Cretaceous-aged sandstone deposits that was expected.

In Mina Franca deposit, classified as granite-related U-type, Perigranitic subtype deposit, and located in Fiambalá hill, Catamarca province, surface systematic radiometric studies and structural-metallogenic maps are being conducted, while mineralogical analysis in the central and south sectors of Mina Franca are also being carried out. In 2015, surface geological reconnaissance activities are expected to be finished, so that the structural geological base map can be used to plan a drill pattern in order to define mineralisation at depth.

Simultaneously, a monitoring plan for water and sediment modules has been implemented as part of the baseline environmental survey. Moreover, communication programmes related to exploration activities in Fiambalá hill, and nuclear technology applications are being conducted in neighbouring populations and provincial offices.

With the aim of studying mineralisation behaviour in depth in the north and centre sectors of the Don Otto deposit, Salta province, classified as Cretaceous-aged sandstone-type U deposit, geophysical techniques (geoelectrical and magnetotelluric methods) were applied in order to collect subsoil data about the existing sequence stratigraphy and structures. Other activities conducted in Tonco valley included geomorphology studies, identification of depositional settings, lithological facies and ichnofacies; and an exploration drilling programme.

Evidence of uranium found in oil wells (and, to a lesser extent, known from surface data) is under analysis in five exploration areas near Catriel town, Río Negro province. Mineralisation is related to sedimentary deposits from the Neuquén basin, which could be classified as a sandstone-type uranium deposit. Exploration developed during the last two years involved the application of geophysical techniques including an audio-magnetotelluric (AMT) study and vertical electrical sounding (VES). These studies were complemented with geochemical exploration and geological radiometric reconnaissance programmes in semi-regional profiles. With the aim of obtaining wider knowledge about subsoil geology and identified uranium anomalies, a drilling programme will be implemented.

Similar activities as those aforementioned were also carried out recently in four exploration areas within the area of Las Mahuidas.

Within the exploration area in Gobernador Ayala, La Pampa province, some semi-regional geological recognition works, geochemical surveys and geophysical studies (AMT and VES) have been conducted. Information obtained from seven VES surveys were correlated to oil drilling records and revealed that there is a radiometrically anomalous level at a depth of less than 200 m. With this information, a drilling programme has been planned for the near future.

Private industry

There are six private uranium exploration companies in Argentina: Meseta Exploraciones S. A.; Sophia Energy S.A.; Minera Cielo Azul S.A.; Cauldron Minerals Ltd; Gaia Energy Argentina S.A. and Ur-America Ltd, all of which are currently members of the *Cámara Argentina de Empresas de Uranio* (CADEU – Argentine Chamber of Uranium Companies). CADEU reports 38 employees related directly to the industry (and 26 indirectly) at the end of 2012. No news has been reported for 2014.

The information about private exploration expenditures must be taken as only partially complete, as the industry is not required to report these expenditures to the government.

Of all private companies mentioned above, only Meseta Exploraciones S. A. (MEXSA), Sophia Energy S.A. and Ur-America Ltd were working with continuity until the end of 2013. The first two companies mentioned undertook uranium exploration in the south of the Chubut Province and in the north sector of Santa Cruz province, where exploration was focused on shallow low-grade uranium anomalies defined as a calcrete-type deposit.

In the Laguna Salada Project technical report of MEXSA, a subsidiary company of U_3O_8 Corporation, the following uranium resources were reported, 8.3 Mlbs U_3O_8 as indicated resources and 4.7 Mlbs U_3O_8 as inferred resources.

The other company, Ur-America Ltd, undertook an intensive underground exploration programme supported by drilling of 250 holes, for a total of approximately 24 000 m, on neighbouring areas of the Cerro Solo ore deposit, in the Chubut Province. They report 19.1 Mlbs eU_3O_8 as inferred resources.

Uranium resources

From governmental studies, there are no changes in reasonably assured, inferred and prognosticated resources since the last edition (2014 Red Book). Private companies have reported several changes, as reported above.

Uranium production

Historical review

Argentina produced uranium from the mid-1950s until 1999 with a total of seven commercial-scale production centres and a pilot plant that operated between 1953 and 1970. The closure of one of the last of these facilities in 1995 (Los Colorados) resulted in a change in the ownership structure of uranium production in Argentina, and since 1996 the uranium mining industry has been wholly owned by CNEA. The last facility that remained operative at that time, San Rafael, was placed on stand-by in 1999. Between the mid-1950s and 1999, cumulative uranium production totalled 2 582 tU.

Status of production facilities, production capability, recent and ongoing activities and other issues

Production projects

Argentina produced about 120 tU/year for about 20 years to provide raw material to fuel the nuclear power plants Atucha I and Embalse, with ore from different sites distributed throughout the national territory. But in the late 1990s, the decline in the international price of uranium made domestic production no longer competitive and the decision to shut down the remaining production plants and import uranium was taken. However, changes in recent years have caused CNEA to review its plans and consider reopening production facilities. These changes include mainly the uncertainties in future external supply and the impending increase in domestic uranium requirements to 265 tU/yr upon completion of the Atucha II reactor. In addition, the potential addition of two new nuclear power plants and the development of the new CAREM-25 reactor will further increase domestic uranium requirements.

The San Rafael Mining-Milling Complex Remediation and Reactivation Project

Once CNEA evaluated the possibility of reopening the production facilities of San Rafael mining-milling complex (Sierra Pintada mine), an environmental impact assessment (EIA-2004, according to provincial Act 5961) was presented to the authorities of the province of Mendoza and to the Nuclear Regulatory Authority. This study evaluated the potential impacts of uranium concentrate and dioxide production and the treatment of the former wastes simultaneously.

This EIA concluded that former operations had not affected the quality of underground and surface waters in the area, or any other environmental component in the surrounding area. Provincial authorities, nonetheless, rejected this proposal, arguing that CNEA must first remediate the open-pit water and the milling wastes stored in drums before restarting the production. In response, CNEA prepared and submitted a new EIA (2006) addressing only the treatment of wastes in temporary storage and pit water. This proposal received technical approval, but not final approval because it lacked the statutory public hearing. A further complication that increases the difficulty of reopening the plant is the approval of Mendoza Provincial Act 7722 (2007) that prohibits the use of sulphuric acid in mining activities.

Currently, CNEA is carrying out the construction of evaporation ponds and defining the basic engineering of the simultaneous treatment of open-pit water and milling wastes stored in San Rafael complex. To date, four effluent evaporation ponds have been finished and an update of the EIA 2006 (EIA, 2013) has been presented to the provincial control authorities.

CNEA secured sufficient funds for the rehabilitation works of uranium production facilities from the Bank for Investment Projects in the Ministry of Economy. Having an approved budget means that more time and resources can be devoted to addressing the remediation and rehabilitation works. These activities involve the removal of obsolete facilities, construction of effluent ponds, purchase of equipment and facilities, and other associated activities. Before the rehabilitation of uranium production in San Rafael, however, it is necessary to obtain both provincial approval and agreement to amend the provincial law that forbids the use of sulphuric acid.

The Cerro Solo Project

CNEA also continues to develop feasibility studies for the proposed mining of the Cerro Solo deposit (Chubut Province). Recently, laboratory-scale tests have been made in order to determine the most economically competitive milling process. Given that the ore contains not only uranium but also molybdenum, finding an appropriate and feasible process is a challenge. For this reason, all preliminary investigations have been critical steps in order to develop a profitable production plan. Recently, the conceptual engineering has been defined.

In the mining sector, a conceptual study was conducted using specific software for geological modelling. A pre-technical-economic feasibility study was completed, with prior validation of all information (grade, geotechnical, geostructural, hydrogeological) with some surface works.

Currently, governmental funds are intended to be used to carry out the basic engineering of both the mining operation and also the processing plant.

Besides technical considerations, a Chubut provincial law (5001/03) that prevents open-pit mining (very similar to the previously mentioned legislation in Mendoza) is still in effect. However, Chubut is considering splitting the province into regions, including one that would allow such operations and Cerro Solo is located in this proposed region.

Ownership structure of the uranium industry

In Argentina, the uranium industry is currently owned by the government. Private sector participation exists only in the exploration phase, even though legislation provides for the participation of both public and private sectors in uranium exploration and development activities.

Employment in the uranium industry

With continued development of the uranium production industry, the current number of employees is around 80, but this number is expected to increase slightly in the near future. At present, most employees are working on development, maintenance and remediation of the San Rafael mining-milling complex.

Future production centres

The strategic plan submitted by CNEA includes the development of a new production centre in the Chubut Province, in the vicinity of the Cerro Solo deposit. The beginning of operations is targeted for 2018 and the nominal production capacity is estimated at 200 tU/year.

Production and/or use of mixed oxide fuels

Argentina neither produces MOX fuel nor uses it in its nuclear power plants.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2
Name of production centre	San Rafael Mining-Milling Complex	Cerro Solo Deposit
Production centre classification	Stand-by	Planned
Date of first production	1976	2018
Source of ore:		
Deposit name(s)	Sierra Pintada	Cerro Solo
Deposit type(s)	Volcaniclastic	Sedimentary
Recoverable resources (tU)	6 000	N/A
Grade (% U)	0.107	N/A
Mining operation:		
Type (OP/UG/ISL)	OP	OP-UG
Size (tonnes ore/day)	550	N/A
Average mining recovery (%)	90	N/A
Processing plant:		
Acid/alkaline	Acid	Acid
Type (IX/SX)	IX	SX
Average process recovery (%)	78	N/A
Nominal production capacity (tU/year)	150	200
Plans for expansion	Yes	N/A
Other remarks	Stand-by since 1999	Preliminary stage

Production and/or use of re-enriched tails

The Mock-up facility for uranium enrichment located in Pilcaniyeu Technological Complex (Bariloche) is a pilot plant which operated in the 1980s and until mid-1990s (operations halted in 1995). The project was relaunched in 2006, restarting its activities in 2007.

The start-up of the operations took place in March 2014, enabling Argentina to produce enriched uranium by gaseous diffusion technology. CNEA aims to use this technology for supplying NPPs currently in operation, plus the projected ones, and for potential uranium exports. Furthermore, CNEA is currently developing other technologies such as ultra-centrifuge and laser.

Environmental activities and socio-cultural issues

Environmental impact assessments

In Argentina, production permits are subject to both, national and provincial legislation. At this moment, environmental studies are being undertaken in two major proposed future production projects.

The San Rafael Mining-Milling Complex Remediation Project (Mendoza province)

As stated in the 2014 edition of the Red Book, an update of the 2004 EIA (2006 EIA and MGIA-2013) was presented to the authorities of the province of Mendoza. This study addresses only the treatment of solid wastes, currently in temporary storage, and open-pit water. The original proposal (2006 EIA) received technical approval, but not final approval because it lacked the statutory public hearing. Final approval will be sought once the 2013-MGIA Edition receives technical endorsement. Nevertheless, CNEA has continued with some improvements in order to preserve the environment along with establishing additional security measures.

- Effluent pond "DN 8-9"

The construction of an evaporation pond (5 ha) with a double liner waterproof high-density polyethylene (HDPE) geo-membrane with a leakage detection system has been completed and hydraulic tests have been successful. CNEA is currently waiting for operational clearance from the provincial authorities.

- Effluent pond "DN 5"

Civil works for ground stabilisation are well advanced. The design of this precipitation facility complex aims to treat solid waste as well as open-pit water; engineering details have been submitted to the local authorities in order to determine the corresponding allowance and to continue with the works. These ponds have an operative capacity of ≈12 000 m^3, and will have security drainage systems and double waterproofing HDPE geo-membrane to control leaks. These ponds are designed for providing the necessary conditions (residence time) to generate As and Ra precipitates before they are conducted to the effluent pond "DN 8-9" for final disposal.

This facility also includes a uranium recovery stage in order to obtain a uranium free effluent.

There are other activities in progress related to waste management, such as waterproofing of cisterns, design of wastewater treatment systems, repairing of various facilities and the installation of pipes for pumping effluent between the quarries and the processing and treatment facilities.

Cerro Solo ore deposit (Chubut Province)

As requested by the provincial authorities, environmental baseline studies are being developed by CNEA through contracts with universities and institutes, and some parts of the studies (archaeological, palaeontological and socio-economic impact) have already been presented to the provincial authorities. In addition, CNEA continues with social communication activities, offering information on mining activities to the neighbourhoods located near the proposed mining projects and areas of exploration.

Monitoring

The San Rafael Mining-Milling Complex Remediation Project (Mendoza province)

CNEA's intense monitoring programme includes:

- Surface water: Systematic sampling of surface water: run-off, upstream and downstream of the facilities are undertaken in order to follow the evolution of possible pollutants concentration (U, As, Ra, among others) inside and outside CNEA's influence area.
- Groundwater: Systematic sampling of groundwater within a redesigned well network inside the complex is being carried out.
- Air pollution: Particulate matter and radon emissions are periodically sampled within key locations of the complex.

Cerro Solo ore deposit (Chubut Province)

The sampling effort includes water samples from exploration wells, water samples from domestic wells (owned by inhabitants of the area), surface run-off and sediment from streams and springs in the watershed (U, Ra, As, F, among others). Air pollution samples include particulate matter and radon emissions measurements.

Effluent management

The San Rafael Mining-Milling Complex Remediation Project (Mendoza province)

Civil works and engineering projects related to "DN 8-9 evaporation pond" and "DN 5" facility for treating open-pit water aim to reduce pollutants and meet provincial water quality standards. Moreover, the design and implementation of a domestic waste water treatment system is under study.

Site rehabilitation

The San Rafael Mining-Milling Complex Remediation Project (Mendoza province)

In general, CNEA is submitting technical proposals to rehabilitate those areas of the complex which will not be used for uranium production in the future. Some of these projects include: former tailing impoundment, open-pits rehabilitation and waste rock piles management.

Uranium Mining Environmental Restoration Programme

At present, CNEA is undertaking the Uranium Mining Environmental Restoration Programme (PRAMU). The aim of this programme is to restore the environment as much as possible in every place where uranium mining and milling activities took place. The sites being studied are: Malargue (Mendoza Province), Córdoba (Córdoba Province), Los gigantes (Córdoba Province), Huemul (Mendoza Province), Pichlñán (Chubut Province), Tonco (Salta Province), La Estela (San Luis Province) and Los colorados (La Rioja Province). PRAMU seeks to improve the current conditions of the tailings deposits and mines and to ensure the long-term protection of people and the environment. Furthermore, CNEA is required to comply with all legislation in force, and it is under the control of various national, provincial and local state institutions.

Regulatory activities

Argentina's provinces have legislation limiting certain aspects of mining activities (e.g. use of certain substances, open-pit mining). Local regulation co-exists with national legislation related to mining activities and environmental protection.

National regulations

Law No. 25 675: "General Environmental Law" establishes minimum standards for achieving a sustainable management of the environment, the preservation and protection of biodiversity and the implementation of sustainable development.

Law No. 1 919: "National Mining Code", which in Title Eleventh (Articles 205 to 212) refers to nuclear minerals.

Law No. 24 585: Obligation of submitting an environmental impact assessment (EIA) prior to each stage of development of a mining project. It sets the maximum acceptable limits of various effluent parameters in water, air and soil.

Mendoza provincial regulations

Law No. 3 790: It creates the Mining General Direction and states that its specific functions are the administration, control and promotion of the mining industry in all its phases and throughout the territory of the province.

Law No. 7 722: It prohibits, on the territory of the Mendoza province, the use of chemicals such as cyanide, mercury, sulphuric acid, and other similar toxic substances in the metalliferous mining processes or searching, prospecting, exploration, exploitation and industrialisation of metal ores obtained by any extraction method.

Resolution No. 778/96 of the General Department of Irrigation (DGI): It regulates all activities that may affect the quality of surface water and groundwater in the territory of the Province of Mendoza.

Chubut provincial regulations

Law XVII-No. 68: It prohibits the metalliferous open-pit mining activity in the Province of Chubut, as well as the use of cyanide in mining production processes. It also mentions the need of zoning the territory of the province for the exploitation of mineral resources with an approved production mode for each case.

Uranium requirements

The uranium requirements listed below correspond to an estimation made in the Strategic Nuclear Energy Planning 2010-2030 and the reactivation of the Argentine Nuclear Energy Plan launched in 2006. As from 2013, the nuclear plan includes:

- extending the life of Atucha I NPP;
- extending the life of Embalse NPP;
- construction of the 4th, 5th and 6th NPPs;
- development and construction of a small modular nuclear power reactor (CAREM);
- reactivation of uranium enrichment;
- reactivation of the uranium mining industry.

The most important update in Argentine nuclear production was the start-up of Atucha II (745 MWe), which went critical for the first time at the end of 2014.

Also proposed is the expansion of the nuclear energy field, which would be covered by means of the construction of a fourth NPP consisting of two PHWR-type reactors (CANDU 6) of 800 MWe each, which would start operations in 2020/2022. Two NPP of 1 000 MWe are also planned to start operations, one in 2024/2026 and the other in 2026/2028, both with PWR technology. In addition, CNEA is completing the development and construction of the CAREM-25 (25 MWe) prototype small modular reactor and is planning to build another two larger units, CAREM-150 (150 MWe), by 2032.

Within the 2015-2016 period, Embalse NPP will be inoperative while enabling its life extension process. Likewise, within the 2019-2020 period, Atucha I will be inoperative for the same reason. In consequence, in both scenarios (high and low), until 2020, the installed nuclear generating capacity will not suffer a significant change despite having a new facility already operative.

Supply and procurement strategy

Argentina is carrying out an exploration programme and it is developing projects for restarting domestic uranium production in order to achieve self-sufficiency in uranium supply.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The Nuclear Activity Law of 1997 establishes the respective roles of CNEA and the Nuclear Regulatory Authority. It also provides for the participation of both public and private sectors in uranium exploration and development activities.

The National Mining Code of 1994 states that the government has the first option to purchase all uranium produced in Argentina and that export of uranium is dependent upon first guaranteeing domestic supply. It also regulates development activities to ensure the use of environmental practices that comply with international standards.

Uranium stocks

Nowadays, CNEA does not have the responsibility of ensuring the uranium concentrate stock. The uranium dioxide producing company (Dioxitek S.A.) and the nuclear power plants operator (NA-SA) hold the responsibility of guaranteeing a uranium stock for at least two years of Argentina's nuclear power plants operation.

Uranium prices

There is no uranium market in Argentina.

Uranium exploration and development expenditures and drilling effort – domestic

(in Argentine pesos [ARS])

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	9 654 545	20 781 104	N/A	N/A
Government exploration expenditures	38 362 566	31 920 200	34 496 531	50 600 000
Total expenditures	**48 017 111**	**52 701 304**	**34 496 531**	**50 600 000**
Industry* exploration drilling (m)	17 185	6 815	N/A	N/A
Industry* exploration holes drilled	146	34	N/A	N/A
Government exploration drilling (m)	1 952	4 445	3 494	2 752
Government exploration holes drilled	13	29	24	27
Total drilling (m)	**19 137**	**11 260**	**3 494**	**2 752**
Total number of holes drilled	**159**	**63**	**24**	**27**

* Non-governmental.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone		2 890	4 599	4 599	72
Volcanic and caldera-related		2 240	4 000	4 000	72
Total		**5 130**	**8 599**	**8 599**	

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	180	180	72
Open-pit mining (OP)		5 130	8 419	8 419	72
Total		**5 130**	**8 599**	**8 599**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching* from UG	0	0	180	180	
Heap leaching* from OP	N/A	5 130	8 419	8 419	72
Total		**5 130**	**8 599**	**8 599**	**72**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone	1 951	2 201	3 762	4 812	72
Volcanic and caldera-related	480	1 800	6 170	6 170	72
Total	**2 431**	**4 001**	**9 932**	**10 982**	

Inferred conventional resources by production method

(tonnes U recoverable, assuming 72% mining and milling recovery)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	2 431	4 001	9 932	10 982	72
Total	**2 431**	**4 001**	**9 932**	**10 982**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP	2 431	4 001	9 932	10 982	72
Total	**2 431**	**4 001**	**9 932**	**10 982**	**72**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
N/A	13 810	13 810

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	56 432*	N/A

* Estimated over seven geological units.

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Sandstone	2 581.7	0	0	0	2 581.7	0
Total	**2 581.7**	**0**	**0**	**0**	**2 581.7**	**0**

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	1 858.7	0	0	0	1 858.7	0
Underground mining[1]	723.0	0	0	0	723.0	0
Total	**2 581.7**	**0**	**0**	**0**	**2 581.7**	**0**

1. Pre-2012 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrate)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	752.7	0	0	0	752.7	0
Heap leaching*	1 829.0	0	0	0	1 829.0	0
Total	**2 581.7**	**0**	**0**	**0**	**2 581.7**	**0**

* Also known as stope leaching or block leaching.

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	78	78	85	82
Employment directly related to uranium production	0	0	0	0

Short-term production capability

(tonnes U/year)

2015				2020				2025			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	150	0	0	0	150	100	0	0	N/A	N/A

2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	5.73	5.26

Installed nuclear generating capacity to 2035

(MWe gross capacity)

2013	2014	2015		2020		2025		2030		2035	
1 010	1 010	Low	High	Low	High	Low	High	Low	High	Low	High
		1 107	1 107	1 568	1 568	3 730	3 880	3 980	5 030	5 130	6 180

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
120	120	Low	High	Low	High	Low	High	Low	High	Low	High
		141	141	224	224	511	544	521	754	915	948

Armenia

Uranium exploration

Historical review

On 23 April 2007, the Director-General of Rosatom (a state corporation of Russia) and the Armenian Minister of Ecology Protection signed a protocol on the realisation of uranium exploration work in Armenia.

Based on this protocol, an Armenian-Russian joint venture CJ-SC Armenian-Russian Mining Company (ARMC) was established in April 2008 for the geological exploration, mining and processing of uranium. The founders of ARMC are the Armenian government and Atomredmetzoloto of Russia.

Within this framework, the collection and analysis of the archival material relevant to uranium mining has been completed. The document *Geologic Exploration Activity for 2009-2010* aimed at the uranium ore exploration in Armenia was developed and approved. According to this document, in the spring of 2009, field work related to uranium ore exploration was started in the province of Syunik.

The geologic prospecting works were carried out on the 1st Voghchi zone of the Pkhrut-Lernadzor licensed area in 2011. Geologic prospecting identified some anomalies. All plans for geologic prospecting in 2011 were fulfilled by January 2012. In 2012, legislated works were implemented.

Exploration of the block 1st Voghchi zone identified reserves of uranium ores classified in category C2. Calculations of inferred resources of the Voghchi zone of the Pkhrut deposit indicate that the deposit is prospective.

However, based on the investigation material provided, as well as for economic reasons, the activity of the Armenian-Russian joint venture was suspended in 2013.

Uranium production

In 2007, the Armenian government decided that Armenia would enter into an agreement with the governments of Kazakhstan and Russia to establish an international uranium enrichment centre (IUEC) at the Angarsk electrolytic chemical combine in Russia. Armenia completed the legal registration of accession and in 2010 joined the IUEC.

Armenia does not produce uranium.

Uranium requirements

There have been no changes to Armenia's nuclear energy programme during the past two years. The country's short-term uranium requirements remain the same and are based on the operation of one VVER-440 unit (Armenian-2). A detailed uranium requirements forecast was done, taking into account the designed lifetime for this reactor, which has an installed capacity of about 407.5 MWe.

The long-term requirements depend on the country's policy in the nuclear energy sector. According to the Armenian energy sector development plan, construction of a new nuclear unit with the capacity of about 1 000 MWe is envisaged in 2026, according to the high-level energy forecast option. The Ministry of Energy and Natural Resources released, in April 2011, the *Armenia New Nuclear Unit Environmental Report*.

Supply and procurement strategy

Nuclear fuel for the reactor of the Armenian NPP is supplied by Russia. Armenia's nuclear fuel requirements remained unchanged during the past two years. The procurement strategy has remained the same and the country's uranium supply position continues to be based on fuel procurement from Russia.

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	2.36	2.27

Installed nuclear generating capacity to 2035

(MW(e) net)

2013	2014	2015		2020		2025		2030		2035	
375	375	Low	High	Low	High	Low	High	Low	High	Low	High
		375	375	375	375	375	375	1 000	1 000	1 000	1 000

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2016		2020		2025		2030		2035	
64	64	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		64	64	64	64	64	64	64	64	154	154	154	154

Australia

Uranium exploration

Historical review

Australia is one of the world's largest producers and exporters of uranium. A review of the history of uranium exploration and mine development in Australia published in 2007 is provided in *Australia's Uranium: Resources, Geology and Development of Deposits*, available at: www.ga.gov.au/webtemp/image_cache/GA9508.pdf.

Recent and ongoing uranium exploration and mine development activities

Soft uranium prices and lower uranium exploration budget trends globally, mirrored declining levels of uranium exploration expenditure in Australia. Exploration expenditure for uranium dropped from AUD 189.6 million in 2011, to AUD 98.3 in 2012, then AUD 52.3 million in 2013 and to AUD 39.5 million in 2014, though a moderate upswing was recorded in the December quarter; as recorded by the Australian Bureau of Statistics. Uranium exploration tended to be around known resources and was carried out in Western Australia, the Northern Territory, South Australia and Queensland. Preliminary exploration was undertaken in New South Wales, with the grant of exploration licences pending.

Western Australia (WA)

Toro Energy continued the development of Western Australia's first uranium mine, Wiluna. The surficial calcrete-hosted regional resource for Wiluna contains more than 34 000 tonnes of U_3O_8 (as uranium oxide), sufficient to run the proposed mine for 25 years. The resource consists of six regional deposits. Of these, Centipede and Lake Way are approved for development. Deposits identified at Millipede, Lake Maitland, Dawson-Hinkler and Nowthanna are available for future development.

North-east of Wiluna, the proposed Kintyre uranium mine operated by Cameco received conditional approval from WA's Environmental Protection Authority early in 2015, pending further governmental approvals. The unconformity-related Kintyre deposit has a resource of more than 25 000 tonnes of U_3O_8. The Kintyre resource is suited to open-pit mining technology, with the uppermost parts of the resource 50 metres below surface, and there is no outcrop.

South Australia (SA)

SA has five approved uranium mines. Only two of these continued production through 2014 - Olympic Dam and Four Mile. Olympic Dam is Australia's largest mine, contributing around two-thirds of Australia's uranium production. Beverley and Beverley North remain approved and could produce again if the company chose to, for example if the uranium price was to increase. Production from Beverley and Beverley North ceased early in 2014 and pregnant solution from the Four Mile mine is being processed at Beverley. Honeymoon remains approved, although it is in care and maintenance.

SA's state government established a Nuclear Fuel Cycle Royal Commission into the potential for nuclear power in the state, due to report in May 2016. The activities of the commission relate to the potential for the expansion of exploration and extraction of minerals, and the undertaking of further processing of minerals and manufacture of materials containing radioactive substances, use of nuclear fuels for electricity generation and the storage and disposal of radioactive and nuclear waste.

Northern Territory (NT)

Ranger remains the only operating uranium mine in the NT. There has been continuous production and export of U_3O_8 from Ranger since 1980. During 2014, the operator of Ranger, Energy Resources of Australia (ERA) continued a revised drilling programme and released a resource update for the Ranger 3 Deeps project. This pre-feasibility study deals with supporting the proposed transition from open-cut to underground mining.

Queensland (Qld)

On 16 March 2015, the incoming Queensland government announced a plan to ban uranium mining in Queensland. The ban had been overturned by the previous government in 2014, at a time when no uranium mining had been undertaken for over 30 years.

New South Wales (NSW)

The incoming NSW government overturned the state ban on uranium exploration in 2012, and six companies were invited to apply for exploration licences. One company has submitted an application to explore for uranium north of the town of Broken Hill.

Uranium exploration and development expenditures – abroad

Through 2013 and 2014, several Australian mineral companies undertook exploration activities for uranium in Namibia and Malawi.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2015, Australia's total identified resources of uranium recoverable at cost of less that USD 130/kg U amounted to 1 814 674 tU, an increase of 6% compared with the estimate for 1 January 2013. Over this two-year period, additional resources were defined at known deposits; with the increase in total resources partly offset by the transfer of resources for some deposits into higher cost categories as a result of increases in the costs of mining and milling uranium ores in recent years. Capital costs have risen and labour costs in the mining industry increased at a higher rate than for other sectors of the economy as a result of a period of rapid growth in the Australian mining sector.

Estimated mining and processing losses were deducted from commercial uranium resource reports for individual deposits submitted under the Australian Joint Ore Reserves Committee (JORC) Code. Mining losses derived from company reports were generally 5-10% for open-cut mines and around 15% for underground mining methods.

Metallurgical recovery rates achieved by operating uranium plants were reported in company annual reports and these deductions were applied to JORC reserve and resource figures. These losses ranged from 14-28%. For in situ leach (ISL) operations, 25% losses were applied for acid leach and 35% for alkaline leach.

Although there are more than 35 deposits with identified resources recoverable at costs of less than USD 130/kg U, the vast majority of Australia's resources are within the following six individual deposits:

- Olympic Dam, the world's largest uranium deposit, and Carrapateena (SA);
- Ranger and Jabiluka in the Alligator Rivers region (NT);
- Kintyre and Yeelirrie (WA).

At the Olympic Dam mine, uranium is a co-product of copper mining; in addition gold and silver are also recovered. At the proposed Carrapateena Mine, uranium could be a co-product of copper mining with gold and silver resources also reported.

Undiscovered conventional resources (prognosticated and speculative resources)

Geoscience Australia does not make estimates of Australia's undiscovered uranium resources.

Unconventional resources and other materials

Geoscience Australia does not make or publish estimates of Australia's unconventional uranium resources.

Uranium production

Historical review

A review of the history of uranium production in Australia is provided in *Australia's Uranium Resources, Geology and Development of Deposits*, available at: www.ga.gov.au/image_cache/GA9508.pdf.

Status of production capability and recent and ongoing activities

By late 2014, Australia had three operating uranium mines: Ranger (NT), Olympic Dam and Four Mile (SA) with that operation's pregnant solution being processed at the Beverley plant. Total uranium mine production for 2014 was estimated by the Commonwealth Department of Industry and Science to be 6 686 tonnes, a 19% decrease on 2012 production of 8 265 tonnes of uranium.

Olympic Dam

Olympic Dam's production of payable metal in concentrate for 2014 was 3 988 tU, a slight drop on the previous year of 4 066 (2013) and an increase of 3.5% on the 3 853 tU produced in 2012. Based on a reserve life of 47 years and more than one million tonnes of uranium resource, the Olympic Dam uranium deposit is the largest single deposit in the world. The Olympic Dam deposit is the only known breccia complex deposit that has significant resources of uranium. Olympic Dam produces copper cathode, refined gold and silver bullion; along with uranium oxide. The wholly BHP Billiton-owned underground mine and plant utilises long hole open stoping technology and cemented aggregate fill, with integrated metallurgical processing. BHP Billiton reported in 2014 that a pre-feasibility study will be conducted regarding an expansion of the Olympic Dam project. An application for assessment was lodged with the Commonwealth and SA governments in July 2014 to construct and operate a demonstration plant on the existing mining lease at Olympic Dam. Proposed trials of heap leach technology should assist the company in assessing less capital intensive mineral processing technology for ore mined underground.

Ranger

The Ranger uranium mine produced 1 165 tonnes of U_3O_8 in 2014, 61% lower than the 2 960 tonnes of U_3O_8 produced in 2013, which in turn was 20% less than 2012 with a total of 3 710 tonnes. Ore was processed at the main metallurgical plant and the laterite treatment plant.

Energy Resources of Australia has produced uranium at Ranger since 1981, with more than 110 000 tonnes of U_3O_8 produced. Mining of Ranger Pit 3 concluded in December 2012, since that time ERA has processed stockpiled ore to produce uranium. Ranger 3 Deeps was discovered in 2009 and is estimated to contain over 34 000 tonnes of U_3O_8. Future production at Ranger hinges on approval for commercialisation of this resource through the implementation of underground mining technology. ERA invested around AUD 120 million in an exploration decline which was commenced in 2012 and completed in 2014, providing access to the resource for further analysis and assessment. Close space drilling of the resource should be completed later in 2015 and the company has allocated AUD 57 million to a pre-feasibility study for the underground mine.

Four Mile

Four Mile comprises two large sandstone-hosted uranium deposits, Four Mile West and Four Mile East, and is 75% owned by Quasar Resources (affiliate of Heathgate Resources) and 25% by Alliance Resources. In October 2012, the companies decided to recommence development of the project. The initial phase of operations consisted of pumping uranium-bearing solutions to the nearby satellite ion-exchange plant at the Pannikan deposit. The resin produced was trucked to Beverley processing plant for elution, precipitation and drying of the uranium concentrates.

The initial phase of ISL mining operations will allow actual production rates to be considered before full-scale production facilities are constructed.

Beverley/Beverley North

Beverley, which is about 550 km north of the SA capital, Adelaide, was established in 1990. Production commenced at the site in late 2000. Operated by Heathgate Resources, production from Beverley and Beverley North ceased in early 2014 and the project is now on care and maintenance. Processing of the product from the Four Mile mine is continuing at the Beverley plant. Government approvals for Beverley and Beverley North remain, and should commercial conditions change, the company could choose to recommence production.

Honeymoon

Operated by Uranium One (Rosatom), production at Honeymoon ceased in November 2013. The project is on care and maintenance, and government approvals remain, so operations could resume if market conditions permit. Pilot production at the Honeymoon ISL mine commenced in September 2011 and commissioning of the plant continued through 2012. Uranium-bearing solutions from the ISL operation were processed using solvent extraction technology at the processing facility, which has a design capacity of 340 tU per year.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4
Name of production centre	Ranger	Olympic Dam	Beverley/Beverley North	Honeymoon
Production centre classification	Existing	Existing	Existing	Existing
Date of first production	1981	1988	2000	2011
Source of ore:				
Deposit name(s)	Ranger No.3 Ranger Deeps	Olympic Dam	Beverley, Pepegoona, Pannikan and Four Mile	Honeymoon, East Kalkaroo
Deposit type(s)	Proterozoic unconformity	Polymetallic Fe-oxide Breccia Complex	Sandstone	Sandstone
Recoverable resources (tU)	68 548	1 067 350	Beverley 3 375 Pepegoona 630	2 030
Grade (% U)	0.06	0.025	0.18	0.109
Mining operation:				
Type (OP/UG/ISL)	OP[(a)]	UG	ISL	ISL
Size (t ore/year)	4.5 Mt	12 Mt	N/A	N/A
Average mining recovery (%)	90	85	65[(d)]	65[(d)]
Processing plant:				
Acid/alkaline	Acid	Acid	Acid	Acid
Type (IX/SX)	SX	FLOT, SX	IX	SX
Size (t ore/year); for ISL (litre/hour)	2.5 Mt/yr	12 Mt/yr	1.62 ML/h	Not reported
Average process recovery (%)	88	72	(d)	(d)
Nominal production capacity (tU/year)	4 660	3 820	850	340
Plans for expansion	No	Yes[(c)]	Yes[(e)]	No
Other remarks	(b)	N/A	(f)	

(a) Production by processing of Stockpile Ore from Pit 3. ERA is investigating the feasibility of underground mining of the Ranger 3 Deeps deposit.

(b) Processing of lateritic ores in a separate plant with capacity to produce 400 tU_3O_8 (340 tU) per annum.

(c) BHP Billiton reported in late 2014 that a pre-feasibility study will be conducted regarding an expansion of the Olympic Dam project. Proposed trials of heap leach technology should assist the company in assessing less capital intensive mineral processing technology for ore mined underground.

(d) Recovery includes combined losses due to ISL mining and hydrometallurgical processing.

(e) Approval has been granted to extend the capacity of the Beverley plant to produce 1 500 tU_3O_8 (1 270 tU) per year when the company decides it is commercially viable to do so.

(f) Satellite ISL operations at the Pepegoona and Pannikan (including Four Mile) deposits. Uranium resins from satellite ion-exchange plants are trucked to Beverley for further processing.

Uranium production centre technical details *(cont'd)*

(as of 1 January 2015)

	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	Four Mile	Yeelirrie	Wiluna	Kintyre
Production centre classification	Existing	Planned	Planned	Pre-feasibility
Date of first production	Late 2013	Not known	2017	N/A
Source of ore:				
Deposit name(s)	Four Mile	Yeelirrie	Centipede, Lake Way	Kintyre
Deposit type(s)	Sandstone	Calcrete	Calcrete	Proterozoic Unconformity
Recoverable resources (tU)	15 740(g)	44 500	24 889	21 050
Grade (% U)	0.32	0.13	0.088	0.58
Mining operation:				
Type (OP/UG/ISL)	ISL	OP	OP	OP
Size (tonnes ore/year)	N/A	N/A	2 Mt per year	N/A
Average mining recovery (%)	65	N/A	90	N/A
Processing plant:				
Acid/alkaline	Acid	Alkaline	Alkaline	Alkaline
Type (IX/SX)	(h)	(j)	IX	N/A
Size (t ore/year); for ISL (litre/hour)	N/A	N/A	N/A	1 700
Average process recovery (%)	N/A	N/A	85	80
Nominal production capacity (tU/year)	(h)	N/A	850(k)	N/A
Plans for expansion	No	No	No	No
Other remarks	(i)			

(g) Four Mile comprises Four Mile West and Four Mile East, product trucked to the Beverley processing plant for elution, precipitation and drying as uranium concentrate.

(h) Uranium-bearing resin from Four Mile will be treated at the Beverley plant to recover uranium.

(i) Uranium will be captured at Heathgates' Pannikan satellite IX plant. Resin will be trucked to the Beverley plant for elution and precipitation.

(j) The company is investigating several options for processing the ores including tank leaching with ion exchange and heap leaching with ion exchange.

(k) Planned production of 1 200 t per year of $UO_4.2H_2O$ which equates to 850 tU per year.

Ownership of uranium production

Australia's uranium mines are owned and operated by a range of domestic and international companies:

- The Ranger uranium mine is owned by Energy Resources of Australia Ltd which is owned by Rio Tinto (68.4%) with the remaining capital held publicly.
- The Olympic Dam mine is fully owned by BHP Billiton, listed on the Australian Stock Exchange (BHP).
- The Beverley and Beverley North mine is fully owned by Heathgate Resources Pty Ltd (Heathgate), a wholly owned subsidiary of General Atomics (United States).
- The Four Mile Project is a joint venture between Quasar Resources Pty Ltd (75%, an affiliate of Heathgate) and Alliance Resources Ltd (25%).
- The Honeymoon mine is wholly owned by Uranium One, following Mitsui Corporation's withdrawal from the joint venture arrangements in 2012. Uranium One's major shareholder is JSC Atomredmetzoloto (ARMZ), a wholly owned subsidiary of Rosatom, the Russian State Corporation for Nuclear Energy.
- The proposed Wiluna mine is wholly owned by Toro Energy Limited, a company listed on the Australian Stock Exchange (TOE).
- The Yeelerie project is wholly owned by Cameco Australia, a subsidiary of Cameco Corporation listed on the Toronto (CCO) and New York Stock Exchanges (CCJ). Cameco acquired Yeelerie from BHP Billiton in 2012. Cameco produces uranium from mines in Canada, Kazakhstan and the United States.
- The proposed Kintyre Mine is 70% owned by Cameco Australia, with the remainder held by Mitsubishi (a global integrated business listed on the Tokyo and other stock exchanges) following acquisition of the project from Rio Tinto in 2008.

Employment in existing production centres

Total employment at Australia's uranium mines increased from 5 620 employees in 2013 to 5 800 employees in 2014. It is anticipated that employment may increase to around 6 000 employees in 2015, particularly if there is an upswing in exploration activity.

Potential future production centres

Wiluna (WA)

The Wiluna Project comprises two approved shallow (less than 8 m deep) calcrete-hosted deposits, Lake Way and Centipede, which are 15 km and 30 km south (respectively) of Wiluna, WA. The project includes another four regional deposits: Millipede, Lake Maitland, Dawson-Hinkler and Nowthanna.

Torohas completed detailed engineering design and commercial studies as part of a definitive feasibility study for the Centipede and Lake Way components of the Wiluna Project. Mining will utilise open-pit technology, pending the outcome of the Public Environmental Review in mid-2015. The company believes that government environmental assessment for Millipede and Lake Maitland can be completed during 2016. It is proposed to use alkaline agitated leaching in tanks at elevated temperatures to process the ore. Production is estimated to be 820 tU_3O_8 (695 tU) per year in concentrates with a 85.6% recovery rate. Toro is currently targeting first production from Wiluna in 2017.

Kintyre (WA)

Located 260 km north-east of the iron ore town of Newman, Cameco's Kintyre uranium project is at the edge of the Great Sandy Desert and near the Karlamilyi (Rudall River) National Park. Cameco has advanced development of the project, with approval of an Indigenous Land Use Agreement and Environmental Review and Management Program. The company has continued work to identify additional resources and is working towards an open-pit operation.

Yeelirrie (WA)

Discovered in 1972, the Yeelirrie deposit, 70 km south-west of Wiluna (WA) is one of Australia's largest undeveloped uranium deposits. It occurs in calcretes within a paleochannel and is at shallow depths down to 15 m below the surface. BHP Billiton carried out a drilling programme to upgrade the resource estimate and commenced a feasibility study for development of the deposit. Cameco acquired Yeelirrie from BHP Billiton in 2012 and continued studies to assess technical, environmental and financial aspects of the project. Environmental approval processes for mining operations were commenced by Cameco in 2014.

Secondary sources of uranium

Australia does not produce or use mixed oxide fuels, re-enriched tails or reprocessed uranium.

Environmental activities and socio-cultural issues

Environmental impact statement

Australian state and territory legislation requires rigorous approval processes for all new uranium projects and expansions of existing uranium operations. At the Commonwealth level, Australian government assessment is conducted under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC). An EPBC assessment is often undertaken bilaterally with the state and territory jurisdictions.

Recent environmental assessments have included the proposed Olympic Dam mine expansion lodged with the Commonwealth and SA governments in July 2014 to construct and operate a demonstration plant on the existing mining lease at Olympic Dam. ERA has formally commenced the statutory approval process for its proposed Ranger 3 Deeps underground mine with a referral under the EPBC and a notice of intent made to the NT government. A suite of agreements covering the Ranger Project Area were signed by the Australian government, Northern Land Council, the Mirarr Traditional Owners and ERA in January 2013. The new arrangements provide greater benefits to traditional owners, including intergenerational benefits through the establishment of the Kakadu West Arnhem Social Trust. Other key features of the agreements include an agreed approach to increasing opportunities for local Aboriginal participation in business development, training and employment.

Cameco's (Mitsubishi 30%) Kintyre uranium project received Commonwealth environmental approval under the EPBC from the Environment Minister on 28 April 2015. Toro Energy Limited's Wiluna Project (WA) obtained final environmental approvals in April 2013. The company plans to integrate additional deposits into its Wiluna Project and is looking to complete the Public Environmental Review in mid-2015. First production from the Wiluna operation is scheduled for 2017.

Regulatory activities

The jurisdictions of South Australia, the Northern Territory and Western Australia allow for the exploration and mining of uranium. Queensland and New South Wales permit exploration only, although the incoming Queensland government (March 2015) has stated this policy will be revoked. Victoria does not permit uranium exploration or mining. Under Regulation 9 of Australia's Customs (Prohibited Exports) Regulations 1958, export of goods listed in Schedule 7 of the Regulations is prohibited unless permission is obtained from the Minister for Industry and Science or an authorised person. Goods listed in Schedule 7 include minerals, ores and concentrates containing more than 500 parts per million (ppm) of uranium and thorium combined. Australian policy states that Australian uranium can only be sold to countries with which Australia has a nuclear co-operation agreement, to make sure that countries are committed to peaceful uses of nuclear energy. They must also have safeguards agreements with the IAEA, including an Additional Protocol.

Following a review of Australia's Uranium Industry Framework in 2009, the Uranium Council was established to assist in the development of a sustainable Australian uranium mining sector in line with world's best practice in environmental and safety standards, thus contributing to national wellbeing. The Uranium Council's responsibilities consist of four themes: Competitiveness, Sustainability, Stewardship and Indigenous Communication and Economic Development. Membership of the council comprises representatives of Commonwealth and state/territory government agencies, industry and non-government organisations. The terms of reference of the Uranium Council are available at: www.industry.gov.au/resource/Mining/AustralianMineralCommodities/Uranium/Pages/UraniumCouncil.aspx.

The attendees at the Uranium Council comprise representatives of: the Australian and state/territory government agencies; industry; industry associations and the Northern Land Council. An Australian government initiative in co-operation with industry led to the development of the Australian National Dose Records (ANRDR). Officially launched on 9 June 2011, the ANRDR is a centralised database designed for the collection and long-term storage of radiation dose records for workers who are occupationally exposed to radiation in the Australian uranium mining and milling industry.

Radiological protection matters arising from uranium mining in Australia are principally the responsibility of the states and territories. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is responsible for developing Australia's national radiation protection framework as laid out in the Radiation Protection Series and which are implemented through jurisdictional legislation and licence conditions.

ARPANSA's Radiation Protection Series (RPS) includes the following codes of practice and safety guides which relate to uranium mining and associated processes: RPS 2 *Code of Practice for the Safe Transport of Radioactive Material* (2008); RPS 2.1 *Safety Guide for the Safe Transport of Radioactive Material* (2008); RPS 2.2 *Safety Guide for Approval Processes for the Safe Transport of Radioactive Materials* (2012); RPS 9 *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (2005); RPS 9.1 *Safety Guide for Monitoring, Assessing and Recording Occupational Radiation Doses in Mining and Mineral Processing* (2011); RPS 15 *Safety Guide for the Management of Naturally Occurring Radioactive Material (NORM)* (2008); RPS 16 *Safety Guide for the Predisposal Management of Radioactive Waste* (2008); and RPS 20 *Safety Guide for Classification of Radioactive Waste* (2010).

ARPANSA has several new Radiation Protection Series documents which take into account the latest international guidance. Those of interest to the uranium industry include a Fundamentals document, a Planned Exposure Situations Code of Practice, a Near Surface Disposal Code of Practice, an Environmental Protection Safety Guide and a Site Closure Safety Guide.

A Radon Progeny Technical Coordination Group was established with representation from the uranium mining industry, state regulators and ARPANSA to develop a national approach to radon progeny dose assessment, including a programme of measurements in Australian uranium mines, to address proposed changes in international recommendations.

The Leading Practice Sustainable Development Program for the Mining Industry (LPSDP) previously developed a number of handbooks to address key issues affecting sustainable development. The Department of Industry and Science, assisted by the LPSDP Steering Committee, has commenced a review of the handbooks to ensure that they remain current in sharing leading practices in sustainable development of the mining industry globally. Further information of the Leading Practice handbooks can be found at: www.industry.gov.au/resource/Programs/LPSD/Pages/default.aspx.

Uranium requirements

Australia has no commercial nuclear power plants and thus has no domestic uranium requirements.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The Australian government supports the development of a sustainable Australian uranium mining sector in line with the world's best practice environmental and safety standards. In September 2012, the New South Wales government passed legislation to overturn the ban on uranium exploration; uranium mining is still prohibited by state legislation. In October 2012, the Queensland government overturned the ban on uranium mining put in place by the previous state government, and allows uranium exploration and mining along with South Australia, Western Australia and the Northern Territory.

In March 2015, the state government of South Australia established a Nuclear Fuel Cycle Royal Commission into the potential for nuclear power in the state, due to report in May 2016. The activities of the commission relate to the potential for the expansion of exploration and extraction of minerals, and the undertaking of further processing of minerals and manufacture of materials containing radioactive substances, use of nuclear fuels for electricity generation and the storage and disposal of radioactive and nuclear waste.

The Australian government's control over uranium exports reflects both national interest considerations and international obligations. The government is committed to ensuring that Australian uranium is only used for peaceful purposes by enforcing a strict safeguards policy. Australia's uranium export policy requires recipient states to have concluded a bilateral nuclear co-operation agreement (NCA) with Australia and to have in place an Additional Protocol with the IAEA. Since 2011, Australia has negotiated an NCA for the export of uranium to the United Arab Emirates; that agreement is yet to be ratified. The Australian government agreed in 2014 to supply uranium to India, despite that country not being a signatory to the nuclear non-proliferation treaty. The agreement was signed by Indian Prime Minister Narendra Modi and Australian Prime Minister Tony Abbott and included bilateral safeguards.

Uranium stocks

For reasons of confidentiality, information on producer stocks is not available.

Uranium prices

The average price of uranium exported from Australia in 2014 was USD 32.74/lb U_3O_8. Average export prices for the last five years are as follows:

	2014	**2013**	**2012**	**2011**	**2010**	**2009**
Average export value (AUD/lb U_3O_8)	31.97	37.36	43.36	40.10	35.12	50.43
(USD/lb U_3O_8)	33.20	38.80	45.03	40.73	32.30	39.97

Uranium exploration and development expenditures and drilling effort – domestic

(AUD millions)

	2012	**2013**	**2014**	**2015 (expected)**
Industry* exploration expenditures	98.3	52.3	39.5	Est. 45.0
Government exploration expenditures	0	0	0	0
Industry* development expenditures	N/A	N/A	N/A	N/A
Government development expenditures	0	0	0	0
Total expenditures	N/A	N/A		
Industry* exploration drilling (m)	N/A	N/A	N/A	N/A
Industry* exploration holes drilled	N/A	N/A	N/A	N/A
Industry* exploration trenches (m)			N/A	N/A
Industry* exploration trenches (number)			N/A	N/A
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Government exploration trenches (m)			0	0
Government exploration trenches (number)			0	0
Industry* development drilling (m)	N/A	N/A	N/A	N/A
Industry* development holes drilled	N/A	N/A	N/A	N/A
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	N/A	N/A	N/A	N/A
Subtotal exploration holes drilled	N/A	N/A	N/A	N/A
Subtotal development drilling (m)	N/A	N/A	N/A	N/A
Subtotal development holes drilled	N/A	N/A	N/A	N/A
Total drilling (m)	N/A	N/A	N/A	N/A
Total number of holes drilled	N/A	N/A	N/A	N/A

* Non-government.

Uranium exploration and development expenditures – non-domestic

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	N/A	N/A	N/A	N/A
Government exploration expenditures	0	0	0	0
Industry* development expenditures	N/A	N/A	N/A	N/A
Government development expenditures	0	0	0	0
Total expenditures	**N/A**	**N/A**	N/A	N/A

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Proterozoic unconformity	N/A	N/A	118 600	117 700
Sandstone	N/A	N/A	28 600	36 900
Polymetallic Fe-oxide breccia complex	N/A	N/A	902 000	902 000
Granite-related	N/A	N/A	0	200
Intrusive	N/A	N/A	1 100	4 300
Volcanic-related	N/A	N/A	2 700	5 100
Metasomatite	N/A	N/A	21 200	18 000
Surficial	N/A	N/A	60 900	62 600
Total	**N/A**	**N/A**	**1 135 200**	**1 146 800**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Underground mining (UG)	N/A	N/A	78 900	83 000
Open-pit mining (OP)	N/A	N/A	127 100	127 100
In situ leaching acid	N/A	N/A	27 200	34 700
Co-product and by-product	N/A	N/A	902 000	902 000
Total	**N/A**	**N/A**	**1 135 200**	**1 146 800**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	N/A	N/A	983 200	983 200
Conventional from OP	N/A	N/A	135 500	146 700
In situ leaching acid	N/A	N/A	16 500	16 900
Total	**N/A**	**N/A**	**1 135 200**	**1 146 800**

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	N/A	N/A	48 300	52 800
Sandstone	N/A	N/A	78 300	98 300
Polymetallic Fe-oxide breccia complex	N/A	N/A	371 800	421 100
Intrusive	N/A	N/A	800	5 000
Volcanic-related	N/A	N/A	1 000	1 500
Metasomatite	N/A	N/A	14 600	16 900
Surficial	N/A	N/A	14 100	35 200
Total	**N/A**	**N/A**	**528 900**	**630 800**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	N/A	N/A	50 000	59 300
Open-pit mining (OP)	N/A	N/A	78 300	98 300
In situ leaching acid	N/A	N/A	14 200	35 200
Co-product and by-product	N/A	N/A	386 400	438 000
Total	**N/A**	**N/A**	**528 900**	**630 800**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	N/A	N/A	420 100	473 900
Conventional from OP	N/A	N/A	92 900	115 200
In situ leaching acid	N/A	N/A	15 900	41 700
Total	**N/A**	**N/A**	**528 900**	**630 800**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
N/A	N/A	N/A

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	N/A	N/A

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Proterozoic unconformity	108 297	3 146	2 500	1 212	114 773	1 000
Sandstone	6 576	477	547		7 053	
Polymetallic Fe-oxide breccia complex	53 105	3 386	3 385	3 764	63 598	3 500
Metamorphite	7 531	0			7 531	
Intrusive	721	0			721	
Total	**176 230**	**7 009**	**6 432**	**4 976**	**193 676**	**4 500**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	115 711	3 146	2 500	1 212	121 881	1 000
Underground mining*	838	0			838	
In situ leaching	6 576	477	547	399	7 640	100
Co-product/by-product	53 105	3 386	3 385	3 365	63 317	3 400
Total	**176 230**	**7 009**	**6 432**	**4 976**	**193 676**	**4 500**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	176 230	7 009	5 885	4 577	193 089	4 400
In situ leaching			547	399	1 064	100
Total	**176 230**	**7 009**	**6 432**	**4 976**	**193 676**	**4 500**

Ownership of uranium production in 2014*

Domestic		Foreign		Totals	
Government/private		Government/private			
(tU)	(%)	(tU)	(%)	(tU)	(%)
1 339	26.9	3 637	73.1	4 976	100

* These figures are estimated based on public ownership information. For reasons of confidentiality, government vs private ownership information is not available.

Uranium industry employment at existing production centres

(person-years)*

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	5 574	5 620	5 800	6 000
Employment directly related to uranium production	3 720	3 750	3 870	4 000

* These figures are estimated and take into account total employment at BHP Billiton's Olympic Dam polymetallic operations also including contractors employed at the mine. A breakdown of employees working for BHP's uranium mining operations was not available.

Short-term production capability

(tonnes U/year)

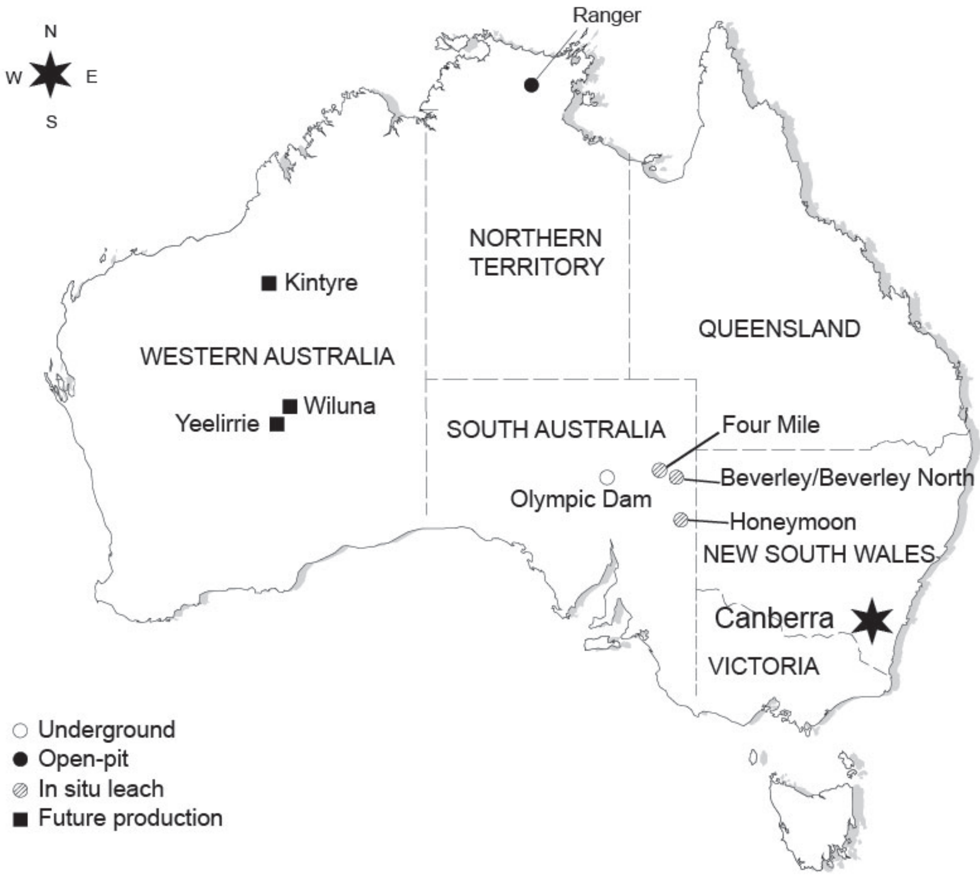
2014				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	5 000	5 000	N/A	N/A	5 637	5 637	N/A	N/A	6 000	9 000

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	8 000	14 000	N/A	N/A	10 000	19 000	N/A	N/A	10 000	24 000

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	Nil	Nil	Nil	Nil	Nil
Producer	N/A	Nil	Nil	Nil	N/A
Utility	Nil	Nil	Nil	Nil	Nil
Total	**Nil**	**Nil**	**Nil**	**Nil**	**Nil**



Botswana*

Uranium exploration and mine development

Historical review

The surge in the uranium price in the 1970s led to exploration activities in Botswana by various foreign and local companies. Large airborne radiometric surveys were followed by ground surveys, soil sampling, trenching and drilling. However, the thick sand cover in many parts of the country hindered exploration activities. Exploration work effectively ceased in the early 1980s with the slump in uranium prices. No deposits of economic interest were discovered in this early phase of exploration but significant mineralisation was shown to occur in the Karoo sandstones and surficial calcretes, particularly in the east-central part of the country.

Rising uranium prices in 2005 renewed interest in uranium exploration by junior Australian companies and by 2011 there were 168 uranium prospecting licences registered in Botswana.

A-Cap Resources has been exploring in Botswana since 2004, following up on mineralisation discovered by Falconbridge in the 1970s in the Serowe area and discovering significant mineralisation at the Letlhakane project. Intensive drilling resulted in A-Cap reporting Botswana's first JORC compliant uranium resource in 2008 of just over 100 000 tU at an average grade of 129 ppm U (0.0129% U).

Impact Minerals Ltd, another Australian junior company, acquired permits around A-Cap's areas in early 2008. Exploration activities in 2009 began with airborne radiometric surveys, followed by field reconnaissance, mapping and drilling, leading to the discovery of four prospects in Karoo siltstones and sandstones. In addition to sandstone-hosted mineralisation, uranium-bearing alaskitic rocks similar to those found at Rossing in Namibia and mineralisation related to Proterozoic sedimentary and basement rocks with similarities to the unconformity-related deposits in Canada and Australia were discovered. Further work is needed to assess the validity of the model and the potential of this unconformity style of mineralisation.

At the end of 2012, A-Cap's prospecting licences for uranium totalled 5 000 km^2 while Impact Minerals Ltd controlled 26 000 km^2. The two companies drilled a total of 12 462 m in 95 reverse circulation holes during 2011 but no drilling was reported in 2012. Both companies completed regional ground gravity surveys and Impact Minerals Ltd completed a soil geochemical survey over an area of 250 km^2 at the Ikongwe prospect.

Recent and ongoing uranium exploration and mine development activities

The Letlhakane uranium deposit has been the focus of detailed technical work for A-Cap since 2010, resulting in the February 2013 release of a positive scoping study. A thorough examination of all aspects of the resource has led to a greater understanding of the framework and grade distribution of uranium mineralisation and the use of appropriate mining techniques to maximise the economics of the deposit.

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* Report prepared by the NEA/IAEA, based on previous Red Books and company reports.

The uranium mineralisation, hosted predominately in carbonaceous mudstones and siltstones, occurs in relatively thin (0.5-5 m), laterally extensive lenses with lower-grade material separating higher-grade ore horizons. The nature of the ore combined with shallow, flat-lying and soft strata lends itself well to open-pit extraction methods. This information has resulted in a resource determination that is less than previously reported, but with higher grades. The current resource estimate is 118 615 tU at 0.018% U.

A drilling programme was completed in September 2014 focusing on shallow high-grade zones where initial optimisation runs delineated possible early pits. This drilling was designed to test the continuity and mine scale variability of mineralisation in three main project areas: Kraken, Gorgon and Serule West, and to provide data for further resource modelling and mine planning. This drilling yielded excellent results and confirmed the presence and continuity of high-grade mineralisation within these areas.

A drill optimisation study has also been completed. The drill study focused on the Kraken area where infill drilling had previously been completed. Holes were then excluded to make pre-infill drilling grids. These were completed at 400 m spacing and 200 m spacing and also 100 x 100 m and 50 x 100 m. At the 400 m and 200 m spacing alternate offset grids were also used to evaluate consistency. The results from the Kraken area concluded that the drilling defines the resource at 200 m spacing and only small variations in grade and contained metal occur when the infill drilling is conducted. This gives A-Cap an excellent guide to defining mineralisation on the project as a whole.

An infill drilling programme following up on the major reverse circulation and diamond drilling programme which was completed in June 2014, commenced in October 2014 to further define potential early start pits. This programme was successfully completed in November with results confirming the presence and continuity of high-grade uranium mineralisation. These results will be incorporated into a new resource model.

Impact Minerals Ltd, another Australian junior company, acquired permits around A-Cap's areas in early 2008. Exploration activities in 2009 began with airborne radiometric surveys, followed by field reconnaissance, mapping and drilling, leading to the discovery of four prospects in Karoo siltstones and sandstones.

At the end of 2014, exploration by Impact Minerals Ltd in Botswana was on hold pending a recovery in the uranium price and market conditions. During the year, the majority of Impact's prospecting licences within the Botswana uranium project licences were not renewed.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

In June 2012, A-Cap Resources upgraded the global JORC Resource of the Letlhakane Uranium Project by 35%. Letlhakane hosts a global resource of 1.04 billion tonnes at 130 ppm uranium (0.013% U) for 351.8 million pounds of contained uranium (135 269 tU), based on an 85 ppm U cut-off grade. Within this resource, A-Cap has defined a higher-grade resource of 143.2 million tonnes at 241 ppm uranium (0.0241% U) for 89.7 million pounds of uranium contained (34 500 tU), based on 170 ppm U cut-off grade.

However, in early 2013, A-Cap Resources released the results of a scoping study on the Letlhakane uranium deposit and in June 2013, released new updated resources based on results of the scoping study. The global in situ resource has been reduced from the 2012 resource of 135 269 tU to 118 615 tU using a cut-off grade of 85 ppm U. Although the size of the uranium resource has been reduced, the grade has increased from 0.013 to 0.018% U. Using a recovery factor of 62%, the total inferred recoverable resource is 73 541 tU in the <USD 260/kg U category.

Undiscovered conventional resources (prognosticated and speculative resources)

The key feature for uranium mineralisation in Botswana is the presence of highly radiogenic granitoid suites, most relating to the Pan-African (~500 Ma) magmatic event, which introduced uranium-rich source material into the upper crust. The uranium mineralisation is highly mobile and through leaching, uranium-bearing solutions became concentrated in reduced environments in sandstones, mudstones and carbonaceous materials in the overlying lower Karoo system.

Most calcareous sediments in the Gojwane and the Foley area, which lies on top of the Karoo and the Karoo-aged sediments are considered to host widespread and continuous uranium mineralisation. These areas are considered to have the same geology as the Letlhakane area, which host one of the biggest undeveloped uranium deposits in Botswana.

Impact Minerals Ltd reports "target conceptual" undiscovered resources of less than 2 000 tU. However, the uncertainty of the term and small amounts reported do not warrant inclusion as undiscovered resources at this time. Although undiscovered resources no doubt exist, further work is required to develop the estimates.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1
Name of production centre	Letlhakane
Production centre classification	Prospective
Date of first production (year)	N/A
Source of ore:	
Deposit name(s)	Gojwane/Serule
Deposit type(s)	Secondary/calcrete
Recoverable resources (tU)	73 541
Grade (% U)	0.0197
Mining operation:	
Type (OP/UG/ISL)	OP
Size (tonnes ore/day)	24 000
Average mining recovery (%)	90
Processing plant:	
Acid/alkaline	Acid
Type (IX/SX)	Heap leaching
Size (tonnes ore/day)	
Average process recovery (%)	69
Nominal production capacity (tU/year)	1 350

Uranium production

From 2013-2015, A-Cap conducted feasibility works required for the application of a mining licence for the Letlhakane uranium project.

Physical testwork on expected lithology mixes were made to evaluate productivity and mining costs using surface miners. Metallurgical testworks were completed to optimise the process design and provide geotechnical, geochemical and hydrological data for studies on heaps and waste products. Process testworks are based on heap leach processing using acid leaching for the primary, oxide and secondary mudstone ore, and alkaline leaching for the secondary calcrete ore. The uranium recoveries vary from 60.5% to 77.7% depending on mineralisation type.

On completion of the feasibility work, the mining licence application was submitted to the Botswana Department of Mines in August 2015.

A-Cap Resources anticipates starting production at its uranium mine by 2018, with a production capacity of 1 350 tU/yr, at an average operating cost of USD 34.9/lb in the first five years and USD 40.7/lb during the life of the mine.

Environmental activities and socio-cultural issues

A-Cap has established a Safety, Health, Radiation, Environment and Community Group aimed at informing, educating and involving local communities with regard to their activities. Meetings are held on a regular basis. The company submitted an environmental and social impact assessment study of the Letlhakane project to the Botswana government in 2011. The scoping study indicates potential for a mine life in excess of 20 years, subject to world market prices for uranium.

A detailed water exploration programme by A-Cap has confirmed that a well field located 30 km west of Letlhakane could supply water of sufficient quality and quantity to meet the project's requirements. A-Cap submitted water rights applications which were subsequently granted by Botswana's Water Apportionment Board in 2012.

In 2014, an environmental and social impact assessment (ESIA) was completed and submitted to the Department of Environmental Affairs (DEA) in line with the Botswana government's requirements. Studies determined that with appropriate mitigation all environmental and social aspects during the construction and planned operations could be addressed. Presentations of the ESIA findings were presented to the Serule and Gojwane Kgoltas, the Mmadindare and Paje subland Boards, and the Tonata council.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

National policies regarding uranium exploitation and production are under development and no regulations for uranium mining and milling are currently in place. However, the government is committed to encouraging private investment in exploration and new mine development and the fiscal, legal and policy framework for mineral exploration, mining and mineral processing in Botswana is continuously being reviewed to make it more competitive. Amendments made to the Mines and Minerals Act in 1999 and the Income Tax Act in 2006 streamlined licensing, enhanced security of tenure and reduced royalty payments and tax rates.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	13 711	13 711
Total	**0**	**0**	**13 711**	**13 711**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	13 711	13 711	62
Total	**0**	**0**	**13 711**	**13 711**	**62**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching* from OP	0	0	13 711	13 711	62
Total	**0**	**0**	**13 711**	**13 711**	**62**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	59 830	59 830
Total	**0**	**0**	**59 830**	**59 830**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	59 830	59 830	62
Total	**0**	**0**	**59 830**	**59 830**	**62**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching* from OP	0	0	59 830	59 830	62
Total	**0**	**0**	**59 830**	**59 830**	**62**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Brazil

Uranium exploration and mine development

Historical review

Systematic prospecting for radioactive minerals by the Brazilian National Research Council began in 1952. These efforts led to the discovery of the first uranium occurrences at Poços de Caldas (State of Minas Gerais) and Jacobina (State of Bahia). In 1955, a technical co-operation agreement was signed with the United States to assess the uranium potential of Brazil. After the creation of the National Nuclear Energy Commission (CNEN), a mineral exploration department was organised with the support of the French Alternative Energies and Atomic Energy Commission (CEA) in 1962.

In the 1970s, CNEN exploration for radioactive minerals progressed due to increased financial resources. Additional incentive for exploration was provided in 1974 when the government opened NUCLEBRAS, an organisation with the exclusive purpose of uranium exploration and production. One of the early achievements of the government organisations was the discovery and development of the Osamu Utsumi deposit on the Poços de Caldas plateau.

In late 1975, Brazil and Germany signed a co-operation agreement for the peaceful use of nuclear energy. It was the beginning of an ambitious nuclear development programme that required NUCLEBRAS to increase its exploration activities. This led to the discovery of eight areas hosting uranium resources including the Poços de Caldas plateau, Figueira, the Quadrilátero Ferrífero, Amorinópolis, Rio Preto/Campos Belos, Itataia, Lagoa Real and Espinharas (discovered and evaluated by Nuclam, a Brazilian-German joint venture).

In 1991, Industrias Núcleares do Brasil S.A (INB) uranium exploration activities were brought to a halt according to the Brazilian nuclear development programme reorganisation of 1988. Since then limited work has been done towards the extension of Lagoa Real province resources.

Recent and ongoing uranium exploration and mine development activities

During 2013/2014 exploration efforts were focused on favourable albititic areas in the north part of the Lagoa Real province

Expenditures totalled BRL 3.5 million (Brazilian reals) during that period, with 7 500 m drilled. For 2015/2016, expected expenditures are BRL 10 million, corresponding to 18 000 m of drilling.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Brazil's conventional identified uranium resources are hosted in the following deposits:

- Poços de Caldas (Osamu Utsumi mine) with the orebodies A, B, E and Agostinho (collapse breccia pipe-type);

- Figueira and Amorinópolis (sandstone);
- Itataia, including the adjoining deposits of Alcantil and Serrotes Baixos (phosphate);
- Lagoa Real, Espinharas (metasomatite);
- Campos Belos (metamorphite);
- Others including the Quadrilátero Ferrífero with the Gandarela and Serra des Gaivotas deposits (paleo-quartz-pebble conglomerate).

No additional resources were identified during the 2011-2012 period.

Undiscovered conventional resources (prognosticated and speculative resources)

Based on exploration activities in the Rio Cristalino (Proterozoic unconformity) area and additional resources at the Pitinga site (granite-related), in situ prognosticated resources are estimated to amount to 300 000 tU.

Uranium production

Historical review

The Poços de Caldas uranium production facility, which started production in 1982 with a design capacity of 425 tU/year, was owned by the state-owned company NUCLEBRAS until 1988. At that time Brazil's nuclear activities were restructured. NUCLEBRAS was succeeded by INB and its mineral assets transferred to Urânio do Brasil S.A. With the dissolution of Urânio do Brasil in 1994, ownership of uranium production is 100% controlled by INB, a state-owned company.

Between 1990 and 1992, the production centre at Poços de Caldas was on stand-by because of increasing production costs and reduced demand. Production restarted in late 1993 and continued until October 1995. After two years on stand-by, the Poços de Caldas production centre was shut down in 1997. A decommissioning programme started in 1998. This industrial facility was used to produce rare earth compounds from monazite treatment until 2006, but is now closed for market reasons. The Caetité unit (Lagoa Real) is currently the only uranium production facility in operation in Brazil.

Status of production facilities, production capability, recent and ongoing activities and other issues

The open-pit part of the Cachoeira deposit was entirely mined out in 2014. The licensing process of the underground part is under way and the production expected to start in 2019.

The expansion of Lagoa Real, Caetité unit to 670 tU/year is progressing but the operation has been delayed somewhat to around 2017. The expansion involves replacement of the current heap leaching (HL) process by conventional agitated leaching. The overall investment in this expansion is estimated to amount to USD 90 million.

The production in the period 2013 and 2014 was 192 and 40 tU, respectively.

Ownership structure of the uranium industry

The Brazilian uranium industry is 100% government-owned through INB.

Employment in the uranium industry

See table.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3
Name of production centre	Caetité	Santa Quitéria	Engenho
Production centre classification	Existing	Planned	Committed
Date of first production	1999*	2020	2016
Source of ore:			
Deposit name(s)	Cachoeira	Santa Quitéria	Engenho
Deposit type(s)	Metasomatite	Phosphate	Metasomatite
Recoverable resources (tU)	10 100	76 100	6 500
Grade (% U)	0.3	0.08	0.2
Mining operation:			
Type (OP/UG/ISL)	UG	OP	OP
Size (tonnes ore/day)	1 000	6 000	1 000
Average mining recovery (%)	90	90	90
Processing plant:			
Acid/alkaline	Acid	Acid	Acid
Type (IX/SX)	HL/SX	SX	SX
Size (tonnes ore/day)			
Average process recovery (%)	80	75	90
Nominal production capacity (tU/year)	340	970	300
Plans for expansion (yes/no)	Yes	Yes	Yes
Other remarks	OP operation from 1999 to 2014	By-product phosphoric acid	To be sent to Caetité mill

Future production centres

The phosphate/uranium project of Santa Quitéria, an INB-Brazilian fertiliser producer partnership agreement, is under development. In 2012, the project applied for a construction licence, expected to be granted in 2015. The operation is now scheduled for 2020.

The Engenho deposit, located 2 km from the currently mined Cachoeira deposit is under development and is expected to provide additional feed for the Caetité mill after 2016.

Environmental activities and socio-cultural issues

Licences in Brazil are issued by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) and also by CNEN.

The closure of Poços de Caldas in 1997 brought to an end the exploitation of this low-grade ore deposit that produced vast amounts of waste rock. Several studies have been carried out to characterise geochemical and hydrochemical aspects of the waste rock and tailings dam in order to better establish the impact they may have had on the environment and to develop the necessary mitigation measures. A remediation/restoration plan, considering several alternatives, was submitted to the regulatory body at the end of 2012. Depending on the option adopted, the costs of implementing the remediation/restoration plan could reach USD 300 million. In the meantime, some measures have been taken to reduce environmental impact, such as: uranium recovery from acid drainage (resin); heavy metals precipitation (ozone) and surface drainage optimisation.

The licensing of Santa Quitéria Uranium/Phosphate Project is split into a non-nuclear part involving milling and phosphate production and a nuclear part involving uranium concentrate production. INB has applied for local construction licences under the guidelines established by IBAMA and CNEN.

Regulatory regime

Licences are issued by IBAMA, according to Brazilian environment law and CNEN regulations.

Government policies and regulations established by CNEN include basic radiation protection directives (NE-3.01 – *Diretrizes Básicas de Radioproteção*), standards for licensing of uranium mines and mills (NE-1.13 – *Licenciamento de Minas e Usinas de Beneficiamento de Minérios de Urânio ou Tório*) and decommissioning of tailings ponds (NE-1.10 – *Segurança de Sistema de Barragem de Rejeito Contendo Radionuclídeos*), as well as standards for conventional U and Th mining and milling (NORM and TENORM NM 4.01 – *Requisitos de Segurança e Proteção Radiológica para Instalações Mínero-Industriais*). In the absence of specific norms, the International Commission on Radiological Protection (ICRP) and IAEA recommendations are used.

CNEN is in charge of nuclear research and regulation and currently controls INB as a major stakeholder. Due to the future growth of the Brazilian nuclear programme, the creation of a separate independent nuclear regulatory agency is under study by the federal government.

Uranium requirements

Brazil's present uranium requirements for the Angra 1 nuclear power plant, a 630 MWe pressurised water reactor, are about 130 tU/yr. The Angra 2 nuclear power plant, a 1 245 MWe PWR, requires 220 tU/yr. The start-up of the Angra 3 nuclear power plant (a similar design to Angra 2), scheduled initially in 2016, will add another 220 U/yr to annual domestic demand.

The long-term electricity energy supply plan includes about 5 000 MWe generated from nuclear sources by 2030.

Supply and procurement strategy

All domestic production is destined for internal requirements. The shortfall between demand and production is met through market purchases. In the period 2013-2014, INB acquired 264 tU (usually as UF_6).

The planned production increases are intended to meet all reactor requirements, including the Angra 3 unit and all units foreseen in the long-term planned expansion of nuclear energy for electricity generation.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

INB, a 100% government-owned company, is in charge of fuel cycle activities which are conducted under state monopoly. Currently INB is working on the increase of uranium concentrate production and towards full implementation of the fuel cycle activities to meet domestic demand.

Uranium stocks

The Brazilian government does not maintain stocks of uranium concentrate or enriched uranium product.

Uranium exploration and development expenditures and drilling effort – domestic

(in BRL [Brazilian real])

	2010	2011	2012	2013	2014	2015/2016 (expected)
Industry* exploration expenditures	0	0	0	0	0	0
Government exploration expenditures	400	200 000	2 500 000	3 500 000	0	10 000 000
Total expenditures	**400**	**200 000**	**2 500 000**	**3 500 000**	**0**	**10 000 000**
Government exploration drilling (m)	0	0	5 200	7 500	0	18 000
Government exploration holes drilled	0	0	41	45	0	120
Total drilling (m)	**0**	**0**	**5 200**	**7 500**	**0**	**18 000**
Total number of holes drilled	**0**	**0**	**41**	**45**	**0**	**120**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related	25 400	50 800	50 880	50 880
Collapse breccia-type	500	500	500	500
Metasomatite	82 300	82 300	82 300	82 300
Phosphate	76 100	76 100	76 100	76 100
Total	**184 300**	**209 700**	**209 700**	**209 700**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	72 900	72 900	72 900	58 300	90 (mine); 90 (process)
Open-pit mining (OP)	9 900	9 900	9 900	7 900	90 (mine); 90 (process)
Co-product and by-product	101 500	126 900	126 900	126 900	70 (process)
Total	**184 300**	**209 700**	**209 700**	**209 700**	

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	72 900	72 900	72 900	72 900	90 (mine); 90 (process)
Conventional from OP	8 100	8 100	8 100	8 100	90 (mine); 90 (process)
Heap leaching** from OP	1 800	1 800	1 800	1 800	90 (mine); 90 (process)
Unspecified	101 500	126 900	126 900	126 900	70 (process)
Total	**184 300**	**209 700**	**209 700**	**209 700**	

* In situ resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone		13 000	13 000	13 000	90 (mine); 80 (process)
Paleo-quartz-pebble conglomerate		15 000	15 000	15 000	90 (mine); 80 (process)
Granite-related		0	67 700	67 700	70 process
Metamorphite		1 000	1 000	1 000	90 (mine); 80 (process)
Collapse breccia-type		26 400	26 400	26 400	90 (mine); 80 (process)
Metasomatite		5 000	5 000	5 000	90 (mine); 80 (process)
Phosphate		44 600	44 600	44 600	70 process
Total		**104 900**	**172 600**	**172 600**	

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)		3 400	3 400	3 400	90 (mine); 80 (process)
Co-product and by-product		44 600	112 300	112 300	70 (process)
Unspecified		56 900	56 900	56 900	70 (average)
Total		**104 900**	**172 600**	**172 600**	

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP		3 400	3 400	3 400	90 (mine); 80 (process)
Unspecified		101 500	169 200	169 200	70 (average)
Total		**104 900**	**172 600**	**172 600**	

* In situ resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
300 000	300 000	300 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	N/A	500 000

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2009	2010	2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Collapse breccia-type	1 097	0	0	0	0	0	1 097	0
Metasomatite	2 089	148	265	326	192	55	3 075	40
Total	**3 186**	**148**	**265**	**326**	**192**	**55**	**4 172**	**40**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2010	2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	3 186	148	265	326	192	55	4 172	40
Total	**3 186**	**148**	**265**	**326**	**192**	**55**	**4 172**	**40**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2009	2010	2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	1 097						1 097	0
Heap leaching*	2 089	148	265	326	192	55	3 075	40
Total	**3 186**	**148**	**265**	**326**	**192**	**55**	**4 172**	**40**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
55	100	0	0	0	0	0	0	55	100

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	620	620	620	590
Employment directly related to uranium production	340	340	340	310

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
340	340	340	340	640	640	640	640

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
640	1 600	640	1 600	N/A	1 300	N/A	1 300	N/A	1 300	N/A	1 300

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	14.64	15.43

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
1 875	1 875	1 875	1 875	3 120	3 120	3 120	3 120	3 120	5 120	3 120	N/A

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
400	400	400	400	550	550	550	550	550	1 000	550	N/A

Canada

Uranium exploration

Historical review

Uranium exploration in Canada began in 1942, with the focus of activity first in the Northwest Territories where pitchblende ore had been mined since the 1930s to extract radium. Exploration soon expanded to other areas of Canada, resulting in the development of mines in northern Saskatchewan and in the Elliot Lake and Bancroft regions of Ontario during the 1950s. In the late 1960s, exploration returned to northern Saskatchewan where large high-grade deposits were discovered in the Athabasca Basin and later developed. Saskatchewan is now the sole producer of uranium in Canada.

Recent and ongoing uranium exploration and mine development activities

During 2013 and 2014, exploration efforts continued to focus on areas favourable for the occurrence of deposits associated with Proterozoic unconformities in the Athabasca Basin of Saskatchewan, and to a lesser extent, similar geologic settings in the Thelon Basin of Nunavut. Uranium exploration also continued in the Central Mineral Belt of Newfoundland and Labrador. Very little exploration activity occurred in other areas of Canada in 2013 and 2014.

Surface drilling, geophysical and geochemical surveys continued to be the main tools used to identify new uranium occurrences, define extensions of known mineralised zones and to reassess previously discovered deposits.

Exploration activity has led to new uranium discoveries in the Athabasca Basin. Notable recent high-grade uranium mineralisation discoveries include Shea Creek (Areva Resources Canada Inc.), Wheeler River (Denison Mines Inc.), and Roughrider (Rio Tinto). In 2013, Fission Uranium discovered the Triple R deposit, a high-grade uranium deposit in the western Athabasca Basin of Saskatchewan. Drilling conducted on the Triple R deposit in 2013 and 2014 outlined a significant uranium resource which is currently the third largest uranium deposit in the Athabasca Basin.

Domestic uranium exploration expenditures were CAD 167 million in 2013, down 18.5% from 2012 exploration expenditures of CAD 205 million. In 2013, overall Canadian uranium exploration and development expenditures amounted to CAD 884 million. Less than one-quarter of the overall exploration and development expenditures in 2013 can be attributed to advanced underground exploration, deposit appraisal activities and care and maintenance expenditures associated with projects awaiting production approvals.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2015, Canada's total identified conventional uranium resources recoverable at a cost of <USD 80/kgU amounted to 321 800 tU, a decrease of 23% from the 2013 estimate of 418 300 tU, due to mining depletion and the re-evaluation of resources into higher cost categories. Canada's total identified uranium resources recoverable at a

cost of <USD 130/kgU were 509 000 tU as of 1 January 2015, an increase of 3% compared to the 2013 estimate of 493 900 tU. These increases are primarily due to new resources being identified as a result of recent exploration activity. Most of Canada's identified uranium resources are re-evaluated annually by the uranium mining companies.

The bulk of Canada's identified conventional uranium resources occur in Proterozoic unconformity-related deposits in the Athabasca Basin of Saskatchewan and the Thelon Basin of Nunavut. These deposits host their mineralisation near the unconformity boundary in either monometallic or polymetallic mineral assemblages. Pitchblende prevails in the monometallic deposits, whereas uranium-nickel-cobalt assemblages prevail in the polymetallic assemblages. The average grade varies from 1% U to over 15% U. None of the uranium resources referred to or quantified herein are a co-product or by-product output of any other mineral of economic importance. Mining losses (~10%) and ore processing losses (~3%) were used to calculate known conventional resources.

All of Canada's identified conventional uranium resources recoverable at <USD 40/kgU are in existing or committed production centres. The percentage of identified conventional uranium resources in existing or committed production centres that are recoverable at <USD 80/kgU, <USD 130/kgU and <USD 260/kgU are 98%, 62% and 45%, respectively.

Undiscovered conventional resources (prognosticated and speculated resources)

Prognosticated and speculated resources have not been a part of recent resource assessments; hence there are no changes to report in these categories since 1 January 2001.

Uranium production

Historical review

Canada's uranium industry began in the Northwest Territories with the 1930 discovery of the Port Radium pitchblende deposit. Exploited from 1933 to 1940 for radium, the deposit was reopened in 1942 in response to uranium demand for the Manhattan Project. A ban on private exploration and development was lifted in 1947, and by the late 1950s some 20 uranium production centres had started up in Ontario, Saskatchewan and the Northwest Territories. Production peaked in 1959 at 12 200 tU. No further defence contracts were signed after 1959 and production began to decline. Despite government stockpiling programmes, output fell rapidly to less than 3 000 tU in 1966, by which time only four producers remained. While the first commercial sales to electric utilities were signed in 1966, it was not until the mid-1970s that prices and demand had increased sufficiently to promote expansions in exploration and development activity. By the late 1970s, with the industry firmly re-established, several new facilities were under development in Saskatchewan and Ontario. Annual output grew steadily throughout the 1980s, as Canada's focus of uranium production shifted increasingly to Saskatchewan. The last remaining Ontario uranium mine closed in mid-1996.

Status of production capability and recent and ongoing activities

All active uranium production centres are located in northern Saskatchewan. Current Canadian uranium production remains well below the full licensed production capacity of the uranium mills. Production in 2014 was 9 136 tU, 2.1% below 2013 production of 9 332 tU. Canadian uranium production is forecast to increase to 11 700 tU in 2015 as the Cigar Lake mine, which began operations in 2014, increases production.

Cameco Corporation is the operator of the McArthur River mine, a Cameco (70%), Areva (30%) joint venture, which is the world's largest uranium mine in terms of annual production and is the world's largest high-grade uranium deposit. Ore from the mine is transported 80 km southward to the Key Lake mill where 7 684 tU and 7 312 tU were recovered from McArthur River ore in 2013 and 2014, respectively. Ground freezing is used to reduce water inflow from the overlying rock formation and the high-grade ore (>10% U) is extracted using raise bore mining. A high-grade ore slurry is produced by underground crushing, grinding and mixing which is then pumped to the surface and loaded on specially designed containers that are shipped by road to the Key Lake mill. Remaining identified resources for McArthur River mine are currently 157 000 tU with an average grade of 10.3% U.

The Key Lake mill is a Cameco (83%) and Areva (17%) joint venture operated by Cameco. Although mining at Key Lake was completed in 1997, the mill maintained its standing as the world's largest uranium production centre by producing 7 744 tU and 7 358 tU in 2013 and 2014, respectively. These totals represent a combination of the uranium extracted from high-grade McArthur River ore and from stockpiled, mineralised Key Lake special waste rock that is blended to produce a mill feed grade of about 5% U.

The McClean Lake production centre, operated by Areva, is a joint venture between Areva (70%), Denison Mines Inc. (22.5%) and Overseas Uranium Resources Development (Canada) Co. Ltd, a subsidiary of Overseas Uranium Resources Development Corporation of Japan (7.5%). Open-pit mining was completed in 2008 and ore containing 2 500 tU was stockpiled to provide mill feed. Production in 2009 and 2010 amounted to 2 045 tU and was obtained from processing the higher-grade ore from the stockpile. The 500 tU of ore remaining in the stockpile was not economic to process so the mill was placed into care and maintenance in July 2010. Production from the McClean Lake JEB mill resumed in 2014 to process low-grade ore from the stockpile and high-grade ore from the Cigar Lake mine. Production in 2014 was 43 tU and 132 tU from the McClean Lake ore stock pile and Cigar Lake ore, respectively. Annual production is expected to increase to 6 900 tU by 2018 as the Cigar Lake mine increases ore production.

The Rabbit Lake production centre, wholly owned and operated by Cameco, produced 1 587 tU and 1 602 tU in 2013 and 2014, respectively. Exploratory drilling at the Eagle Point mine during the last several years has increased identified resources to 18 200 tU, extending the life of the mine to at least 2018. Cameco indicates that there is good potential for identifying additional resources and an environmental assessment is underway on a proposal to expand tailings storage capacity to allow additional ore to be processed.

Cigar Lake, with identified resources of 130 600 tU at an average grade of 14.2% U, is the world's second-largest high-grade uranium deposit. The mine began operation in March 2014 and is a Cameco (50.025%), Areva (37.1%), Idemitsu (7.875%) and TEPCO (5%) joint venture operated by Cameco. When in full production in 2018, the mine is expected to have a full annual production capacity of 6 900 tU. Ground freezing is used to reduce groundwater inflow and ore is extracted using an innovative jet bore mining method. The high-grade ore slurry is then shipped by road to the McClean Lake (JEB) mill for processing. In 2014, the McClean Lake mill produced 132 tU from Cigar Lake ore.

Ownership structure of the uranium industry

Cameco Corporation and Areva Canada Resources Inc. (Areva) are the operators of the current uranium production centres in Canada. Cameco is the owner and operator of the Rabbit Lake production centre which includes the Eagle Point mine and the Rabbit Lake mill. Cameco is also the operator of the McArthur River mine and the Key Lake mill which are joint ventures with Areva. Cameco is the majority owner and operator of the Cigar Lake mine, in which Areva, Idemitsu and TEPCO have minority ownership. Areva is the majority owner and operator of the McClean Lake production centre in which Denison Mines Inc. and Overseas Uranium Resources Development (Canada) Co. Ltd. have minority ownership.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7
Name of production centre	McArthur River /Key Lake	McClean Lake	Rabbit Lake	Cigar Lake	Midwest	Millennium	Kiggavik
Production centre classification	Existing	Existing	Existing	Existing	Planned	Planned	Planned
Start-up date	1999/1983	1999	1975	2014	N/A	N/A	N/A
Source of ore:							
Deposit name(s)	P2N et al.	JEB, McClean, Sue A-E, Caribou	Eagle Point	Cigar Lake	Midwest	Millennium	Kiggavik, Andrew Lake, End Grid
Deposit type(s)	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity
Resources	170 000 tU	4 400 tU	14 700 tU	120 000 tU	3 700 tU	34 800 tU	44 000 tU
Grade (% U)	11.5	1.96	0.61	14.0	0.78	3.8	0.47
Mining operation:							
Type (OP/UG/ISL)	UG	OP/UG	UG	UG	OP	UG	OP/UG
Size (tonnes ore/day)	N/A	N/A	N/A	~200	N/A	~500	~1 500
Average mining recovery (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	Processed at McClean Lake	To be processed at McClean Lake	To be processed at Key Lake	Acid
Type (IX/SX)	SX	SX	SX				SX
Size (tonnes ore/day)	864	300*	2 880				N/A
Average process recovery (%)	98	97	97				N/A
Nominal production capacity (tU/year)	7 200	4 615	6 500	~5 000	~2 300	~2 750	~3 000
Plans for expansion	Expansion to 9 600 tU/year	Expansion to 9 200 tU/year	Expansion of tailings capacity				

* Capacity of 170 tonnes ore/day for high-grade ore.

Employment in the uranium industry

Direct employment in Canada's uranium industry totalled 1 406 in 2013 and 1 829 in 2014. Total employment, including head office and contract employees, was 2 148 in 2013 and 2 874 in 2014.

Future production centres

Two uranium mining projects in Saskatchewan could enter into production within the next decade, should uranium prices increase, extending the lives of the existing mills. Ore from the proposed Midwest mine would provide additional feed for the McClean Lake mill. Ore from the proposed Millennium mine would be processed at the Key Lake mill. There are several other exploration projects in the Athabasca Basin which have identified significant high-grade uranium mineralisation that may develop into proposals for new mines.

There is also a possibility of mines being developed outside of Saskatchewan, but uranium prices would have to increase substantially. Areva has proposed to develop the Kiggavik and Sissons deposits in Nunavut should market conditions improve and mining becomes economic. Paladin Energy has indicated it may consider developing the Michelin and Jacques Lake deposits in Labrador, but a uranium price of at least USD 200/kgU would be required.

Secondary sources of uranium

Canada does not use secondary sources of uranium. Canada does not produce or use mixed oxide fuels nor use re-enriched tails.

Environmental activities and socio-cultural issues

Environmental impact assessments

In December 2007, Areva Resources Canada Inc. announced a decision to proceed with an economic feasibility study and to commence the regulatory process to obtain approval for the development of the Kiggavik Project in Nunavut. The deposits have an estimated 44 000 tU with an average grade of 0.47% U. An environmental impact statement was submitted to the Nunavut Impact Review Board in May 2012 as part of the Canadian Nuclear Safety Commission (CNSC) licensing process. A final environmental impact assessment was submitted in October 2014 and a decision on the environmental assessment is expected in 2015. Areva has not defined a start date for the project as market conditions would have to improve for the project to be economic.

The environmental assessment for the Matoush Exploration Project, located in the Otish Mountains of Quebec, was approved by the federal government in February 2012. The project would allow Strateco Resources Inc. to conduct underground exploration on the Matoush deposit which has identified resources of 6 500 tU with an average grade of 0.42% U. The project has not yet obtained provincial approval and in March 2013, the Quebec government announced a moratorium on uranium projects as a result of public concerns. This moratorium will be in effect while the Quebec environmental assessment agency conducts a study on the uranium industry. The project has therefore been delayed.

In August 2009, Cameco submitted a proposal to the CNSC to develop the Millennium deposit which is located 35 km north of Key Lake. The proposed underground mine would produce 150 000 to 200 000 tonnes of ore annually for 6-7 years. Ore and associated waste materials, other than clean waste rock, would be transported to the Key Lake mill along a new 21 km access road. Due to lower than expected uranium demand, Cameco has postponed plans to develop the mine, and in May 2014, withdrew the project from the environmental assessment process.

A proposal to extend the lifespan and increase the annual production capacity of the Key Lake milling operation by 33% (from 7 200 tU/yr to 9 600 tU/yr) was submitted to the federal nuclear regulator, the CNSC in May 2010. The proposal includes increasing the storage capacity of the tailings management facility and modifications to the mill to allow treatment of a wider range of ore and waste rock from other deposits. The environmental assessment of the Key Lake Extension Project was approved in July 2014. Cameco is awaiting provincial approval to increase the McArthur River mine production to 9 600 tU/yr which will then match the capacity of the Key Lake mill.

In April 2014, Rio Tinto Canada Uranium Corporation submitted a proposal to the government of Saskatchewan to conduct an underground exploration project to evaluate the Roughrider deposit in northern Saskatchewan. The environmental assessment of the project was approved in August 2014.

Effluent management

Water treatment and minor engineering works continued to be the main activities at the closed Elliot Lake area uranium mine and mill sites in 2013 and 2014. Water quality within the Serpent River Watershed has improved since the closure and decommissioning of the mines and currently meets Ontario Drinking Water Standards.

Site rehabilitation

The Cluff Lake mine, located in the western Athabasca Basin of Saskatchewan, ceased mining and milling operations in May 2002. A two-year decommissioning programme was initiated in 2004, following a five-year comprehensive environmental assessment study. Decommissioning was essentially completed by 2006 and Areva continues to work on-site. Activities conducted in 2013 included improving drainage and the demolition and disposal of the warehouse buildings. Environmental monitoring and inspections are conducted quarterly and an environmental performance report is to be submitted in 2015 confirming that the objectives of the decommissioning plan are being met.

In northern Saskatchewan, several mines (principally the Gunnar and Lorado mines) were operated from the late 1950s to early 1960s by private sector companies that no longer exist. When the sites were closed, there was no regulatory requirement in place to appropriately contain and treat the waste, which has led to environmental impacts on local soils and lakes.

In 2014, the government of Saskatchewan began a project to place a cover of till and sand on the exposed tailings at the Lorado mill site. The cover was to be completed in 2014, but the lack of a sufficient quantity of suitable cover material in the area has delayed completion until 2015. In 2014, an acidic lake adjacent to the tailings was treated with lime to neutralise the pH of the water.

A project to remediate the Gunnar mine site, also managed by the government of Saskatchewan, received a licence from the CNSC in January 2015. However, no remediation option has yet been chosen as further site characterisation is required. The buildings at the Gunnar site were demolished in 2010 and 2011.

Uranium requirements

Nuclear energy represents an important component of Canada's electricity sources. In 2014, nuclear energy provided close to 17% of Canada's total electricity needs (over 60% in Ontario) and should continue to play an important role in supplying Canada with power in the future. Canada has a fleet of 22 CANDU pressurised heavy water reactors, of which

19 are currently in full commercial operation (18 in Ontario and 1 in New Brunswick). The only unit in Quebec was shut down at the end of December 2012 and two units in Ontario have been placed in guaranteed safe shutdown state.

In Canada, the responsibility for deciding on energy supply mix and investments in electricity generation capacity, including the planning, construction and operation of nuclear power plants, resides with the provinces and their provincial power utilities. In 2012, the environmental assessment associated with the development of new nuclear power at the Darlington Nuclear Power Plant in Ontario was approved. The CNSC issued a site preparation licence for Darlington, which is the first of three licences required to build and operate a new nuclear facility in Canada. In June 2013, detailed analyses were submitted to Ontario Power Generation by the two prospective vendors. However, in December 2013, the Ontario government released its Long-Term Energy Plan that outlined its decision to shelve plans to build two new nuclear reactors at Darlington due to the lack of growth in power demand in the province.

Refurbishment projects in New Brunswick (Point Lepreau) and Ontario (Bruce A units 1 and 2) have been successfully completed and the reactors returned to service in the fall of 2012. Ontario's 2010 Long-Term Energy Plan recommended the refurbishment of up to ten nuclear reactors (four at Darlington, two at Bruce A and four at Bruce B), starting in 2016, and to decommission the Pickering nuclear station, starting in 2020. The CNSC announced the approval of the environmental assessment of the proposed Darlington refurbishment project on 14 March 2013. On 13 December 2013, Ontario Power Generation submitted an application to renew Darlington's operating licence to be valid until December 2028, covering the estimated time to complete the refurbishment project. Before the refurbishment can proceed, this application will be considered in public hearings, with dates to be announced by the CNSC in spring 2015.

Supply and procurement strategy

Approximately 15% of Canada's uranium production is used domestically to generate nuclear power. The nuclear utilities fill uranium requirements through long-term contracts and periodic spot market purchases.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The Nuclear Fuel Waste Act (NFWA), which came into force on 15 November 2002, requires nuclear energy corporations to establish a Nuclear Waste Management Organization (NWMO) to safely and securely manage nuclear fuel waste over the long term.

Adaptive phased management (APM) was chosen as Canada's approach for safely managing nuclear fuel waste over the long term. The APM involves the containment and isolation of nuclear fuel waste in a deep geological repository (DGR). The APM approach recognises that people benefiting from nuclear energy produced today must take steps to ensure that the wastes are dealt with responsibly and without unduly burdening future generations. At the same time, it is sufficiently flexible to adapt to changing social and technological developments. The APM is implemented by the NWMO, using funds provided by the owners of nuclear fuel waste.

The NWMO has developed a siting process to identify an informed willing host community with a safe, secure and suitable site for a DGR. This nine-step siting process was collaboratively designed, refined and finalised through an iterative two-year public engagement and consultation process. In May 2010, the NWMO initiated the siting process with an invitation to communities to learn more about the APM project and the plan to safely manage the waste. The expression of interest phase of the siting process was suspended as of 30 September 2012. By the end of 2014, the NWMO had actively engaged with 21 communities in Ontario and Saskatchewan, including First Nations and Métis communities that had expressed an interest in hosting the waste management facility. The ultimate success of the project depends upon community engagement and lasting partnerships.

As of April 2015, nine candidate communities remain involved in the NWMO siting process. Detailed field work to address the scientific and technical aspects, as well as the social dimensions of site selection, will proceed over the next several years. Field studies, borehole drilling, airborne surveys, environmental mapping, socio-economic studies and other assessments will be carried out to determine the suitability of sites and the willingness of communities. The NWMO will continue to build and strengthen its working relationships with participating communities as this process advances.

The Nuclear Liability Act (NLA) sets out a comprehensive scheme of liability for civil injury and damage arising from nuclear accidents and a compensation system for victims. It embodies the principles of absolute and exclusive liability of the operator, mandatory insurance and limitations on the operator's liability in both time and amount. Under the act, operators of nuclear installations are absolutely and exclusively liable for civil nuclear damage to a limit of CAD 75 million. All suppliers or contractors providing parts or services to the nuclear installation are thereby indemnified.

The Nuclear Liability and Compensation Act, which is expected to come into force in 2016, will replace the NLA with stronger legislation to better deal with liability and compensation for a nuclear accident within Canada; and implement Canadian membership in the IAEA Convention on Supplementary Compensation for Nuclear Damage to address liability and compensation for damage within member countries arising from trans-boundary and transportation nuclear accidents. The key improvements of the legislation are: an increased liability limit for nuclear power plant operators to CAD 1 billion; a mechanism for periodic updating of the operator's liability; expanded categories of compensable damage to address environmental damage, economic loss, and costs related to preventive measures; and a longer limitation period for submitting compensation claims for bodily injury.

Uranium stocks

The Canadian government does not maintain any stocks of natural uranium and data for producers and utilities are not available. Since Canada has no enrichment or reprocessing facilities, there are no stocks of enriched or reprocessed material in Canada. Although Canadian reactors use natural uranium fuel, small amounts of enriched uranium are used for experimental purposes and in booster rods in certain CANDU reactors.

Uranium prices

In 2002, Natural Resources Canada suspended the publication of the average price of deliveries under export contracts for uranium.

Uranium exploration and development expenditures and drilling effort – domestic

(CAD millions)

	2012	2013	2014 (preliminary)	2015 (expected)
Industry* exploration expenditures	205	167	179	165
Government exploration expenditures	0	0		
Industry* development expenditures	669	717	384	374
Government development expenditures	0	0		
Total expenditures	**874**	**884**	**563**	**539**
Industry* exploration drilling (m)	357 450	385 200	N/A	N/A
Industry* exploration holes drilled	N/A	N/A	N/A	N/A
Industry* exploration trenches (m)				
Industry* exploration trenches (number)				
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Government exploration trenches (m)				
Government exploration trenches (number)				
Industry* development drilling (m)	154 745	116 500	N/A	N/A
Industry* development holes drilled	N/A	N/A	N/A	N/A
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	357 450	385 200	N/A	N/A
Subtotal exploration holes drilled	N/A	N/A	N/A	N/A
Subtotal development drilling (m)	154 745	116 500	N/A	N/A
Subtotal development holes drilled	N/A	N/A	N/A	N/A
Total drilling (m)	**512 195**	**501 700**	**N/A**	**N/A**
Total number of holes drilled	N/A	N/A	N/A	N/A

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Proterozoic unconformity	226 120	240 050	368 229	441 773
Sandstone			6 000	6 000
Paleo-quartz-pebble conglomerate				5 255
Metasamotite				38 626
Total	**226 120**	**240 050**	**374 229**	**486 399**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)	225 830	239 760	337 621	416 319	N/A
Open-pit mining (OP)	290	290	36 608	70 080	N/A
Total	**226 120**	**240 050**	**374 229**	**486 399**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Conventional from UG	225 830	239 760	337 621	411 064
Conventional from OP	290	290	36 608	70 080
In-place leaching*				3 153
Heap leaching** from UG				2 102
Total	**226 120**	**240 050**	**374 229**	**486 399**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Proterozoic unconformity	25 050	81 790	128 763	169 7485
Sandstone			6 044	12 241
Paleo-quartz-pebble conglomerate				18 947
Metasomatite				16 520
Total	**25 050**	**81 790**	**134 807**	**217 193**

Inferred conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)	25 050	81 790	109 500	171 736	N/A
Open-pit mining (OP)			25 307	45 457	N/A
Total	**25 050**	**81 790**	**134 807**	**217 193**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	25 050	81 790	109 500	152 467
Conventional from OP			25 307	45 457
In-place leaching*				11 368
Heap leaching** from UG				7 579
Total	**25 050**	**81 790**	**134 807**	**217 193**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
50 000	150 000	150 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
700 000	700 000	0

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Proterozoic unconformity	281 123	8 998	9 332	9 136	308 589	11 700
Paleo-quartz-pebble conglomerate	144 182				144 182	
Intrusive	6 088				6 088	
Metasomatite	25 098				25 098	
Total	**456 491**	**8 998**	**9 332**	**9 136**	**483 957**	**11 700**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	119 044			44	119 088	4
Underground mining*	337 447	8 998	9 332	9 092	364 869	11 696
Total	**456 491**	**8 998**	**9 332**	**9 136**	**483 957**	**11 700**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	455 491	8 998	9 332	9 136	482 957	11 700
In-place leaching*	1 000				1 000	
In situ leaching						
Total	**456 491**	**8 998**	**9 331**	**9 136**	**483 957**	**11 700**

* Also known as stope leaching or block leaching.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
0	0	6 829	74.7	2 286	25.0	21	0.2	9 136	100

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	2 109	2 148	2 874	2 900
Employment directly related to uranium production	1 361	1 406	1 829	1 850

Short-term production capability

(tonnes U/year)

2014				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
18 700	18 700	18 700	18 700	18 700	18 700	18 700	18 700	12 330	18 850	12 330	18 850

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
12 330	18 850	12 330	18 850	12 330	18 850	12 330	18 850	12 330	18 850	12 330	18 850

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	97.0	100.9 p

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
13 350	13 350 p	Low	High	Low	High	Low	High	Low	High	Low	High
		13 500	13 500	9 900	N/A	10 200	N/A	11 100	N/A	11 100	N/A

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
1 750	1 800	Low	High	Low	High	Low	High	Low	High	Low	High
		1 875	N/A	1 550	N/A	1 600	N/A	1 700	N/A	1 700	N/A

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	0	0	0	0
Producer	N/A	0	0	0	N/A
Utility	N/A	0	0	0	N/A
Total	**N/A**	**0**	**0**	**0**	**N/A**

Chad*

Uranium exploration and mine development

Historical review

Beginning in 1946, the French Alternative Energies and Atomic Energy Commission sent several missions to countries in Africa, including Chad. A preliminary reconnaissance of the north-western part of Chad did not produce positive results.

From 1972-1980, the United Nations Development Programme (UNDP) assisted the government in exploring for metallic and non-metallic mineral resources in the Mayo-Kebbi area of south-western Chad. An area of about 10 000 km² was covered by an aerial radiometric and magnetic survey and several anomalies were found in granitic and sedimentary terrain. As a result of this survey, vein uranium mineralisation was found in the Lere alkaline granite, although the anomalies were not particularly favourable.

In 1978, Phase II of the UNDP supported project resulted in the discovery of uranium mineralisation in the Mayo-Kebbi area near the border with Cameroon. The uranium minerals (pitchblende and coffinite) were found as disseminations and in veinlets in syenitic rocks. Following a wide-spaced airborne radiometric survey, uranium mineralisation was discovered at Mandagzang and confirmed by diamond drilling. However, exploration drilling had to be discontinued in 1980 due to political instability.

In early 2008, the London-based Brinkley Exploration SA was granted three exploration permits for uranium, gold and base metals in the Mayo-Kebbi area in south-western Chad. The Mayo-Kebbi region covers an area of approximately 8 000 km² of exposed basement complex with syntectonic alkaline intrusions and a Cretaceous platform cover. Despite conducting a detailed airborne survey that delineated a number of radiometric anomalies, Brinkley Exploration SA ended all uranium exploration activities in Chad in 2008.

Recent and ongoing uranium exploration and mine development activities

Signet Mining Services Ltd (Signet), a European-based mining company that has been active in Africa since 2005, has six concessions comprising 841 km² that include the Lere Project in south-western Chad near the towns of Lere and Pala.

The Lere deposit has uranium hosted near vertical shear zones and secondary foliation in albitised and silicified granite in a mixed terrain of Precambrian units. Exploration activities have included an airborne geophysical survey, a geological survey and a surface radiometric survey. Uranium anomalies and potentially significant structures have been identified. Anomaly A and B have been drilled by percussion drilling (18 541 m) and core drilling (2 676 m), enabling the development of a geological model and providing sufficient data for resource estimation.

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* Report prepared by the NEA/IAEA, based on company reports and government data.

Resources compliant with the South African code for the reporting of exploration results, mineral resources and minerals reserves (The South African Mineral Resource Committee [SAMREC] Code) have been evaluated to amount to 3 190 tU, at an average grade of 200 ppm U (0.020% U). At a uranium price of less than USD 50/lb U_3O_8, the identified deposit is considered uneconomic. Further structures will need to be identified to increase the resources in order to move the project to a development stage.

At Pala, exploration activities included an airborne geophysical survey and percussion drilling (72 m). Uranium anomalies have been identified associated with surficial laterite, underlain by unweathered granite.

Total exploration expenditures for all projects from 2006 to 2011 amount to USD 26 million, including USD 10.9 million for exploration costs, USD 6.8 million of operating expenditure and USD 8.3 million of corporate expenditure.

Uranium resources

Identified conventional resources

At Lere, uranium resources have been estimated to amount to 3 190 tU at an average grade of 0.020% U. These resources have been classified as inferred resources in the USD 130-260/kgU cost category.

Uranium production

No uranium has been produced in Chad.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related	0	0	0	3 190
Total	**0**	**0**	**0**	**3 190**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	3 190	N/A
Total	**0**	**0**	**0**	**3 190**	**N/A**

* In situ resources.

Chile

Uranium exploration and mine development

Historical review

Uranium exploration was initiated in the 1950s with a review of uranium potential in mining districts with Cu, Co, Mo, Ag mineralisation conducted by the US Atomic Energy Commission. Following a delay of about ten years, activities were renewed in 1970 by the Spanish Nuclear Energy Organization (JEN), focusing for four years on Region IV of the Tambillos mining district.

Between 1976 and 1990, regional prospecting encompassing an area of 150 000 km^2 was conducted in co-operation with the IAEA using geochemical drainage surveys, aerial radiometry, ground-based geology and radiometry. This work led to the detection of 1 800 aerial anomalies, 2 000 geochemical and radiometric anomalies and the definition of 120 sectors of interest. Subsequent investigation of 84 of these sectors of interest led to the detection of 80 uranium occurrences, stimulating further study of the 12 most promising uranium prospects, preliminary exploration of these prospects and eventually the evaluation of uranium resources as a by-product of copper and phosphate mining.

From 1980 to 1984, Cía Minera Pudahuel (the Pudahuel Mining Company), in co-operation with the Chilean Nuclear Energy Commission (CCHEN), conducted drilling of the Sagasca Cu-U deposit, Region I (Tarapacá), leading to a technical and economic evaluation of the Huinquintipa copper deposit, Region I. The Production Development Corporation (Corporación de Fomento de la Producción – CORFO) and CCHEN conducted exploration and technical-economic evaluation of the Bahía Inglesa phosphorite deposit, Region III (Atacama) in 1986 and 1987.

Between 1990 and 1996, CCHEN undertook geological and metallogenic uranium research, mainly in the north of the country. From 1996 to 1999, CCHEN and the National Mining Company (ENAMI) investigated rare earth elements in relation to radioactive minerals in the Atacama and Coquimbo regions. Dozens of primary occurrences were studied, with the “Diego de Almagro” Anomaly-2 chosen as a priority. The study of this 180 km^2 sector found disseminations and veins of davidite, ilmenite, magnetite, sphene, rutile and anatase, with 3.5 to 4.0 kg/t of rare earth oxides (REO), 0.3 to 0.4 kg/t of U and 20 to 80 kg/t of Ti. The geological resources of the ore contained in this prospect were estimated at 12 000 000 t. The metallurgical recovery of REOs from these minerals was also investigated with a purpose of investigating mining resources with economic potential in the medium term.

In 1998 and 1999, CCHEN created the National Uranium Potential Evaluation Project, encompassing the activities of uranium metallogeny research and development of a geological database. The aim of this project was to set up a portfolio of research projects to improve the evaluation of national uranium ore potential. Between 2000 and 2002, a preliminary geological evaluation for uranium and rare earth oxides of the Cerro Carmen prospect (2000-2002), located in Region III (Atacama), was completed as part of the specific co-operation agreement between CCHEN and ENAMI. Geophysical exploration work was undertaken (magnetometry, resistivity and chargeability), defining targets with metallic sulphur minerals with uranium and associated rare earths.

In 2001, a project portfolio document was developed that updated the metallogeny and geological favourability for uranium in Chile. A total of 166 research projects were proposed, ranging from regional activities to detailed scientific studies, to be undertaken sequentially in accordance with CCHEN capacities. In the extractive metallurgy area, work has been ongoing since 1996, through a co-operation agreement between CCHEN and ENAMI, to develop processes to produce commercial concentrates of rare earths. High-purity concentrates of light rare earths, as well as yttrium have been obtained.

In 2003, regional reconnaissance was undertaken for uranium and rare earths in Region I of the country, after which the CCHEN-ENAMI co-operation agreement was terminated. Through 2004, database work was continued by CCHEN and commercial services were provided to the mining industry through 2010.

Recent and ongoing uranium exploration and mine development activities

From 2008 to 2012, CCHEN completed a broad scope co-operation agreement with the National Copper Corporation (CODELCO Norte) for geological and metallurgical investigation of natural atomic material occurrences. From 2009 to 2012, CCHEN and CODELCO Norte completed an agreement on activities to investigate recovery of uranium and molybdenum from copper ore leaching solutions.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

No new uranium resources have been identified since the 2011 edition of the Red Book. Using a recovery factor of 75%, total identified recoverable resources are 1 447 tU in the <USD 260 kg/U category.

Surface deposits

(tonnes U)

Surface deposits	RAR	IR	PR	SR	% U_3O_8	Minerals
Boca Negra		3.0			0.02-0.600	Silica, yellow minerals
Manuel Jesús		2.5			0.10-0.190	Silica, yellow minerals
Casualidad					0.018	Silica, yellow minerals
San Agustín					0.20-0.250	Silica, yellow minerals
Poconchile					0.028	Silica, yellow minerals
Quebrada Vítor					0.028	Autunite
Pampa Chaca		2.0			0.028	Autunite
Pampa Camarones		3.5	3.5		0.030	Autunite, shronquingierite
Salar Grande	28.0		100.0		0.023	Carnotite
Quebrada Amarga		2.0			0.117	Carnotite
Quillagua		22.0			0.165	Carnotite
Chiu Chiu		5.0	5.0	15.0	0.04-0.140	Yellow minerals
Total	**28.0**	**40.0**	**108.5**	**15.0**		

Uranium resources by deposit type

(tonnes U)

Deposits, areas and other resources	RAR + IR	PR + SR	SR*
Surface deposits	68.0	123.5	
Metasomatic deposits	1 762.8	4 060.0	
Cenozoic volcanogenic deposits	100.0	5 000.0	
Unconventional deposits and resources	1 798.0	5 458.0	1 000
Deposit areas:			
1 – Surface deposits, Cenozoic	--	--	500
2 – Metasomatic deposits, Cretaceous	--	--	500
3 – Magmatic deposits, Cenozoic			250
4 – Polymtallic deposits, Cretaceous	--	--	100
Favourable areas:			
A – Acid volcanism, Tertiary	--	--	500
B – Jurassic-Cretaceous intrusives	--	--	500
C – Volc. acid-sedimentary, Cretaceous	--	--	200
D – Palaeozoic magmatism. Main Cordillera	--	--	50
E – Sedimentary-volcanic, Middle Cretaceous	--	--	100
F – Palaeozoic plutonism, Nahuelbuta	--	--	300
G – Clastic sedimentary, Cretaceous-Tertiary	--	--	300
Total	**3 728.8**	**10 141.5**	**4 300**

* Undiscovered resources are expected to exist remotely from the known occurrences, either in the aforementioned uranium deposit areas or in favourable areas. In the case of unconventional resources, the figures correspond to uranium that could be recovered from the copper leaching plant solutions of the country's medium and large-scale mining activities. The latter could be several orders of magnitude greater, considering that large-scale national mining, both state-owned and private, produces large reserves of minerals in projects lasting up to 20 years. CCHEN has not updated its studies on this subject.

Metasomatic deposits

(tonnes U)

Metasomatic and hydrothermal deposits	RAR	IR	PR	SR	% U_3O_8	Minerals
Anomaly-2, Diego de Almagro (Cerro Carmen prospect)	595.3	796.5	1 400.0	1 500.0	0.03-0.10	Davidite, sphene, Ilmenite, anatase
Agua del Sol	15.0			50.0	0.02-0.06	Davidite
Sierra Indiana			15.0	15.0	0.02-0.08	Davidite
Estación Romero						
Carmen	20.0	10.0		50.0	0.01-0.12	Davidite
Producer	60.0	236.0	300.0	500.0	0.01-0.28	Autunite, torbernite
Tambillos	10.0			100.0	0.01-0.20	Uraninite, pitchblende
Pejerreyes – Los Mantos	20.0			130.0	0.01-0.05	Davidite, aut., torbernite
Total	**720.3**	**1 042.5**	**1 715.0**	**2 345.0**		

Unconventional resources and other materials

(tonnes U)

Mines, prospects, materials	RAR	IR	PR	SR	% U_3O_8	Minerals
Copper-uranium paleochannels						
Sagasca – Cascada[1]	164				0.0046	Crisocola, U
Huinquintipa[2]	46				0.0030	Crisocola, U
Chuquicamata Sur[3]	950				0.0007	Crisocola, U
Quebrada Ichuno[4]				25	0.0060	Crisocola, U
El Tesoro[5]				50	0.0070	Crisocola, U
North Chuquicamata (oxides zone)[6]				1 000	0.0008	Oxides Cu, U
Gravel from Chuquicamata oxides plant[7]				2 000	0.0008	Oxides Cu, U
Seams of high-temperature copper						
Algarrobo – El Roble[8]			513		0.0400	Sulph., Cu, U
Carrizal Alto[8]				500	0.0250	Sulph., Cu, U
Tourmaline breccias[8]						
Campanani[8]						
Sierra Gorda[8]				60	0.0020	Sulph., Cu, U
Los Azules[8]			5			
Cabeza de Vaca[8]				5		
Uranium-bearing phosphorites						
Mejillones			1 300		0.0026	Colophane – U
Bahía Inglesa[9]	638				0.0062	Colophane – U
Total	**1 798**		**1 818**	**3 640**		

Note: The figures shown in this table represent historical data and are of little current value. Studies need to be done to validate or eliminate these figures.

1. The Sagasca deposit is exhausted, the Cascada deposit (continuation of the mineralised body) is practically exhausted; however, new explorations in the area have found new mineralised bodies, so the figure could vary substantially.
2. Huinquintipa currently forms part of the Collahuasi Project, a contractual mining company belonging to Anglo American Plc and Xstrata Copper, a division of the Swiss mining company Xstrata Plc, each of which has a 44% stake. The remaining 12% belongs to JCR, a consortium of Japanese companies led by Mitsui & Co., Ltd. The oxidised mineral reserves amount to 53 million tonnes, for which copper extraction and production began in 2000 and will last for 20 years. The figures shown in the foregoing table could rise by a factor of between 10 and 20.
3. Chuqui Sur: Although this deposit is not exhausted, the surcharge makes it expensive to operate, so the uranium resources contributed to the Chuquicamata Division oxides plant could be zero. Accordingly, the figures indicated above could decrease significantly.
4. Quebrada Ichuno, has not been studied and there are only preliminary works, so the figure mentioned above is maintained.
5. The uranium resources assigned to the El Tesoro mine correspond to preliminary geological reconnaissance data obtained in 1983. This deposit is currently a nationally important mining centre, 70% owned by Antofagasta Minerals S.A., which belongs to Antofagasta Plc, and 30% owned by the Marubeni Corporation of Japan. Its mineral reserves amount to 186 million tonnes, with a useful life of 21 years. Preliminary samples suggest uranium contents of between 5 and 200 ppm, with an average of between 15 and 20 ppm. Investigating this uranium source could change the figure indicated above substantially.
6. The "Chuquicamata Norte" prospect currently corresponds to the Radomiro Tomic mining centre, with reserves of 970 million tonnes of minerals that could be leached from copper and a useful life of 22 years. A programme of activities is currently being developed to recover uranium and molybdenum.
7. Estimations performed in the 1970s assigned a potential of 1 000 tU that could be recovered from copper leaching solutions obtained from the gravels of the old oxides plant of the Chuquicamata copper mine. This project began its activities in 1998 and will be active for 12 years. By the end of the period it will produce 467 000 t of fine copper. Recovery of uranium from these leaching solutions has not been researched.

   In addition to the uranium resources present in the leaching solutions from the aforementioned mines, there are other large copper deposits in the large-scale mining sector, whose leaching solutions have not been researched. An example is El Abra. This deposit, owned by Phelps Dodge Mining Co (51%) and CODELCO Chile (49%), started production of 800 million tonnes of is copper minerals for a 17-year period.
8. These figures have historical value only and as geological background data. The low copper content of these districts and the small volume of their reserves makes it difficult to recover their uranium content.
9. No experiments have been done to recover uranium from the uranium content in marine phosphorites. The only deposit currently being exploited is Bahía Inglesa, in Region III (Atacama), which produces a solid phosphate concentrate of direct use as fertiliser. In 2001, Compañía Minera de Fosfatos Naturales Ltda., (BIFOX LTDA.), which operates the aforementioned mine, began producing phosphoric acid, which would make it possible to recover uranium from the mother solutions.

Volcanogenic deposits

(tonnes U)

Volcanogenic deposits	RAR	IR	PR	SR	% U_3O_8	Minerals
Acid and intermediate volcanism, regions I to III						Not investigated
El Laco sector, Region II		100	500			Aut., torbernite, REE
El Perro sector, Region III						Not investigated
Total		**100**	**500**			

REE = rare earth elements.

Unconventional resources and other materials

Deposit	RAR	IR	PR	SR	% U	Mineral
Unconventional	1 798	0	1 818	3 640	0.0008-0.1	Leaching solution 7 to 15 g/m^3 Oxide plants gravel Cu silicate and oxides, 20-70 ppm Sulphur oxide veins of 500-1 000 ppm
Total	**1 798**	**0**	**1 818**	**3 640**		

The uranium present in copper oxide ores could be recovered from the leaching solutions. These processes were trialled at the pilot level in the Chuquicamata Division between 1976 and 1979, obtaining 0.5 t of yellow cake from copper-rich solutions containing 10 to 15 ppm U (0.001 to 0.0015% U), which was sent for purification at the CCHEN metallurgy pilot plant at the Lo Aguirre nuclear centre. The production of copper oxide minerals has quadrupled in Chile over the last decade.

The copper mining industry, particularly large-scale mining, has strategic (sub-economic) uranium potential in the large volumes of copper oxide leaching solutions. These resources are assigned a potential of 1 000 tU in mining centres not included in the previous table. However, no background studies have been performed to confirm these figures, either as mining resources or in terms of the volumes of solutions treated annually, so the information should be treated as unofficial. Over the last decade, private firms, both domestic and foreign, have explored 12 “exotic copper” deposits in Chile, which correspond to paleochannels filled with gravel, mineralised with copper silicates, oxides and sulphates as a result of the natural leaching of porphyry copper deposits or other contribution areas. These mineralisations contain variable uranium contents ranging between 7 to 116 ppm (0.007 to 0.016% U). The leaching solutions in the plants that treat these copper oxide minerals display uranium levels of up to 10 ppm. This uranium content is technically recoverable using ion-exchange resins, at a likely production cost of over USD 80/kgU.

There has been no experience in recovering uranium from phosphorites in Chile. The only deposit currently being worked is Bahía Inglesa in Region III (Atacama), which produces a solid phosphate concentrate used directly as fertiliser. In 2001, Compañía Minera de Fosfatos Naturales Ltda., (Bifox Ltda.) began producing phosphoric acid from this deposit, opening the potential of recovering uranium from the acid.

Speculative resources in uranium geological favourable areas

Growing knowledge of the distribution of uranium mineralisation in Chile has made it possible to define four areas of uranium occurrence and seven favourable areas, five of which have occurrences of uranium.

Areas of uranium occurrences:

1. Upper Cenozoic surface deposits – potential in SR: 500 tU.
2. Upper Cretaceous metasomatic deposits – potential in SR: 500 tU.
3. Upper Cenozoic magmatic and hydrothermal deposits – potential in SR: 250 tU.
4. Upper Cretaceous polymetallic and uranium deposits – potential in SR: 100 tU.
5. Tertiary volcanogenic deposits – potential not investigated.

Areas favourable for uranium occurrences (only minimum potential is indicated owing to a lack of research):

A. Acid volcanism and tertiary-quaternary alluvial deposits, Main Cordillera, Regions I and II – potential: 500 tU.

B. Intrusive Jurassic and Cretaceous rocks, Coastal Range, regions I and II – potential: 500 tU.

C. Acid volcanism and upper Cretaceous clastic sedimentary rocks; Central Valley, regions II and III – potential: 200 tU.

D. Paleozoic magmatism, Main Cordillera, Region IV – potential: 50 tU.

E. Sedimentary-volcanic rocks of the Middle Cretaceous period, neogenic intrusives, Main Cordillera, regions VI, VII and Metropolitan Region – potential: 100 tU.

F. Paleozoic plutonism, Nahuelbuta Range, regions VIII and IX – potential: 300 tU.

G. Acid and intermediate sedimentary clastic volcanism, Tertiary and Tertiary [sic], Main Cordillera, regions VII, VIII and IX – potential: 300 tU.

Uranium production

Outside of trial production mentioned above, no uranium has been produced in Chile.

Environmental activities and socio-cultural issues

The CCHEN runs a permanent programme to disseminate information on peaceful uses of nuclear energy, attached to the Office of Dissemination and Public Relations (Oficina de Difusión y Relaciones Públicas).

Uranium requirements

Chile has achieved significant technological development in the manufacture of MTR-type (materials test reactor) combustible elements, based on U_3Si_2 (uranium silicide). In March 1998, the manufacture of 47 combustible elements began at the CCHEN combustible elements plant, ending in 2004. For this work, 60 kg of metallic uranium was purchased from Russia, enriched to 19.75% in ^{235}U, covering uranium requirements up to the indicated date. At the present time, 47 combustible elements have been manufactured, 16 of which are operating in the RECH-1 reactor, and another was sent to the Petten Research Centre in the Netherlands, to be classified under radiation in the high-flow reactor, which ended in November 2004.

Supply and procurement strategy

Should other loads of combustible elements be required, consideration will be given to purchasing enriched metallic uranium.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

There have been no changes in legislation relating to uranium in Chile.

Uranium stocks

There are no uranium stocks.

Undiscovered conventional resources (prognosticated and speculative resources)

Deposit	Type	Prognosticated tonnes U	Speculative tonnes U	Grade % U	Rocks hosting age
Cenozoic surface Deposits[1]	Surface	108.5	15.0		Diatomite, volcanic ash with organic material. Pliocene – Pleistocene.
Cretaceous metasomatics[2]	Metasomatics	1 715	2 345	0.025-0.17	Intrusive, volcanic and metasomatic rocks. Upper cretaceous.
Cenozoic volcanogenics[3]	Volcanic	500	0	0.085-0.15%	Tuffs with high magnetite and haematite content. Mineralisation of secondary REE minerals observed. Oligocene Pleistocene.
Total		**2 323.5**	**2 360**		

REE = rare earth elements.

1. Salar Grande (100 t), Pampa Camarones (4 t), Prosperidad – Quillagua (24 t).

   No new uranium prospecting has been done in the area of Cenozoic surface deposits.

2. Diego de Almagro Anomaly-2 (1 400 t); Diego de Almagro Alignment (1 500 t); Agua del Sol (50 t), Sierra Indiana (30 t), Sector Estación Romero: Carmen prospect (50 t) and Productora Prospect (800 t), Tambillos district (100 t), Sector Pejerreyes – Los Mantos (130 t).

   In 1999-2000, at the Diego de Almagro Anomaly-2 (Cerro Carmen prospect), 1 400 tU was assigned as prognosticated and speculative undiscovered resources. The regional alignment that controls the mineralisation of this prospect extends 60 km to the north-west. This structure, visible in satellite images, involves other mining districts for which a potential of 1 500 tU of speculative resources is assigned.

3. In 1999-2000, data held by CCHEN was reviewed as part of the National Uranium Potential Evaluation Project. It was concluded that the acidic and intermediate volcanism present in a broad area of the Main Cordillera stretching from regions I to III constituted an inclined plane dipping towards the west, ending in a lagoon environment situated in a central depression, with a similar conditions occurring to the east. This volcanism covered the pre-volcanic landscape, preserving the surface drainage courses (now paleochannels). The leaching of these volcanic rocks contributed large amounts of uranium into the lagoon systems, paleochannels and other structures in which solutions circulate. This process is represented by extensive layers of calcilutites, diatomites (Pampa Camarones), layers of salt (Salar Grande), argillites, limestones, limolites and volcanic ash (Quillagua, Prosperidad, Quebrada Amarga, Chiu Chiu), with uranium contents ranging between 100 and 1 000 ppm. These uranium occurrences and mineralisations have been classified historically as "surface deposits". There are also paleochannels with copper and associated uranium (the Sagasca, Cascada, Huinquintipa, Quebrada Ichuno, Chuqui Sur, El Tesoro deposits and others). Within the volcanic area, uranium mineralisation (torbernite and autunite) has been discovered in volcanic structures containing iron (El Laco and El Perro). This environment is considered to have great potential and requires further research. In structures associated with the U mineralisation indicated above, 500 tU is assigned as EAR-II (now prognosticated).

Identified conventional resources (reasonably assured and inferred resources)

Deposit	Type	RAR tonnes U	IR tonnes U	Grade % U_3O_8	Rocks, hosting age
Cenozoic surface deposits[1]	Surface	28	40	0.023	Diatomite, volcanic ash with organic material (Pliocene – Pleistocene)
Cretaceous metasomatics[2]	Metasomatics	720	1 043	0.028-0.20	Intrusive, volcanic and metasomatic rocks (upper Cretaceous)
Cenozoic volcanogenics[3]	Volcanic	0	100	0.01-0.18	Magnetite and haematite tuffs. Secondary U-REE mineralisation (Oligocene Pleistocene)
Total		**748**	**1 183**		

Surface deposits:

1. Salar Grande (28 t), Mina Neverman (?), Boca Negra (3 t), Manuel Jesús (2.5 t), Mina Casualidad (?), Mina San Agustín (?), Quebrada Vítor (?), Pampa Chaca (2 t), Pampa Camarones (3.5 t), Quebrada Amarga (2 t), Quillagua (22 t), Prosperidad (?), Chiu Chiu (5 t).

Metasomatic deposits:

2. Estación Romero 326 t (Carmen and Productora prospects), Cerro Carmen prospect (1 391.8 t), Agua del Sol (15 t), Sector Pejerreyes – Los Mantos (20 t), Tambillos district (10 t). The following estimates were produced at the prospect of the Diego de Almagro Anomaly-2 (Cerro Carmen prospect) in 1999-2000, as a result of detailed geological and radiometry work, together with magnetometry, excavation and sampling of exploration trenches, undertaken as part of the activities of the co-operation agreement between ENAMI and CCHEN: Calculations indicate that the deposit hosts a total of 595.3 tU as indicated resources, 796.5 tU as inferred resources, making a total in situ of 1 391.8 tU as identified resources (RAR + inferred). The cost of extracting these resources was not estimated.

Volcanogenic deposits:

3. In the El Laco iron ore deposit, produced during Cenozoic volcanism on the "altiplano" of Region II (Antofagasta), a total of 100 tU (in situ) was identified as inferred.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related	0	0	0	540
Surficial	0	0	0	21
Total	**0**	**0**	**0**	**561**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	561	75
Total	**0**	**0**	**0**	**561**	**75**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	561	75
Total	**0**	**0**	**0**	**561**	**75**

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related	0	0	0	75
Metasomatite	0	0	0	782
Surficial	0	0	0	30
Total	**0**	**0**	**0**	**887**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	887	75
Total	**0**	**0**	**0**	**887**	**75**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	887	75
Total	**0**	**0**	**0**	**887**	**75**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	2 324

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	N/A	2 360

Reasonably assured unconventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Copper deposit	0	0	0	754
Phosphorite	0	0	0	415
Total	**0**	**0**	**0**	**1 169**

Reasonably assured unconventional resources by mining method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	0	1 169	65
Total	**0**	**0**	**0**	**1 169**	**65**

Reasonably assured unconventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Co-product/by-product	0	0	0	1 169	65
Total	**0**	**0**	**0**	**1 169**	**65**

Prognosticated unconventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	1 818

Speculative unconventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	3 640

China (People's Republic of)

Uranium exploration and mine development

Historical review

Before the 1990s, China's uranium resource exploration activities were mainly carried out on hydrothermal-related granite-type and volcanic-type uranium deposits in the Jiangxi, Hunan and Guangdong provinces and the Guangxi Autonomous Region of southern China. With decades of exploration experience, the Bureau of Geology (BOG), China National Nuclear Corporation (CNNC), had been successful in discovering some significant uranium deposits such as the Xiangshan and Xiazhuang ore fields and the Chengxian deposit in the Southern China Fold Belt. These deposits mainly occur in intermediate to acid magmatic rocks (such as granitoid) and volcanic rocks. As a number of these deposits are of relatively small size, low to middle grade and their transportation and power supply are not easily accessible, the mining costs turned out to be much higher than those that could be accepted by the commercial nuclear reactor operators. At the beginning of the 1990s, when China initiated its nuclear energy programme, the demand for uranium from China's NPPs was not so urgent. In the mid-1990s, China experienced relatively high currency inflation, resulting in a decrease in uranium exploration activities in China from the mid to the end of the 1990s.

Facing financial difficulties, as well as the challenge of meeting demand for economic uranium resources for China's mid-term and long-term nuclear energy development plan, the BOG made the decision of changing its prospecting direction from "hard rock" types to in situ leach amenable deposits in northern and north-west China. From the mid-1990s, the pace of construction of NPPs in coastal areas increased, and accordingly the demand of uranium increased steadily. As the low-cost identified uranium resources declined, the BOG initiated in the early 1990s with limited funding some regional geological reconnaissance projects and drilling survey projects in the Yili, Turpan-Hami, Junggar, Er'lian and Songliao basins in northern and north-west China. Due to limited funding from the government, the average annual drilling footage was just maintained at about 40 000 m.

In 1999, the government conducted a significant structural reform in China's mineral exploration sector, during which a large part of the personnel who had been involved in geological exploration were transferred to local governments. After the transfer of most of the geological organisations, the staff of BOG was reduced from more than 45 000 to near 5 500. At the end of the 1990s, the government gradually became aware of the importance of increasing uranium resources of economic interest to meet rising demand from the domestic nuclear power industry. Beginning in 2000, investment in uranium exploration steadily increased and drilling rebounded from 40 000 m to 70 000 m in 2000, gradually increasing to 130 000 m in 2003 and 140 000 m in 2004. All this drilling was directed at identifying in situ leach amenable sandstone-type uranium deposits in northern China, with important target areas including the Yili, Erdos, Turpan-Hami, Er'lian, Junggar and Songliao basins.

Since 2008, CGNPC Uranium Resources Co., Ltd (renamed CGNPC Nuclear Fuel Co., Ltd in 2012), a subsidiary of China General Nuclear Power Group (CGNPC), has carried out domestic uranium resources exploration, including several uranium exploration projects in the northern edge of Tarim basin in Xinjiang Uygur autonomous region and the northern part of Guangdong province.

Recent and ongoing uranium exploration and mine development activities

Domestic uranium prospecting and exploration have intensified and increased as a result of additional financial input between 2013 and 2014. The scope of work has also been expanded to potential prospects selected after regional prognosis and assessment has been completed, apart from the continued prospecting and exploration on areas within previously discovered metallogenic regions/belts.

The exploration, including regional uranium potential assessment and further works on previously discovered mineralisation and deposits in northern China has principally been focused on the Yili, Turpan-Hami, Junggar and Tarim basins of the Xinjiang Autonomous Region; the Erdos, Erlian, Songliao, Badanjili and Bayingebi basins of Inner Mongolia; the Caidaum basin in Qinghai province and the Jiuquan basin in Gansu province.

Different geophysical methods, such as audio magnetotellurics, controlled source audio magnetotellurics, combined with some drilling and shallow seismic methods were used in these assessments, followed by further drilling in mineralised areas in order to identify ISL amenable sandstone-type deposits, conventional mining mudstone-type deposits and shallow sandstone-type deposits.

The exploration work in southern China is directed at identifying metallogenic belts relating to volcanic-type and granite-type deposits, distributed in the Xiangshan and Taoshan uranium fields in Jiangxi province; the Xiazhuang and Zhuguang uranium fields in Guangdong province; the Miaoershan uranium field in the Guangxi Autonomous Region; the Lujing field in Hunan province; the Daqiaowu field in Zhejiang province and the Ruoergai area of Sichuan province. Potential deposits in carbonaceous siliceous mudstones are secondary targets in this exploration campaign.

The total drilling footage completed in the last two years amounted to over 1 720 000 m (870 000 m in 2013 and 850 000 m in 2014). As a result, uranium resources in northern China such as those contained in the Yili, Tarim, Erdos, Erlian, Bayinebi, and Songliao basins have been dramatically increased. In addition, important progress has been achieved in old mining areas of southern China, such as the Xiangshan, Taoshan, Xiazhuang and Miaoershan uranium fields.

Referring to the CNNC's overseas uranium development, the Azelik Uranium Project in Niger has produced 360 tons of uranium during the last two years. The Semizbay and Irkol mines in Kazakhstan, which were invested together with CGNPC, had produced 6 000 tons of uranium by the end of 2014. CGNPC acquired the Husab Project in Namibia in 2012 and the project is under construction with operation expected to begin in 2016.

In addition, the above-mentioned Chinese companies have also carried out exploration activities in Australia, Namibia and Uzbekistan completing over 32 000 m drilling in two years.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As a result of the exploration in 2013 and 2014, a total of about 100 700 tU, categorised reasonably assured resources and inferred resources, have been added to China's uranium resource base. These additional resources are distributed in northern China (a total of 71 000 tU in the Yili, Erlian, Erdos, Songliao and Bayingebi basins, as well as Longshoushan) and in southern China (a total of 29 000 tU in the Rouoergai and Dazhou uranium fields). As of 1 January 2015, uranium resources in China totalled 366 200 tU according to this latest data, as listed in the following table.

No.	Location (province and place/name)		tU
1	Jiangxi	Xiangshan	32 000
		Ganzhou	34 000
		Taoshan	12 500
2	Guangdong	Xiazhuang	15 000
		Zhuguangnanbu	25 000
		Heyuan	4 000
3	Hunan	Xiangcaodawan	9 000
4	Guangxi	Ziyuan	11 000
5	Xinjiang	Yili	40 000
		Tuha	10 000
6	Inner Mongolia	Erdos	70 200
		Erlian	48 000
		Tongliao	13 000
		Bayingebi	10 500
7	Hebei	Qinglong	8 000
8	Yunnan	Tengchong	6 000
9	Shanxi	Lantian	2 000
10	Gansu	Longshoushan	2 000
11	Zhejiang	Dazhou	5 000
12	Liaoning	Benxi	2 000
13	Sichuan	Ruoergai	7 000
Total			**366 200**

Undiscovered conventional resources (prognosticated and speculative resources)

China has great potential for uranium resources. According to statistical studies conducted by several institutes in China, 2 million tonnes of potential uranium resources are predicted. Favourable areas in the Erlian basin of the Inner Mongolia Autonomous Region have been identified in the last few years and other areas such as the Tarim and Junggar basins in the Xinjiang Autonomous Region and the Songliao basin in north-east China are regarded as favourable target areas. More uranium resources may also be added to the known uranium deposits in southern China as prospecting and exploration works continue.

Unconventional resources and other materials

No systematic appraisal of unconventional uranium resources has been conducted in China.

Uranium production

Historical review

The more than 50-year history of China's uranium industry has included both a boom in activities during the first two decades and a decline in late 1980s to 1990s. In the early 2000s, a surge in activities took place, driven principally by the ambitious new NPP construction programme announced by the Chinese government and the increased uranium spot price. As a result, uranium production became a focus again.

As uranium demand from NPPs is increasing rapidly in the coming decade, China has accelerated the pace of domestic uranium exploitation. Several uranium production centres such as Fuzhou and Yining are being developed and put into construction to keep pace with the uranium mining production in those regions. On the other hand, in order to promote uranium production, the development of other uranium deposits with potential reserves if appropriate technology is available, such as Tongliao uranium deposit, has been accelerated. Finally some new sandstone uranium deposits with abundant reserves that are suitable for ISL mining, such as Erduos and Erlian, are undergoing pilot tests and feasibility studies.

Status of production capability

There are currently a total of six production centres in China: Fuzhou and Chongyi in Jiangxi province, east China; Lantian in Shaanxi province, central China; Benxi in Liaoning province, north-east China; Shaoguan in Guangdong province, south China; and Yining in the Xinjiang Autonomous Region of north-west China.

The Fuzhou production centre is an underground mine, which exploits Xiangshan volcanic uranium resources with conventional ion-exchange processing. Currently exploited ore zones have steady capacity and primary preparation and sampling of potential new ore zones is in progress.

The Chongyi production centre in the Jiangxi province, is an underground mine, which exploits Ganzhou and Taoshan granite uranium resources with a hydrometallurgical process using heap leaching and ion-exchange. Production capacity of this centre has been steady in recent years and a previously closed pit is now under remediation.

The Yining facility in the Xinjiang Autonomous Region is an ISL production centre, which exploits Yili and Tuha sandstone-hosted uranium resources using ion-exchange. This centre supports development of sandstone-hosted uranium resources in the Kujieertai deposit and its neighbouring areas, such that expansion plans and increased production capacity are expected to occur relatively rapidly.

The Benxi production centre in the Liaoning province is an underground mine, which exploits Benxi granite-type and Qinglong volcanic-type uranium resources with heap leaching and solvent extraction.

The Shaoguan production centre in the Guangdong province is an underground mine, which exploits Xiazhuang and Zhuguang granite-type uranium resources using heap leaching and solvent extraction.

Shaogun is now developing uranium resources of the Guangxi Region and will gradually increase production capacity.

Uranium production in China amounted to 1 500 tU in 2013 and 1 550 tU in 2014. Production is expected to continue to steadily increase to 1 600 tU in 2015.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5		Centre #6
Name of production centre	Fuzhou	Chongyi	Yining	Lantian	Benxi		Shaoguan
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Existing
Date of first production	1966	1979	1993	1993	1996	2007	N/A
Source of ore:							
Deposit name(s)			Kujieertai	Lantian	Benxi	Qinglong	
Deposit type(s)	Volcanic	Granite	Sandstone	Granite	Granite	Volcanic	Granite
Resources (tU)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grade (% U)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mining operation:							
Type (OP/UG/ISL)	UG	UG	ISL	UG	UG	UG	UG
Size (tonnes ore/day)	700	500	N/A	200	100	200	500
Average mining recovery (%)	92	90	N/A	80	85	85	90
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	SX	IX	SX
Size (tonnes ore/day); for ISL (l/day or l/h)	700	500	N/A	N/A	N/A	N/A	N/A
Average process recovery (%)	90	84	N/A	90	90	96	90
Nominal production capacity (tU/year)	350	200	480	100	120	100	200
Plans for expansion	Up to 500	Up to 300	Up to 800	N/A	N/A	Up to 200	Up to 300
Other remarks	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Ownership structure of the uranium industry

The uranium industry is owned by state companies in China.

Employment in the uranium industry

With a few new mines and uranium production centres undertaking and preparing for pilot tests, new employees are required. Hence, employment in the industry will increase slightly.

Future production centres

Industry tests have been launched on the sandstone-hosted uranium deposit in the Tongliao area and a corresponding expansion at the associated production centre is planned. ISL tests are being carried out in some parts of the Erdos and Erlian uranium deposits in order to obtain relative technical parameters and economic indicators of these two deposits and provide reliable technical support for the development of sandstone-hosted uranium deposits in Inner Mongolia. Driven by the active nuclear power development strategy in China, some of the current sub-economic uranium mines are expected to be put into operation again.

Uranium requirements

As of 1 January 2015, the total installed capacity of NPPs is 20 305 MWe. Annual uranium requirements amount to about 4 200 tU. According to the government's nuclear power programme, the total capacity of NPPs will reach between 40 GWe and 58 GWe by the end of 2020. Based on preliminary calculations, uranium requirements will amount to between 10 100 tU and 12 000 tU in 2020, then rise to between 12 300 and 16 200 tU in 2030, then increase to 14 400 and 20 500 tU in 2035.

Supply and procurement strategy

In order to meet the demand of NPPs planned within the development programme approved by the central government, the policy "facing two markets and using of two kinds of resources" has been adopted. This means that China will actively develop domestic uranium resources and make full use of non-domestic resources and mine development in advance of requirements. Uranium supply will be guaranteed through a combination of domestic production, development of non-domestic resources and international trade to ensure a stable supply of nuclear fuel. As a supplement to national supply and to balance uranium supply, international supply will be acquired through different channels in order to reduce market risks, ensure stable supply and to realise reasonable prices.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

In order to meet the demand driven by increasing domestic nuclear power development, the Chinese government has given greater importance to uranium fuel supply. Measures taken by the central government include intensification of uranium exploration in China, promotion of domestic production, introduction of regulations to allow non-government organisations to explore for uranium in China, and further development of the "two markets and two resources" policy, including overseas purchases and production.

Uranium stocks

N/A.

Uranium prices

The uranium price has been gradually streamlined with the international market price in order to follow the global trend of uranium prices. Accordingly, it is priced in China following the fluctuations in the international market.

Uranium exploration and development expenditures and drilling effort – domestic

(USD millions)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	35	52	55	55
Government exploration expenditures	85	123	127	129
Industry* development expenditures	11	14	15	15
Government development expenditures	0	0	0	0
Total expenditures	**131**	**189**	**197**	**199**
Industry* exploration drilling (m)	272 600	244 700	264 700	262 500
Industry* exploration holes drilled	692	599	664	630
Government exploration drilling (m)	650 000	610 000	610 000	590 000
Government exploration holes drilled	1 800	1 527	1 726	1 773
Industry* development drilling (m)	N/A	N/A	N/A	N/A
Industry* development holes drilled	N/A	N/A	N/A	N/A
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	922 600	854 700	874 700	852 500
Subtotal exploration holes drilled	2 492	2 126	2 390	2 403
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**922 600**	**854 700**	**874 700**	**852 500**
Total number of holes drilled	**2 492**	**2 126**	**2 390**	**2 403**

* Non-government.

CNNC uranium exploration and development expenditures – non-domestic

(USD millions)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	8.62	17.20	3.76	6.32
Government exploration expenditures				
Industry* development expenditures	73.07	581.90	759.22	767.35
Government development expenditures				
Total expenditures	**81.69**	**599.10**	**752.98**	**773.67**

* Non-government.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	10 100	60 000	85 300	85 300
In situ leaching acid	20 300	37 200	54 000	54 000
In situ leaching alkaline	20 300	31 600	34 000	34 000
Total	**53 400**	**128 800**	**173 300**	**173 300**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	10 100	60 000	85 300	85 300
In situ leaching acid	20 300	37 200	54 000	54 000
In situ leaching alkaline	20 300	31 600	34 000	34 000
Total	**53 400**	**128 800**	**173 300**	**173 300**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	26 100	59 900	89 900	89 900
In situ leaching acid	50 200	80 400	94 000	94 000
In situ leaching alkaline	4 000	8 600	9 000	9 000
Total	**80 300**	**148 900**	**192 900**	**192 900**

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	26 100	59 900	89 900	89 900
In situ leaching acid	50 200	80 400	94 000	94 000
In situ leaching alkaline	4 000	8 600	9 000	9 000
Total	**80 300**	**148 900**	**192 900**	**192 900**

* In situ resources.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2012	2015 (expected)
Sandstone	N/A	380	430	480	N/A	530
Granite-related	N/A	620	620	620	N/A	620
Volcanic-related	N/A	450	450	450	N/A	450
Total	**N/A**	**1 450**	**1 500**	**1 550**	**N/A**	**1 600**

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	N/A	350	350	350	N/A	300
In-place leaching*	N/A	120	70	70	N/A	70
In situ leaching	N/A	380	430	680	N/A	650
Heap leaching**	N/A	600	650	580	N/A	580
Total	**N/A**	**1 450**	**1 500**	**1 550**	**N/A**	**1 600**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2009	2012	2013	2014	Total through end of 2012	2015 (expected)
Underground mining[1]	N/A	1 070	1 070	1 070	N/A	1 070
In situ leaching	N/A	380	430	480	N/A	530
Total	**N/A**	**1 450**	**1 500**	**1 550**	**N/A**	**1 600**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
1 550	100							1 550	100

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	7 560	7 650	7 660	7 670
Employment directly related to uranium production	6 860	6 950	6 960	6 970

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	N/A	N/A

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
N/A	20 305	Low	High	Low	High	Low	High	Low	High	Low	High
		N/A	N/A	40 000	58 000	N/A	N/A	N/A	N/A	N/A	N/A

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
N/A	4 200	N/A	N/A	10 100	12 000	N/A	N/A	12 300	16 200	14 400	20 500

Czech Republic

Uranium exploration and mine development

Historical review

Following its start in 1946, uranium exploration in former Czechoslovakia grew rapidly and developed into a large-scale programme in support of the country's uranium mining industry. A systematic exploration programme including geological, geophysical and geochemical surveys and related research was carried out to assess the uranium potential of the entire country. Areas with identified potential were explored in detail using drilling and underground exploration methods.

Exploration continued in a systematic manner until 1989, with annual exploration expenditures in the range of USD 10-20 million and an annual drilling effort in the range of 70-120 km. Exploration was traditionally centred around vein deposits located in metamorphic complexes (Jáchymov, Horní Slavkov, Príbram, Zadní Chodov, Rozná, Olsí and other deposits), granitoids (Vítkov deposit) of the Bohemian massif and around the sandstone-hosted deposits in northern and north-western Bohemia (Hamr, Stráz, Brevniste, Osecná-Kotel, Hvezdov, Vnitrosudetská pánev, Hájek and other deposits).

In 1989, the decision was made to reduce all uranium-related activities. Following this decision, in 1990, expenditures decreased to about USD 7 million and have declined since. No field exploration has been carried out since the beginning of 1994.

Recent and ongoing uranium exploration and mine development activities

Recent uranium exploration activities have been focused on the conservation and processing of previously collected exploration data from Czech uranium deposits. Advance processing of the exploration data and building the exploration database will continue in the coming years.

In the past, the most significant exploration works were carried out to accurately identify the uranium resources in the deep parts of Rozná deposit (industry exploration expenditures CZK 1.5 million in 2013, CZK 26.3 million in 2014). These exploration works at the Rozná deposit will continue in 2015 (the expected amount CZK 12.8 million).

Uranium resources

Historically, most of the known uranium resources of the Czech Republic occurred in 23 deposits, of which 20 have been mined out or closed. Of the three remaining deposits, only Rozná and Stráz are being mined. Resources at the Stráz deposit are, however, limited due to the remediation process. Other deposits (the Osecná-Kotel part of the Stráz bloc and Brzkov) have resources that are not mineable because of environmental protection.

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2015, total identified conventional resources (reasonably assured resources and inferred resources) amounted to 119 261 tU. A slight increase of 5 tU from previous estimates as of 1 January 2013, due to the delineation of uranium resources in the deep parts of Rozná deposit.

In detail, the reasonably assured resources recoverable at a cost of <USD 130/kgU amounted to 1 200 tU. These are recoverable resources in existing production centres at the Rozná and Stráz deposits. The reasonably assured resources recoverable at a cost of <USD 260/kgU amounted to 50 955 tU are unchanged compared to the estimates as of 1 January 2013.

Inferred resources at a cost of <USD 130/kgU amounted to 106 tU, an increase of 5 tU compared with the previous estimates. These additional resources are tributary to the Rozná and Stráz deposits. Inferred resources recoverable at a cost of <USD 260/kgU amounted to 68 306 tU, an increase of 5 tU compared the estimations as of 1 January 2013. These high-cost resources are located in the Stráz bloc (the Stráz, Hamr, Osecná-Kotel and Brevniste deposits) and remain strictly protected because of environmental concerns.

Undiscovered conventional resources (prognosticated and speculative resources)

As of 1 January 2015, total undiscovered conventional resources (prognosticated resources and speculative resources) have been increased to a total of 239 980 tU. Prognosticated resources at a cost <USD 130/kgU totalling 280 tU, an increase of 100 tU from previous estimates, are located at the Rozná deposit only. Prognosticated resources at a cost <USD 260/kgU amounted to 222 980 tU, an increase of 100 tU from previous estimates as of 1 January 2013 due to the delineation of uranium resources at the Rozná deposit. These resources occur mainly (98%) in the sandstone deposits of the Northern Bohemian Cretaceous Basin (Stráz block, Tlustec block and Hermanky deposits) and to a lesser extent (2%) in the metamorphic complex of Western Moravia (Rozná and Brzkov deposits).

Speculative resources at a cost of about or greater than USD 260/kgU are estimated to amount to 17 000 tU and are reported in the unassigned cost category. Since these resources occur in Northern Bohemian Cretaceous sandstone deposits in a groundwater source protection zone, further exploration and evaluation is not permitted.

Uranium production

Historical review

Industrial development of uranium production in former Czechoslovakia began in 1946. Between 1946 and the dissolution of the former Soviet Union, all uranium produced in former Czechoslovakia was exported to the former Soviet Union.

The first production came from Jáchymov and Horní Slavkov mines, which completed operations in the mid-1960s. Príbram, the main vein deposit, operated from 1950 to 1991. The Hamr and Stráz production centres, supported by sandstone deposits, started operation in 1967. Peak annual national production of about 3 000 tU was reached around 1960 and production remained between 2 500 and 3 000 tU/yr from 1960 until 1989/1990 and declined thereafter. A cumulative total of 111 765 tU was produced in the Czech Republic during the period 1946-2014, of which about 85% was produced by underground and open-pit mining methods and the remainder was recovered by in situ leaching.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2
Name of production centre	Dolni Rozinka	Stráz pod Ralskem
Production centre classification	Existing	Existing
Date of first production	1957	1967
Source of ore:		
Deposit name(s)	Rozná	Stráz
Deposit type(s)	Metamorphite	Sandstone
Recoverable resources (tU)	208	992
Grade (% U)	0.251	0.030
Mining operation:		
Type (OP/UG/ISL)	UG	ISL
Size (tonnes ore/day)	550	-
Average mining recovery (%)	91.5	60.0 (estimated)
Processing plant:		
Acid/alkaline	Alkaline	Acid
Type (IX/SX)	IX, CWG	IX
Size (tonnes ore/day)	530	-
For ISL (mega or kilolitre/day or litre/hour, specify)	-	540
Average process recovery (%)	90.4	92
Nominal production capacity (tU/year)	300	100
Plans for expansion	No	No
Other remarks	-	Production under remediation process

CWG = carburetted water gas.

Status of production facilities, production capability, recent and ongoing activities and other issues

Two production centres remain in the Czech Republic. One is a conventional deep mine and mill (Rozná) in the Dolni Rozinka uranium production centre (Western Moravia) and the second is a chemical mining centre in Stráz pod Ralskem (Northern Bohemia). Both the Dolni Rozinka and Stráz pod Ralskem production centres are wholly operated by the state-owned enterprise DIAMO.

The Dolni Rozinka centre (Rozná metamorphite deposit, resources of 208 tU, stoping at 1 100 m underground) produced 200 tU in 2013 and 139 tU in 2014. Expected production in 2015 is 96 tU. Because the remaining resources are located in the deepest boundary parts of the mine, they are expected to be recovered at a higher cost and will result in a gradual decrease in production.

At the Stráz pod Ralskem chemical mining centre (Stráz sandstone deposit, with resources of 992 tU recoverable at cost <USD 260/kgU), the former acid in situ leaching (~180 m underground) production centre, produced 15 tU in 2013, as well as in 2014. Uranium production at this centre results from environmental remediation activities that began in 1996. Production capability during remediation (without acid) has decreased because of lower uranium concentration in solutions. Production in 2015 is expected to amount to 20 tU. The slight increase of 5 tU as compared to the previous two years is merely the result of remediation technologies. In the long term, a gradual decline in production is expected.

Uranium is also obtained from mine water treatment (at existing and former facilities), with a total recovery of 6 tU expected in 2015 (not including U recovery from ISL mining restoration activities).

Ownership structure of the uranium industry

All uranium activities, including exploration, production and related environmental activities are being carried out by the state-owned enterprise, DIAMO, a mining and environmental engineering company, based in Stráz pod Ralskem.

Employment in the uranium industry

Total employment in the Czech uranium production centres was 2 110 workers in 2013 and 2 072 workers in 2014 (i.e. employment related to production including head office, auxiliary divisions, mining emergency services).

Employment directly related to uranium production at Dolni Rozinka and Stráz pod Ralskem centres was 1 137 in 2013 and 1 105 in 2014, however some uranium production is associated with remediation.

Future production centres

No other production centres are committed or planned in the near future. A potential production centre at the Brzkov deposit is a possibility to be discussed in the distant future.

Secondary resources of uranium

Production and/or use of mixed oxide fuels

The Czech power utility čEZ, a.s., as the sole owner and operator of NPPs in the Czech Republic, does not use MOX fuels in its reactors.

Production and/or use of re-enriched tails

čEZ, a.s. does not use re-enriched tails in its reactors.

Production and/or use of reprocessed uranium

čEZ, a.s. does not use RepU in its reactors.

Environmental activities and socio-cultural issues

Both the environmental activities and the resolution of social issues are the responsibility of the government contraction programme of the Czech uranium mining industry. These activities began in 1989. Although this programme was formally terminated in 2009, extensive environmental remediation projects and some associated social issues continue to be addressed with state budget and EU funding.

This programme has been aimed at gradually decreasing employment related to declining uranium production and the development of alternative (mainly environmental) projects to address social issues.

In general, the environmental activities include project preparation, environmental impact assessment, decommissioning, tailings impoundments and waste rock management, site rehabilitation and maintenance, water treatment and long-term monitoring.

The key environmental remediation projects are as follows:

- Remediation of the after-effects of the ISL used in Stráz pod Ralskem that impacted a total 266 million m^3 groundwater and an enclosure of 600 ha surface area.
- Rehabilitation of the tailings impoundments in Mydlovary, Príbram, Stráz pod Ralskem and Rozná (a total of 19 ponds with a total area 589 ha).
- Rehabilitation (including reprocessing) of the waste rock dumps in Príbram, Hamr, Rozná, Western Bohemia and other sites (a total of 67 dumps with a capacity 38.2 million m^3).
- Mine water treatment from former uranium facilities in Príbram, Stráz, Horní Slavkov, Licomerice, Olsí and others, amounting to a total of approximately 14.9 million m^3/yr which, results in the recovery of about 10 tU annually.

The major part of environmental expenses (about 85%) is being funded by the state budget, with the remainder financed by the EU (9-12%) and DIAMO (3-6%). Since 1989, CZK 40 448 million (about USD 1.6 billion) has been spent on the environmental remediation projects. The projects, expected to continue until approximately 2040, are expected to cost in total more than CZK 60 000 million (about USD 2.4 billion).

The social part of the programme (obligatory spending, compensation, damages, rent) is financed entirely by the state budget.

Expenditures related to environmental activities and social issues

(CZK millions)

	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Uranium environmental remediation	34 390	2 376	1 775	1 907	40 448	2 660
Social programme and social security	8 590	328	295	263	9 476	246
Total	**42 980**	**2 704**	**2 070**	**2 170**	**49 924**	**2 906**

Uranium requirements

There are two NPPs with a total of six units in operation in the Czech Republic. The older Dukovany NPP with four VVER-440 reactors, upgraded up to 510 MWe (gross) in the period of 2009-2015, and the younger Temelin NPP with two VVER reactors have been in a finalisation stage of uprating to 1 076 MWe (gross). The sole owner and operator of these NPPs is the Czech power company ČEZ, a.s.

Total uranium requirements of both NPPs have been hovering at the level of about 650 tU/year. A gradual increase to about 680 tU/year is planned until 2018 as a result of deployment of advanced fuel with a slightly higher amount of enriched uranium product/heavy metal in the fuel assemblies at both operating NPPs.

In April 2014, ČEZ cancelled a tender for building of two new Temelin units. As a result, the previously considered increase in the total installed nuclear capacity was postponed. Projections of uranium and fabrication requirements were adjusted accordingly.

Supply and procurement strategy

ČEZ has been procuring uranium on the basis of middle and long-term contracts. About one-third of its uranium needs has been currently covered from domestic production of DIAMO, s.p. Some uranium has been partially purchased in the world market, and partially purchased in the form of already fabricated fuel, delivered from the Russian fabricator TVEL as a package.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The reduction programme of the Czech uranium industry from the end of the 1980s has already been formally terminated. An extensive programme of the environmental remediation of former uranium production facilities continues.

On the basis of the last government decision (Government Decree No. 1086/2014 Coll.), the existing Rozná uranium deposit will be mined by DIAMO until 2017 with no government financial assistance. According to the government's Concept of the Raw Materials and Energy Security of the Czech Republic, a feasibility study of early development at Brzkov uranium deposits was completed in 2014, as well as new technological possibilities of uranium mining that strictly respect environmental protection.

The government of the Czech Republic approved the launch of the legislative process for mining activities by DIAMO at the Brzkov deposit (Vysocina region), however there are significant disagreement of local municipalities and the strong public backlash against the resumption of the uranium mining.

Uranium stocks

The Czech power company ČEZ maintains uranium stocks on the level of about two and half years of forward reactors consumption in all forms of processed uranium. A substantial portion of these stocks is in the form of already fabricated fuel stored at the NPP site.

Uranium prices

Uranium prices are not available as they are commercially confidential. In general, uranium prices in supply contracts between the domestic producer DIAMO and ČEZ reflect price indicators of the world market incorporated according to agreed formulas.

Uranium exploration and development expenditures and drilling effort – domestic

(CZK millions)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	0.2	1.5	26.3	12.8
Government exploration expenditures	4.0	2.0	0.5	0.0
Industry* development expenditures	0.0	0.0	0.0	0.0
Government development expenditures	0.0	0.0	0.0	0.0
Total expenditures	**4.2**	**3.5**	**26.8**	**12.8**
Industry* exploration drilling (m)	0.0	0.0	0.0	0.0
Industry* exploration holes drilled	0.0	0.0	0.0	0.0
Industry* exploration trenches (m)	0.0	0.0	0.0	0.0
Industry* exploration trenches (number)	0.0	0.0	0.0	0.0
Government exploration drilling (m)	0.0	0.0	0.0	0.0
Government exploration holes drilled	0.0	0.0	0.0	0.0
Government exploration trenches (m)	0.0	0.0	0.0	0.0
Government exploration trenches (number)	0.0	0.0	0.0	0.0
Industry* development drilling (m)	0.0	0.0	0.0	0.0
Industry* development holes drilled	0.0	0.0	0.0	0.0
Government development drilling (m)	0.0	0.0	0.0	0.0
Government development holes drilled	0.0	0.0	0.0	0.0
Subtotal exploration drilling (m)	0.0	0.0	0.0	0.0
Subtotal exploration holes drilled	0.0	0.0	0.0	0.0
Subtotal development drilling (m)	0.0	0.0	0.0	0.0
Subtotal development holes drilled	0.0	0.0	0.0	0.0
Total drilling (m)	**0.0**	**0.0**	**0.0**	**0.0**
Total number of holes drilled	**0.0**	**0.0**	**0.0**	**0.0**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Sandstone	0	0	992	49 245
Metamorphite	0	0	208	1 710
Total	**0**	**0**	**1 200**	**50 955**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	208	1 710	92
In situ leaching acid	0	0	992	49 245	60
Total	**0**	**0**	**1 200**	**50 955**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	208	1 710	90
In situ leaching acid	0	0	992	49 245	92
Total	**0**	**0**	**1 200**	**50 955**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	0	67 800
Metamorphite	0	0	106	506
Total	**0**	**0**	**106**	**68 306**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	106	506	92
In situ leaching acid	0	0	0	67 800	60
Total	**0**	**0**	**106**	**68 306**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	106	506	90
In situ leaching acid	0	0	0	67 800	92
Total	**0**	**0**	**106**	**68 306**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	280	222 980

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	17 000

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Proterozoic unconformity	N/A	0	0	0	N/A	0
Sandstone	32 834	15	15	15	32 879	20
Granite-related	N/A	0	0	0	N/A	0
Metamorphite*	458**	213	200	139	797	96
Metasomatite	N/A	0	0	0	N/A	0
Lignite and coal	N/A	0	0	0	N/A	0
Other/unspecified	N/A	0	0	0	N/A	0
Total	**111 168**	**228**	**215**	**154**	**111 765**	**116**

* Includes uranium recovered from mine water treatment; 10 tU in 2012, 11 tU in 2013 and 8 tU in 2014.

** Historical uranium production is N/A; the total given from 2010 onwards.

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Underground mining*	93 668	213	200	139	94 220	96
In situ leaching	17 500	15	15	15	17 545	20
Total	**111 168**	**228**	**215**	**154**	**111 765**	**116**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	91 010	188	174	115	91 487	70
In-place leaching*	3	0	0	0	3	0
Heap leaching**	125	0	0	0	125	0
In situ leaching	17 500	15	15	15	17 545	20
Other methods***	2 530	25	26	24	2 605	26
Total	**111 168**	**228**	**215**	**154**	**111 765**	**116**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
154	100	0	0	0	0	0	0	154	100

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	2 126	2 110	2 072	2 106
Employment directly related to uranium production	1 147	1 137	1 105	1 112

Short-term production capability

(tonnes U/year)

2014				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	200	200	0	0	150	150	0	0	50	50

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	50	50	0	0	50	50	0	0	30	30

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
3 830	3 940	Low	High	Low	High	Low	High	Low	High	Low	High
		3 960	3 965	3 965	3 970	3 965	3 970	3 965	3 970	6 150	6 250

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
632	677	Low	High	Low	High	Low	High	Low	High	Low	High
		658	660	680	685	680	685	680	690	1 080	1 110

The following facts have an influence on ČEZ’s uranium requirements, which are somewhat higher in comparison with the NEA’s requirement estimations:

- Gradual deployment of improved fuel with a higher amount of enriched uranium product in the fuel assemblies (FAs) (135.5 kg instead of current 126.3 kg in the FAs) at the Dukovany NPP began in 2014.
- Usage of improved fuel with a higher amount of uranium in FAs (an increase from 465 kgU to 500 kgU) at the Temelin reactors would begin from 2018.

First core loads for two previously planned new reactors are not included in the U requirements data (considerations are that the procurement of needed uranium and services shall be spread out over the period from 2031-2033).

The U requirement figures do not include any plans to build stockpile of U.

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	0	0	0	0
Producer	<250	0	0	0	<250
Utility	N/A	N/A	0	0	N/A
Total	<250	0	0	0	<250

Denmark/Greenland

Uranium exploration and mine development

Historical review

A brief review of the history of uranium exploration is provided in the previous editions of the Red Book (1998, 2003 and 2014).

Recent and ongoing uranium exploration and mine development activities

Since 2007, Greenland Minerals and Energy Ltd (GMEL) has conducted REE (U-Zn) exploration activities in the Kvanefjeld area, South Greenland, including drilling of 57 710 m of core; the business concept encompasses uranium and zinc by-products in addition to the main products of REE. The Kvanefjeld Feasibility Study, as well as the environment and social impact assessments (EIA and SIA), were carried out in 2014-2015 and will form the basis for an exploitation licence application, which is expected during 2015.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The Mesoproterozoic Ilímaussaq alkaline complex of South Greenland hosts the REE-U-Zn-F deposit referred to as Kvanefjeld. It is a high-tonnage, low-grade uranium-enriched intrusive deposit, with concentrations around 300 ppm U. Uranium is planned to be mined as a by-product in a potential open-pit mine; the revenue from uranium is estimated by GMEL to account for 7% (based on USD 70/pound). Kvanefjeld is the only uranium deposit or occurrence in Greenland with reasonably assured uranium resources. The complex composition and processing of the ore results in the resource being placed in the highest cost category (<USD 260/kg U). The total identified conventional resource inventory for Kvanefjeld is 102 820 tU. Additional inferred resources of 338 Mt ore exist in the Zone Sørensen and Zone 3, related to the Kvanefjeld, equivalent to 125 143 tU.

Undiscovered conventional resources (prognosticated and speculative resources)

Several uranium occurrences are known in Greenland. However, uranium exploration has been banned since 1985 and up to 2013. Consequently, only few uranium resource data are available. An evaluation of the potential for uranium deposits in Greenland is available on http://mima.geus.dk/publikationer/mima-rapport-20141.

Unconventional resources and other materials

Unknown.

Uranium production

Historical review

No uranium has been produced in Greenland, however, 4 500 tonnes of ore was transported to the Risø National Laboratory, Denmark, for test work during the 1980s, and another 30 tonnes of ore has recently been sent to Outokumpu, Finland, for further test work.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Greenland is part of the Danish Realm. Greenland enjoys autonomous authority in domestic affairs while Denmark remains constitutionally responsible for foreign affairs, defence and security. In 2009, the Act on Greenland Self-Government granted Greenland authority over its natural resources (Mineral Resources Act 2009). The Ministry of Mineral Resources (MMR) is responsible for strategy and policymaking, legal issues, licence assessment, approvals and inspections, and marketing of mineral resources in Greenland.

On 24 October 2013, the Greenland parliament, Inatsisartut, lifted a decades-long moratorium on mining radioactive elements, which has opened the way for potential future exploration of uranium and thorium.

Uranium exploration and development expenditures and drilling effort – domestic

(AUD and Danish krone [DKK])

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures		AUD 2 728 000[1]	AUD 6 294 000[1]	
Government exploration expenditures		DKK 400 000	DKK 400 000	DKK 400 000

* Non-government.

1. Total Industry exploration expenditures; it is not possible to break the expenditures up according to the different elements.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Intrusive				102 820
Total				**102 820**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Co-product and by-product				102 820	65
Total				**102 820**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from OP				102 820	65
Total				102 820	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Intrusive	0	0	0	125 143
Total	**0**	**0**	**0**	**125 143**

Inferred conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Co-product and by-product	0	0	0	125 143	65
Total	**0**	**0**	**0**	**125 143**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Unspecified	0	0	0	**125 143**	65
Total	**0**	**0**	**0**	**125 143**	

Finland

Uranium exploration and mine development

Historical review

Uranium exploration in Finland was first carried out between 1955 and 1989, initially by Atomienergia Oy, Imatran Voima Oy and Outokumpu Oy, and from 1973 by the Geological Survey of Finland (GTK). In the late 1980s, exploration activities were stopped. Exploration began again in the 2000s by Areva and some junior companies. In 2010, Areva closed down its Finnish subsidiary, and its exploration assets in Finland were purchased by Mawson Resources Ltd. Uranium exploration in Finland has slowed down since 2011, as Mawson's focus of exploration has shifted increasingly to gold.

Five main areas with uranium potential can be delineated in Finland, all being associated with Palaeoproterozoic metamorphic supracrustal schist belts: the Kolari-Kittilä area, the Peräpohja Schist Belt, the Kuusamo Schist Belt, the Koli area and the Uusimaa area.

Recent and ongoing uranium exploration and mine development activities

There is currently no actual uranium exploration in Finland. However, uranium is included as a so-called mining mineral in some exploration permits and exploration permit applications of Mawson Resources Ltd. In Finland, applications for an exploration permit shall be submitted to the permit authority (Tukes), including a preliminary assessment of the mining minerals in the area. Mawson Resources is focused on the Rompas exploration project in the Peräpohja Schist Belt, located a few kilometres south of the Arctic Circle in the municipality of Ylitornio, northern Finland. High-grade gold and uranium have been found within an area approaching 10 km by 10 km.

Rompas was discovered by Areva Resources Finland Oy in 2008 as part of regional uranium exploration. Mawson acquired the project from Areva in 2010 and outlined the initial hydrothermal gold vein discovery over a 6 km strike and 200-250 m width. In 2013, a new style of disseminated gold mineralisation was drilled at Rajapalot, 8 km east of the Rompas vein system. At Rompas, hydrothermal vein-type gold and uranium mineralisation is mostly hosted by carbonate/calc-silicate veins in mafic metavolcanic rocks. Gold is intimately associated with uraninite, typically in microfractures of uraninite.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Finland reports a total of 1 500 tU of reasonably assured conventional resources recoverable at costs of USD 80-130/kgU in the Palmottu and Pahtavuoma U deposits. No inferred conventional resources are reported.

Undiscovered conventional resources (prognosticated and speculative resources)

None reported.

Unconventional resources and other materials

Unconventional resources of uranium in the black schist of Talvivaara are approximately 22 000 tU in the measured and indicated resources of 1 305 Mt, and about 35 000 tU in the total mineral resources (measured, indicated and inferred) of 2 053 Mt, calculated from the resource update 2012 by Talvivaara Mining Company Plc.

Another potential by-product uranium target is the Sokli carbonatite in northern Finland, presently under development by Yara International for the exploitation of the regolithic phosphate ore on top of the magmatic carbonatite. In the hardrock carbonatite, uranium-bearing pyrochlore occurs in specific zones which have been evaluated to contain 2 500 tU at a grade of 0.01% U.

Uranium production

Historical review

Uranium production in Finland has been confined only to the now restored Paukkajanvaara mine that operated as a pilot plant between 1958 and 1961. A total of 40 000 tonnes of ore was hoisted and the concentrates produced amounted to about 30 tU. As reported in the *Red Book Retrospective* (NEA, 2006), the total historical production calculated from the mining register statistics is no more than 41 tU from 1958 to 1961.

Future production centres

There is currently no uranium production in Finland. In recent years, Talvivaara Mining Company Plc. has prepared for uranium recovery as a by-product. The Talvivaara black schist-hosted nickel deposit is located in Sotkamo, eastern Finland. Talvivaara is an open-pit mine which has been in operation since 2008, using heap leaching to extract metals (Ni, Zn, Cu, Co) from low-grade, uranium-bearing black schist ore which contains 17 ppm U on average.

In 2010, Talvivaara announced its plans to recover uranium as a by-product using solvent extraction, resulting from the fact that uranium dissolves in the pregnant leach solution during heap leaching. Currently, dissolved uranium mostly ends up in the gypsum pond tailings and partly in the Ni-Co sulphide concentrate product. Uranium is present as an impurity in the Ni-Co sulphide consigned to the Norilsk Nickel refinery at Harjavalta. During 2011-2013, the uranium extraction plant was built as a new unit in the metals recovery complex of Talvivaara. As of January 2015, mining was suspended as a result of the bankruptcy of Talvivaara Sotkamo Ltd, the operative subsidiary of Talvivaara Mining Company Plc. In addition, the licensing process for uranium production was unfinished as of January 2015. Therefore, there is no precise estimate for expected start of uranium recovery at Talvivaara.

In March 2015, Audley Capital Advisors LLP entered into a conditional asset purchase agreement to acquire the assets of Talvivaara Sotkamo Ltd from its Bankruptcy Estate. At the same time, the State of Finland, through its wholly owned special purpose company Terrafame Ltd, entered into an investment agreement with Audley. The purpose of the asset purchase agreement and the investment agreement was to re-establish the operations and continue the business of the Talvivaara mine on a viable, long-term basis within a new mining company that will be established in connection with the transaction.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1
Name of production centre	Talvivaara
Production centre classification	Planned
Date of first production	N/A
Source of ore:	
Deposit name(s)	Kuusilampi and Kolmisoppi
Deposit type(s)	Black schist
Recoverable resources (tU)*	15 800*
Grade (% U)	0.0017
Mining operation:	
Type (OP/UG/ISL)	OP
Size (tonnes ore/day)	N/A
Average mining recovery (%)	80
Processing plant:	
Acid/alkaline	Acid (heap leaching)
Type (IX/SX)	SX
Size (tonnes ore/day)	N/A
Average process recovery (%)	90
Nominal production capacity (tU/year)	350
Plans for expansion	N/A
Other remarks	Heap leaching by-product

* Overall recovery factor of 72% used in the estimate.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Finland does not produce or use mixed oxide fuels.

Production and/or use of re-enriched tails

Re-enriched tails have not been used in 2013 and 2014.

Environmental activities and socio-cultural issues

Talvivaara received an environmental permit for the uranium recovery from the Northern Finland Regional State Administrative Agency in April 2014. The permit decision is not yet in legal force due to an appeal process. It is expected that the appeal process will last for several years.

In March 2012, the Finnish government granted a uranium extraction licence to Talvivaara in accordance with the nuclear energy legislation. In December 2013 however, the Supreme Administrative Court returned the permit to the Finnish government for reassessment due to several changes in the operations of Talvivaara, including the corporate reorganisation, after the permit decision. Therefore, the government needs to reassess the permit application documentation and obtain additional information on the economical and safety related requirements. In November 2014, Talvivaara Sotkamo Ltd filed for bankruptcy as a result of financial problems. As of January 2015, the consequences were not yet known but near-future progress is not foreseen to include uranium production.

Uranium residuals are currently extracted from the nickel products at Harjavalta Nickel Refinery and at Freeport Cobalt in Kokkola, and reported to the Finnish Radiation and Nuclear Safety Authority (STUK).

Regulatory regime

The Mining Act regulates exploration and mining activities in Finland. Tukes is the mining authority and all licences under the Mining Act are decided by Tukes. The mine closure process is regulated by mining and environmental legislation, as well as a number of EU and other specifications.

STUK is the regulatory body for uranium production, as specified in the Nuclear Energy Act and the Radiation Act. Production of uranium or thorium needs a licence from the Finnish government according to the Nuclear Energy Act. A licence application must be submitted to the government. Statements from different authorities (including STUK) are required for the decision on the licence which is prepared by the Ministry of Employment and the Economy and decided by the government.

According to the Mining Act of 2011, an exploration licence is required for uranium exploration (e.g. drilling and trenching). Permit applications concerning a uranium mine under the Mining Act and the Nuclear Energy Act are handled jointly and decided on in a single decision by the government. The granting of a permit for a uranium mine requires that the mining project activities are aligned with the overall interests of the society, the municipality in question has given its consent, and safety requirements are met.

STUK's regulatory control covers radiation exposure of workers and public, environmental monitoring, waste management, emergency preparedness, nuclear material accountancy and physical protection of nuclear materials. STUK verifies that safety and security requirements are met. Radioactive tailings are regarded as nuclear waste and are subject to funding for the future costs of waste management. Uranium concentrate export, controlled by the Ministry for Foreign Affairs, is also subject to national and international safeguards control.

Mining also needs an environmental permit from the Regional State Administrative Agencies (AVI) and a permit is regulated by the Centres for Economic Development, Transport and the Environment (ELY).

The environmental impact assessment procedure is applied to all uranium mining projects, without any limitations on the annual amount of the extracted resource or on the area of an opencast mine. In addition, other legislation to be applied includes the Environmental Protection Act, the Nature Conservation Act, the Wilderness Act, the Reindeer Husbandry Act, the Land Use and Building Act, and the Occupational Safety and Health Act.

Uranium requirements

Four units (two each at the Olkiluoto and Loviisa NPPs) with a total generating capacity of 2.7 GWe (net) are in operation, providing about 34% of domestic electricity generation.

These four reactors require about 450 to 500 tU annually. Olkiluoto units are owned and operated by Teollisuuden Voima (TVO), Loviisa units by Fortum.

TVO's Olkiluoto 3 European pressurised reactor (EPR; 1.6 GWe net) is under construction. TVO selected EPR technology for Olkiluoto 3 in 2003 and Areva-Siemens Consortium started the construction works in 2005. According to the plant supplier Areva-Siemens Consortium, the start of the regular electricity production of the Olkiluoto 3 nuclear power plant unit will take place in late 2018, some nine years later than originally planned.

In 2010, the Finnish parliament ratified the decisions-in-principle (DIP) for the construction of two new reactors, one at the existing Olkiluoto site (OL4) and a single reactor at the greenfield Pyhäjoki site (Fennovoima). According to the DIP, the deadline for submitting the applications for the construction licences of these units was the end of June 2015.

In May 2014, TVO applied for an extension to submit construction licence application of the Olkiluoto 4 (OL4) plant unit due to the delay of the start-up of Olkiluoto 3 plant unit. In September 2014, the Finnish government rejected TVO's application to extend the validity of the DIP of the OL4. TVO's application therefore did not proceed to the parliament for ratification. According to the DIP, the deadline for submitting the construction licence application of OL4 was the end of June 2015.

Fennovoima is a new nuclear power company, established by a group of Finnish companies in 2007. Fennovoima will build a new nuclear power plant unit (Hanhikivi) in Pyhäjoki, northern Finland. Fennovoima has two main owners: Voimaosakeyhtiö SF (66%) and Rosatom's subsidiary RAOS Voima Oy (34%). Voimaosakeyhtiö SF is owned by Finnish energy and industrial companies.

In spring 2014, Fennovoima applied a supplement to the DIP received in 2010. The supplementary application reflected changes, e.g. reactor type, in the project after the initial DIP was granted. In September 2014, the Finnish government approved a supplement to Fennovoima's DIP, with the condition that the Finnish ownership must be at least 60% at the submitting time of the construction licence application. The Finnish parliament ratified Fennovoima's supplement to the DIP in December 2014. Fennovoima's deadline for submitting the application for the construction licence of the Hanhikivi unit was the end of June 2015.

The nuclear power plant unit of Fennovoima (AES-2006; 1.2 GWe net) will be delivered by Rusatom Overseas which is part of the Russian Rosatom Group. The start of construction of the Hanhikivi unit is scheduled for 2018. According to Fennovoima, the electricity production of the unit will begin in 2024.

Supply and procurement strategy

TVO procures the nuclear fuel using a diversified fuel procurement chain. TVO purchases its uranium as raw uranium and separately selects its partners for each further processing phase. TVO's uranium procurement is based on the principle of having at least two suppliers at each phase of the delivery chain. This reduces the dependence on individual uranium suppliers, conversion and enrichment service providers and nuclear fuel manufacturers. TVO has long-term contracts with uranium and fuel suppliers which are monitored and assessed by TVO on a regular basis. TVO renewed fuel contracts with Areva and Westinghouse in November 2014. Both Areva and Westinghouse Electric Sweden (WSE) will supply nuclear fuel to the existing nuclear power plant units in Olkiluoto during 2016-2019. The fuel assemblies of OL1 are produced by Areva, while WSE delivers fuel assemblies to OL2. The fuel assemblies ordered by TVO are currently produced and assembled in Germany and Sweden.

The fuel assemblies used at Fortum's Loviisa nuclear power plant are entirely of Russian origin. Nuclear fuel for the Loviisa power plant is acquired from the Russian

TVEL as a turnkey delivery, from the acquisition of the uranium concentrate to the manufacturing of the fuel assemblies. TVEL acquires uranium from ARMZ Uranium Holding Co, from the Krasnokamensk, Khiagda and Dalur mines. Fortum regularly assesses the quality, environmental, and occupational health and safety management systems of its nuclear fuel suppliers and the manufacturing of nuclear fuel assemblies. In summer 2014, Fortum's experts reviewed the fuel supplier's conversion and enrichment facility operations in Russia.

Fennovoima will acquire the nuclear fuel as an integrated fuel supply from TVEL. The integrated delivery will cover the procurement of the uranium and the manufacturing of the fuel for the first ten years of NPP operation. Fuel supply agreement between Fennovoima and TVEL was approved by the Euratom Supply Agency in spring 2014. Fennovoima has chosen to use reprocessed uranium during the first years of operation. However, natural uranium is kept as a secondary option.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The nuclear energy legislation ensures that the use of nuclear energy is conducted in a manner that benefits the overall good of society. The main rules of the use of nuclear energy, monitoring the use, and nuclear safety, are included in the Finnish Nuclear Energy Act and Nuclear Energy Decree, as well as lower level statutes issued pursuant to them, such as the Radiation and Nuclear Safety Authority's YVL (NPP) guidelines. Other regulations pertaining to the use of nuclear energy are included in the Radiation Act.

The Finnish nuclear waste management is guided by the Nuclear Energy Act and Decree. All nuclear waste generated in Finland must be handled, stored and permanently disposed of in Finland. The act also prohibits the import of nuclear waste. Contributions to the Finnish State Nuclear Waste Management Fund are paid by the nuclear power companies annually. The purpose of the fund is to collect, store and reliably invest the funds that are going to be needed to take care of nuclear waste in the future.

Spent nuclear fuel from the nuclear power plants of TVO and Fortum will be packed in copper canisters and embedded in Olkiluoto bedrock at a depth of 400-450 m. Posiva Oy, owned by TVO and Fortum, is responsible for the final disposal of spent nuclear fuel of the owners.

Posiva submitted its construction licence application for a final repository for spent nuclear fuel to the government in December 2012. Safety assessment of STUK is required for the decision on construction licence which will be prepared by the Ministry of Employment and the Economy and decided by the government. STUK submitted its statement to the Ministry of Employment and the Economy in February 2015. STUK notes that the spent nuclear fuel encapsulation plant and final disposal facility designed by Posiva can be built to be safe. The statement is based on the safety review and assessment conducted by STUK to ensure that the requirements of the Nuclear Energy Act are met.

Before the actual commencement of final disposal operations for spent nuclear fuel, an operating licence from the government is required for the encapsulation plant and final disposal facility. Posiva plans to submit the operation licence application in 2020. The final disposal of spent nuclear fuel is planned to start in the 2020s.

The 2010 DIP approved for Fennovoima's new nuclear power plant is conditional. According to the DIP, Fennovoima shall submit specified plans for its nuclear waste management in connection with the construction licence application of the Hanhikivi NPP. In addition, Fennovoima shall develop its plan for the final disposal of spent nuclear fuel so that by the end of June 2016, it will either have an agreement on nuclear waste co-operation with the current nuclear waste management custodians, or an environmental impact assessment programme concerning its own final disposal facility for spent nuclear fuel.

Uranium stocks

The nuclear power utilities maintain reserves of fuel assemblies from seven months to one year's use, although the legislation demands only five months use.

Uranium prices

Due to commercial confidentiality price data are not available.

Uranium exploration and development expenditures and drilling effort – domestic

(EUR)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	2 210 000	2 500 000	1 290 000	N/A
Government exploration expenditures	0	0	0	0
Industry* development expenditures	45 200 000	14 600 000**	N/A	N/A
Government development expenditures	0	0	0	0
Total expenditures	**47 410 000**	**17 100 000**	**1 290 000**	**N/A**
Industry* exploration drilling (m)	5 400	3 900	2 674	N/A
Industry* exploration holes drilled	51	58	N/A	N/A
Industry* exploration trenches (m)	N/A	N/A	N/A	N/A
Industry* exploration trenches (number)	N/A	N/A	N/A	N/A
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Government exploration trenches (m)	0	0	0	0
Government exploration trenches (number)	0	0	0	0
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	5 400	3 900	2 674	N/A
Subtotal exploration holes drilled	51	58	N/A	N/A
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**5 400**	**3 900**	**2 674**	**N/A**
Total number of holes drilled	**51**	**58**	**N/A**	**N/A**

* Non-government.

** Covers only an environmental investment for uranium plant of Talvivaara.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Metamorphite	0	0	500	500
Intrusive	0	0	1 000	1 000
Total	**0**	**0**	**1 500**	**1 500**

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	0	0	500	500
Open-pit mining (OP)	0	0	1 000	1 000
Total	**0**	**0**	**1 500**	**1 500**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Conventional from UG	0	0	500	500
Conventional from OP	0	0	1 000	1 000
Total	**0**	**0**	**1 500**	**1 500**

* In situ resources.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Sandstone	30	0	0	0	30	0
Total	**30**	**0**	**0**	**0**	**30**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	15	0	0	0	15	0
Underground mining[1]	15	0	0	0	15	0
Total	**30**	**0**	**0**	**0**	**30**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	30	0	0	0	30	0
Total	**30**	**0**	**0**	**0**	**30**	**0**

Re-enriched tails production and use

(tonnes natural U-equivalent)

Re-enriched tails	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Production	0	0	0	0	0	0
Use	843	0	0	0	843	0

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	22.6	22.2

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
2 760	2 760	Low	High	Low	High	Low	High	Low	High	Low	High
		2 760	2 760	4 380	4 380	5 580	7 390	5 080	6 890	4 580	6 390

Annual reactor-related uranium requirements* to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
567	424	Low	High	Low	High	Low	High	Low	High	Low	High
		440	480	700	1 360	700	1 050	520	850	520	1 070

* Refers to natural uranium acquisitions, not necessarily consumption during the calendar year.

France

Uranium exploration and mine development

Historical review

Uranium exploration began in 1946, focusing on previously discovered deposits and a few mineralisation occurrences discovered during radium exploration. In 1948, exploration led to the discovery of the La Crouzille deposit, formerly of major importance. By 1955, additional deposits had been identified in the granite areas of Limousin, Forez, Vendée and Morvan. Prospecting activities were subsequently extended to sedimentary formations in small intra-granitic basins and terrigeneous formations, arising from eroded granite mountains and mainly located north and south of the Massif Central.

Recent and ongoing uranium exploration and mine development activities

No domestic activities have been carried out in France since 1999.

During 2012-2014, Areva and its subsidiaries have been working outside France focusing on targets aimed at the discovery of exploitable resources in Australia, Canada, Gabon, Kazakhstan, Mongolia, Namibia and Niger. In Canada, Kazakhstan, Namibia and Niger, Areva is involved in uranium mining operations and projects. In addition, without being an operator, it holds shares in several mining operations and research projects in different countries.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Areva no longer reports resources or reserves in France since the historic data on which these estimates are based do not conform to modern international standards.

Undiscovered conventional resources (prognosticated and speculative resources)

No systematic appraisal is made of undiscovered resources.

Uranium production

Status of production facilities, production capability, recent and ongoing activities and other issues

Following the closure of all uranium mines in 2001, all ore processing plants were shut down, dismantled and the sites reclaimed. Only a few tonnes of uranium per year are recovered from resins during the water cleaning process at the outflow of the former Lodève mine in the south of France. The resins are eluted at the Malvesi refinery, where the uranium is recovered.

In France, a total of 244 sites, ranging from exploration sites to mines of various sizes, 8 mills and 17 tailings deposits (containing a total of 52 Mt of tailings) resulted from the production of more than 75 000 tU. All of these sites have been remediated. Monitoring continues at only the most important sites and 14 water treatment plants were installed to clean drainage from the sites. Areva is responsible for the management of 234 of these sites.

The targets of remediation are to:

- ensure public health and safety;
- limit the residual impact of previous activities;
- integrate the industrial sites into landscape;
- maintain a dialogue and consultation with local populations.

Future production centres

There are no plans to develop new production centres in France in the near future.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

The annual licensed capacity of MOX fuel production in France is about 195 tHM, roughly corresponding to 1 560 tU equivalent (tNatU) using the recommended Red Book conversion factor. Actual yearly production of MOX in France varies below this licensed capacity in accordance to contracted quantities. Most of the French MOX production is used to fuel French NPPs (a total of about 120 t/yr, or 960 tNatU) and the remainder is delivered abroad under long-term contract arrangements.

Production and/or use of reprocessed uranium

In France, reprocessed uranium is produced at the la Hague reprocessing plant. The annual production from Électricité de France (EDF) of spent fuel is around 1 000 tU. Reprocessed uranium was recycled at the EDF nuclear power plant of Cruas. The last fuel assemblies containing reprocessed uranium were loaded in 2013, and EDF is currently studying the possibility of resuming the recycling process.

Regulatory regime

In France, mines are nationally regulated according to the Mining Code and processing plants according to regulations specified in the legislation governing the operation of installations that present environmental risks (ICPE – *installation classée pour la protection de l'environnement*). These regulations are applied by regional environmental authorities (DREAL – Directions régionales de l'Environnement, de l'Aménagement et du Logement) on behalf of the prefect (the state representative in a particular department or region).

In order to open a mine, the mining company must present a report to the regional authorities that will allow them to confirm that the project will be operated in accordance with all regulations. Once this is confirmed, a public enquiry must be held. If these processes are successfully completed, the mining company will be allowed to open the mine according to requirements laid out in an *Ordre du Préfet*. When mining is completed, the mining company must prepare a report for local authorities who can then give authorisation for decommissioning through an *Ordre du Préfet*.

In theory, according to Mining Code, after remediation and a period of monitoring to verify that there is no environmental impact, the mining company can transfer the responsibility of the site to the state but, if there is a problem, the state asks the mining company to remediate the problem.

After decommissioning, the mining company retains responsibility for the site, including monitoring and maintenance. There has not been a transfer of responsibility for a uranium mine from the mining company to the state because Areva is always present. However, Areva is in discussion with authorities on the transfer of responsibility.

The cost of mine remediation is the responsibility of the mining company. In the case of processing plants (mills), local authorities request financial guarantees for the costs of all remediation works and monitoring. A draft revision of the Mining Code is currently under development.

Uranium requirements

As of 31 December 2014, France's installed nuclear capacity consisted of 58 pressurised water reactors (34 x 900 MWe units, 20 x 1 300 MWe units and 4 x 1 450 MWe units), with uprates now totalling 63.2 GWe (net), requiring about 8 000 tU/yr.

A national debate on the French energy transition was launched in late 2012. The current government expressed a policy goal of reducing nuclear electricity generation to a 50% share of total generation, from the current share of about 75%. The debate is a way of gathering the views of citizens on energy policy to address four key questions:

- How can demand be reduced through improvements in energy efficiency and energy conservation?
- What is the most effective path to reach the desired energy mix in 2025? What would moving to this path do in terms of 2030 and 2050 scenarios with respect to current national climate change commitments (i.e. reducing greenhouse gas emissions)?
- What realistic choices exist for renewable energy and new energy technologies? What strategy of industrial and regional development should be adopted to achieve the introduction of these technologies?
- What costs are involved in the energy transition and what sources of transitional funding could be used?

Legislation was expected to be presented to the government in late 2014 after a national debate on energy policy came to a close in September 2013.

The current government also wants to shut down the oldest reactors in France, the Fessenheim nuclear power plant (2 units with a combined capacity of 1.76 GWe that entered into service in 1978), by the end of the current term of President Hollande's government in 2016. An inter-ministerial delegate has been appointed on this issue with the mission of clarifying the timing and manner of closing.

Construction of the 1.6 GWe Flamanville 3 EPR began in late 2007. The reactor is due to be connected to the grid in 2017.

In 2014, major construction steps were achieved:

- the reactor pressure vessel (425 tonnes) was introduced in the reactor building in January;
- the first steam generator was installed in the reactor building in September, and the fourth steam generator (530 tonnes) was delivered on the construction site in March;

- the four main diesel engines are now installed;
- a significant number of tests, including hydraulic tests, were successfully implemented in the turbine hall;
- the control room was commissioned.

There are currently no short-term plans for additional nuclear generating capacity in France after Flamanville 3 is brought into service.

In 2006, Areva began work at the Tricastin site on construction of the Georges Besse II uranium centrifuge enrichment plant to replace the Eurodif gaseous diffusion plant that has been in service since 1978. In 2012, production at the Eurodif plant was stopped and the facility will be dismantled in the coming years. The Georges Besse II facility will produce 7 million SWU during 2015. The project is currently on track to reach a nominal capacity of 7.5 million SWU in 2016.

Supply and procurement strategy

Since France is a net importer of uranium, its policy towards procurement is one of supply diversification. French entities participate in uranium exploration and production outside France within the regulatory framework of the host countries. Uranium is also purchased under short- or long-term contracts, either from mines in which French entities have shareholdings or from mines operated by third parties.

Uranium policies, uranium stocks and uranium prices

Uranium stocks

EDF possesses strategic uranium inventories, the minimum level of which has been fixed at the equivalent of a few years' forward consumption to offset possible supply interruptions.

Uranium prices

Information on uranium prices is not available.

Uranium exploration and development expenditures – non-domestic

(EUR millions)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	52	55	37.5	39
Government exploration expenditures				
Industry* development expenditures	N/A	N/A	N/A	N/A
Government development expenditures				
Total expenditures	52	55	37.5	39

* Non-government.

Historical uranium production by deposit type

(tonnes U in ores)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2015	2015 (expected)
Sandstone	16 781	0	0	0	16 781	0
Granite-related	63 683	0	0	0	63 683	0
Metamorphite	395	0	0	0	395	0
Volcanic-related	1	0	0	0	1	0
Black Shale	3	0	0	0	3	0
Other/unspecified	97	3				
Total	80 960*	3				

* Pre-2010 total updated from 2011 Red Book after review of historic records.

Historical uranium production by production method

(tonnes U in ores)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	5 427	0	0	0	5 427	0
Underground mining*	1 511	0	0	0	1 511	0
Open-pit and underground**	73 925	0	0	0	73 925	0
Co-product/by-product	97	3	5	3	108	3
Total	80 960	3	5	3	80 971	3

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

** Not possible to separate in historic records.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	75 890	0	0	0	75 890	0
In situ leaching						
Other methods*	97	3	5	3	108	3
Total	75 987	3	5	3	75 998	3

* Includes mine water treatment and environmental restoration.

Mixed oxide fuel production and use

(tonnes natural U-equivalent)

Mixed oxide (MOX) fuel	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Production	17 520*	1 200	992	1 072	20 784	1 200
Use	N/A	880	880	880	N/A	880
Number of commercial reactors using MOX		22	22	22		22

* Includes Cadarache historical production and Marcoule production adjustment.

Reprocessed uranium use

(tonnes natural U-equivalent)

Reprocessed uranium	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Production	15 900	1 000	1 000	1 000	18 900	1 000
Use	4 700	600	600	0	5 900	0

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	403.7	415.9

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
63 200	63 200	63 200	63 200	61 000	63 200	37 000	63 200	37 000	63 200	37 000	63 200

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
		8 000	9 000	8 000	9 000	5 000	9 000	5 000	9 000	5 000	9 000

Germany

Uranium exploration and mine development

Historical review

After World War II, and until reunification in 1990, exploration for uranium occurred in two separate countries (see below) in what is today Germany. A summary of the activities is provided below.

Former German Democratic Republic before 1990

Uranium exploration and mining were undertaken from 1946 to 1953 by the Soviet stock company, SAG Wismut. These activities were centred around old mining locations of silver, cobalt, nickel and other metals in the Erzgebirge (Ore Mountains) and in Vogtland, Saxony, where uranium had first been discovered in 1789.

Uranium exploration had started in 1950 in the vicinity of the radium spa at Ronneburg. Using a variety of ground-based and aerial techniques the activities covered an extensive area of about 55 000 km^2 in the southern part of the former German Democratic Republic (GDR). About 36 000 holes in total were drilled in an area covering approximately 26 000 km^2. Total expenditures for uranium exploration over the life of the GDR programme were on the order of GDR mark 5.6 billion.

Uranium mining first began shortly after World War II in cobalt and bismuth mines near Schneeberg and Oberschlema (a former famous radium spa). During this early period more than 100 000 people were engaged in exploration and mining activities. The rich uraninite and pitchblende ore from the vein deposits was hand-picked and shipped to the USSR for further processing. Lower-grade ore was treated locally in small processing plants. In 1950, the central mill at Crossen near Zwickau, Saxony was brought into operation.

In 1954, a new joint Soviet-German stock company was created, Sowjetisch-Deutsche Aktiengesellschaft Wismut (SDAG Wismut). The joint company was held equally by both governments. All production was shipped to the USSR for further treatment. The price for the final product was simply agreed upon by the two partners. Profits were used for further exploration.

At the end of the 1950s, uranium mining was concentrated in the region of Eastern Thuringia. From the beginning of the 1970s, the mines in Eastern Thuringia provided about two-thirds of SDAG Wismut's annual production.

Between the mid-1960s and the mid-1980s, about 45 000 people were employed by SDAG Wismut. In the mid-1980s, Wismut's employment decreased to about 30 000. In 1990, only 18 000 people worked in uranium mining and milling and the number of employees has declined since as remediation activities are completed.

Federal Republic of Germany before 1990

Starting in 1956, exploration was carried out in several areas of geological interest: the Hercynian Massifs of the Black Forest, Odenwald, Frankenwald, Fichtelgebirge, Oberpfalz, Bayerischer Wald, Harz, the Paleozoic sediments of the Rheinisches Schiefergebirge, the Permian volcanics and continental sediments of the Saar-Nahe region and other areas with favourable sedimentary formations.

The initial phase included hydro-geochemical surveys, car borne surveys, field surveys, and, to a lesser extent, airborne prospecting. Follow-up geochemical stream sediment surveys, radon surveys and detailed radiometric work, followed by drilling and trenching, were carried out in promising areas. During the reconnaissance and detailed exploration phases both the federal and state geological surveys were involved, whereas the actual work was carried out mainly by industrial companies.

Three deposits of economic interest were found: the partly high-grade hydrothermal deposit near Menzenschwand in the southern Black Forest, the sedimentary Müllenbach deposit in the northern Black Forest and in the Grossschloppen deposit in north-eastern Bavaria. Uranium exploration ceased in Western Germany in 1988 but by then about 24 800 holes had been drilled, totalling about 354 500 m. Total expenditures were on the order of USD 111 million.

Recent and ongoing uranium exploration and mine development activities

There have been no exploration activities in Germany since the end of 1990. Several German mining companies did perform exploration abroad (mainly in Canada) through 1997.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Identified conventional resources were last assessed in 1993. These identified conventional resources occur mainly in the closed mines that are in the process of being decommissioned. Their future availability remains uncertain.

Undiscovered conventional resources (prognosticated and speculative resources)

All undiscovered conventional resources are reported as speculative resources in the cost category above USD 260/kgU.

Unconventional resources and other materials

None reported.

Uranium production

Historical review

Federal Republic of Germany before 1990

In the Federal Republic of Germany, a small (125 tonnes per year) uranium processing centre in Ellweiler, Baden-Württemberg began operating in 1960 as a test mill. It was closed on 31 May 1989 after producing a total of about 700 tU.

Former German Democratic Republic before 1990

Two processing plants were operated by SDAG Wismut in the territories of the former GDR. A plant at Crossen, near Zwickau in Saxony, started processing ore in 1950. The ore was transported by road and rail from numerous mines in the Erzgebirge. The composition of the ore from the hydrothermal deposits required carbonate pressure leaching. The plant had a maximum capacity of 2.5 million tonnes of ore per year. Crossen was permanently closed on 31 December 1989.

The second plant at Seelingstadt, near Gera, Thuringia, started ore processing operations in 1960 using the nearby black shale deposits. The maximum capacity of this plant was 4.6 million tonnes of ore per year. Silicate ore was treated by acid leaching until the end of 1989. Carbonate-rich ores were treated using the carbonate pressure leaching technique. After 1989, Seelingstadt's operations were limited to the treatment of slurry produced at the Königstein mine using the carbonate method.

A total of over 200 000 tU was produced in the GDR between 1950 and 1989.

Status of production facilities, production capability, recent and ongoing activities and other issues

There is no commercial production of uranium in Germany today. Decommissioning of the historic German production facilities started in 1989 (former Federal Republic of Germany) and 1990 (former GDR). Between 1991 and 2014, uranium recovery from mine water treatment and environmental restoration amounted to a total of 2 600 tU. Since 1992, all uranium production in Germany has been derived from the clean-up operations at the Königstein mine.

Ownership structure of the uranium industry

The production facilities in the former GDR were owned by the Soviet-German company Wismut (SDAG Wismut). After reunification, the German Ministry of Economy inherited the ownership from SDAG Wismut. The German federal government through Wismut GmbH took responsibility for the decommissioning and remediation of all production facilities. The government retains ownership of all uranium recovered in clean-up operations.

In August 1998, Cameco completed its acquisition of Uranerz Exploration and Mining Ltd (UEM), Canada, and Uranerz USA Inc. (UUS), from their German parent company Uranerzbergbau GmbH (Preussag and Rheinbraun, 50% each). As a result, there remains no commercial uranium industry in Germany.

Employment in the uranium industry

All employment is engaged in decommissioning and rehabilitation of former production facilities. Employment decreased within the last 4 years from 1 489 (2010) to 1 147 (2014).

Future production centres

None reported.

Uranium policies, uranium stocks and uranium prices

According to the energy concept 2010, the federal government decided to phase-out use of nuclear power for commercial electricity generation on a staggered schedule. With the adoption of the Thirteenth Act amending the Atomic Energy Act (*Dreizehntes Gesetz zur Änderung des Atomgesetzes*), all reactors will be shut down by no later than the end of 2022. The German Bundestag (parliament) passed the amendment on 30 June 2011 and it came into force on 6 August 2011. For the first time in the history of the Federal Republic of Germany, a fixed deadline has been laid down in law for the end of the use of nuclear power in the country. The withdrawal is to be undertaken in stages with specific shutdown dates.

The country's seven nuclear power plants commissioned prior 1980, along with the Krümmel nuclear power plant, were shut down during a provisional three-month operational shutdown period in 2011 and will remain permanently closed. The final shutdown dates for the nine remaining nuclear power plants are determined according to the following schedule: 2015, Grafenrheinfeld; 2017, Gundremmingen B; 2019, Philippsburg 2; 2021, Grohnde, Gundremmingen C and Brokdorf; and 2022, the three youngest nuclear power plants, Isar 2, Emsland and Neckarwestheim 2.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				3 000	
Total				**3 000**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				3 000	
Total				**3 000**	

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				4 000	
Total				**4 000**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified				4 000	
Total				**4 000**	

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	N/A					0
Underground mining*	N/A					0
Total	**219 576**				**219 576**	**0**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	**Total through end of 2011**	**2012**	**2013**	**2014**	**Total through end of 2014**	**2015 (expected)**
Other methods*	2 490	50	27	33	2 600	0
Total	**219 576**	**50**	**27**	**33**	**219 686**	

* Includes mine water treatment and environmental restoration.

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
		74 000

Ownership of uranium production in 2014

Domestic				**Foreign**				**Totals**	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
33	100							33	100

Uranium industry employment at existing production centres

(person-years)

	2012	**2013**	**2014**	**2015 (expected)**
Total employment related to existing production centres	1 372	1 204	1 147	1 062
Employment directly related to uranium production	N/A			

Mixed oxide fuel production and use

(tonnes natural U-equivalent)

Mixed oxide (MOX) fuel	**Total through end of 2011**	**2012**	**2013**	**2014**	**Total through end of 2014**	**2015 (expected)**
Production	0					
Use	6 730	100				
Number of commercial reactors using MOX		2*				

* Reactors loading fresh MOX.

Re-enriched tails production and use

(tonnes natural U-equivalent)

Re-enriched tails	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Production	N/A	N/A	N/A	N/A	N/A	N/A
Use	N/A	0	0	0	0	0

Reprocessed uranium use

(tonnes natural U-equivalent)

Reprocessed uranium	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Production	N/A	0	0	0	0	0
Use	N/A	N/A	N/A	N/A	N/A	N/A

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	92.1	91.8

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
12 068	12 068	Low	High	Low	High	Low	High	Low	High	Low	High
			12 100		8 100		0		0		0

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
2 000	2 000	Low	High	Low	High	Low	High	Low	High	Low	High
			2 000		1 200		0		0		0

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	N/A	N/A	N/A	N/A	N/A
Producer	N/A	N/A	N/A	N/A	N/A
Utility	N/A	N/A	N/A	N/A	N/A
Total	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Hungary

Uranium exploration

Historical review

The first reconnaissance for uranium started in 1952 when, with Soviet participation, material from Hungarian coal deposits was checked for radioactivity. The results of this work led in 1953 to a geophysical exploration programme (airborne and surface radiometry) over the western part of the Mecsek Mountains. The discovery of the Mecsek deposit was made in 1954 and further work was aimed at the evaluation of the deposit and its development. The first shafts were placed in 1955 and 1956 for the mining of sections I and II. In 1956, the Soviet-Hungarian uranium joint venture was dissolved and the project became the sole responsibility of the Hungarian state. That same year, uranium production began.

Recent and ongoing uranium exploration and mine development activities

In accordance with the expectation of the Hungarian Office for Mining and Geology, the resource estimate was re-evaluated in 2012, but since that time there has not been any relevant exploration activity in the region.

Uranium resources

Hungary's reported uranium resources are limited to those of the Mecsek deposit. The ore occurs in Upper Permian sandstones that may be as thick as 600 m. The sandstones were folded into the Permian-Triassic anticline of the Mecsek Mountains. The ore-bearing sandstone in the upper 200 m of the unit is underlain by a very thick Permian siltstone and covered by Lower Triassic sandstone. The thickness of the green-grey ore-bearing sandstone, locally referred to as the productive complex, varies from 15 to 90 m. The ore minerals include uranium oxides and silicates associated with pyrite and marcasite.

Identified conventional resources (reasonably assured and inferred resources)

Following the resource estimate re-evaluation in 2012, 17 946 tU are now reported as in situ high-cost inferred resources, an increase of over 6 000 tU from the previous estimate.

Undiscovered conventional resources (prognosticated and speculative resources)

Prognosticated resources amount to a total of 13 427 tU recoverable at costs of USD 130-260/kgU, which is the same as what was reported in the last edition. These resources are tributary to the former Mecsek production centre. Speculative resources are not estimated.

Uranium production

Historical review

The Mecsek underground mine and mill situated near the city of Pécs was the only uranium production centre in Hungary. Prior to 1 April 1992, it was operated by the state-owned Mecsek Ore Mining Company (MÉV). It began operation in 1956 and was producing ore from a depth of 100-1 100 m until it was definitively shut down in 1997. During operation, it produced about 500 000-600 000 tonnes ore/year with an average mining recovery of 50-60%. The ore processing plant had a capacity of 1 300 to 2 000 tonnes ore/day and employed radiometric sorting, agitation acid leach (and alkaline heap leaching) with ion-exchange recovery. The nominal production capacity of the plant was about 700 t/year.

The Mecsek mine consisted of five sections with the following history:

- section I: operating from 1956 to 1971;
- section II: operating from 1956 to 1988;
- section III: operating from 1961 to 1993;
- section IV: operating from 1971 to 1997;
- section V: operating from 1988 to 1997.

The ore processing plant became operational in 1963. Prior to its operation, 1.2 million tonnes of raw ore was shipped to the Sillimae metallurgy plant in Estonia. After 1963, processed uranium concentrates were shipped directly to the former Soviet Union.

Mining and milling operations were closed down at the end of 1997 because changes in market conditions made the operation uneconomic. Throughout its operational history, total production from the Mecsek mine and mill, including heap leaching, amounted to a total of about 21 000 tU.

Status of production capability

Since the closure of the Mecsek mine in late 1997, the only uranium production in Hungary has been recovered as a by-product of water treatment activities, amounting to a total of about 1-6 tU/yr.

Environmental activities and socio-cultural issues

Closure and large-scale site remediation activities at the Mecsek uranium production centre were carried out between 1998 and 2008. The remediation consisted of: removing several hundred thousand tonnes of contaminated soil from various areas around the site to an on-site disposal facility; remediation of tailings ponds and waste rock piles through the placement of protective earthen covers; abandonment and closure of underground mine workings, as well as groundwater extraction and treatment. Although the large-scale remediation programme was completed by the end of 2008, long-term care activities – such as groundwater remediation, environmental monitoring and maintenance of the engineered disposal systems – will have to continue for some years to come. Because of flooding of the abandoned underground mining openings, in the next years the enlargement of the water management system and the mine water treatment plant is crucial, the planning and implementation works began in 2014.

Since April 2014 the long-term aftercare works on the Hungarian uranium mining and ore processing legacy site are under the direct responsibility of the Public Limited Company for Radioactive Waste Management (PURAM, www.rhk.hu/en/).

The legal successor of the former Mecsek mine (a state-owned company) is also responsible for paying compensation including damages for occupational disease, income and pension supplements, reimbursements of certified costs and dependent expenses to people formerly engaged in uranium mining. Costs associated with the environmental remediation of the Mecsek mine are provided in the following table.

Costs of environmental management

(HUF thousands [Hungarian forints])

	Pre-1998	1998 to 2008
Closing of underground spaces	N/A	2 343 050
Reclamation of surficial establishments and areas	N/A	2 008 403
Reclamation of waste rock piles and their environment	N/A	1 002 062
Reclamation of heap leaching piles and their environment	N/A	1 898 967
Reclamation of tailings ponds and their environment	N/A	8 236 914
Water treatment	N/A	1 578 040
Reconstruction of electric network	N/A	125 918
Reconstruction of water and sewage system	N/A	100 043
Other infrastructural service	N/A	518 002
Other activities including monitoring, staff, etc.	N/A	2 245 217
Total	**5 406 408**	**20 056 616**

N/A = Not available.

After remediation of the uranium mining and ore processing legacy site, the annual cost of long-term activities amounts to some HUF 600-750 million (about USD 2.2-2.6 million).

After the IAEA organised an international peer review in 2010, a strategic plan was developed for future long-term (30-year) activities. The main findings and recommendations of the peer review programme were, with few exceptions, incorporated into this plan.

Uranium requirements

On 14 January 2014, Hungary signed an intergovernmental agreement with Russia to maintain the generating capacity of the NPP. The agreement covers the design, construction and commissioning of two new nuclear units, the supply of nuclear fuel, as well as the return of the spent fuel to Russia. Rosatom, the Russian nuclear state authority, will be in charge of the implementation of the design and construction works. The financial contract was elaborated by the stakeholders covering the state loan and investments details. The contract was approved by parliament on 23 July 2014, with the following conditions: 80% of the investment will be covered by a state loan of EUR 10 billion to be provided by Russia; while 20% will be covered by Hungarian resources, due at the end of the project.

In order to fulfil the specific requirements stated in the intergovernmental agreement, separate contracts – implementation agreements – were concluded on 9 December 2014. The following agreements were elaborated: design, procurement and construction contract (EPC contract); operation and maintenance contract; nuclear fuel supply and nuclear waste management contract. All documents were elaborated in compliance with the applicable EU rules and regulations.

A total of 15 648.6 GWh of electric energy was generated by the Paks NPP in 2014, which represents 53.6% of the gross domestic electricity production of Hungary. This amount was generated by four units as follows: unit 1 (4 015.4 GWh); unit 2 (4 128.1 GWh); unit 3 (3 815.3 GWh); unit 4 (3 689.8 GWh). As for the produced energy, the fourth largest production result in the history of the power plant was achieved in 2014. The total of all electricity that has been generated by Paks NPP since the date of the first connection of unit 1 to the grid was higher than 413.6 TWh as of the end of 2014.

On 14 November 2008, the Paks NPP submitted its programme for service life extension of the units of the NPP to the nuclear regulator. In its resolution issued in June 2009, the Hungarian Atomic Energy Authority approved the conditions, the required additional actions, and tasks for the implementation of the Service Life Extension Program. The implementation of the programme on the extension of the service life of unit 1 went on as specified in the resolution so the operation licence of unit 1 was granted for a further 20 years. The operations for the extension of the service life of unit 2 of the Paks NPP by a further 20 years continued in 2014. On 24 November 2014, the Hungarian Atomic Energy Authority issued the operation licence of unit 2 for a further 20-year period.

National policies relating to uranium

Since the shutdown of the Hungarian uranium mining industry in 1997, there are no uranium-related policies.

Uranium stocks

The by-product ($UO_4\ 2H_2O$) of the water treatment activities on the former uranium mining and ore processing site is stored at the mine water treatment facility until export. At the end of 2014, the inventory amounted to 8 059 kg.

Uranium prices

Uranium prices are not available as they are commercially confidential.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone				17 946
Total				**17 946**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)				17 946	
Total				**17 946**	

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG				17 946	
Total				**17 946**	

* In situ resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
		13 427

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Sandstone	21 061	1	3	2	21 067	4
Total	**21 061**	**1**	**3**	**2**	**21 067**	**21 071**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Underground mining*	21 000					
Co-product/by-product	61	1	3	2	67	4
Total	**21 061**	**1**	**3**	**2**	**21 067**	**21 071**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	20 475					
Heap leaching*	525					
In situ leaching						
Other methods**	61	1	3	2	67	4
Total	**21 061**	**1**	**3**	**2**	**21 067**	**21 071**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

** Includes mine water treatment and environmental restoration.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
2	100							2	100

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
1 890	1 890	Low	High	Low	High	Low	High	Low	High	Low	High
		1 890	1 890	2 000	2 000	2 000	3 200	2 000	4 400	1 000	3 400

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
367	214	Low	High	Low	High	Low	High	Low	High	Low	High
		470	470	392	392	392	1 060	392	1 034	196	838

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government					
Producer	8				8
Utility					
Total	**8**				**8**

India

Uranium exploration and mine development

Historical review

The history of uranium exploration in India dates from 1949. Until the mid-1970s, uranium exploration was mainly confined to uranium provinces in the Singhbhum, Jharkhand and Umra-Udaisagar belt in Rajasthan targeting vein-type of mineralisation. This resulted in establishing 16 low-grade uranium deposits of varying size in Singhbhum Shear Zone, Jharkhand and one deposit at Umra, Rajasthan. Seven out of the 16 deposits in Singbhum are under exploitation. Presently, exploration is being carried out in several sectors of the 160 km long Singhbhum Shear Zone. Subsequently, investigations were expanded to other geologically favourable domains, which resulted in establishing a number of small uranium deposits such as Bodal and Bhandaritola, Chhattisgarh in Paleoproterozoicamphibolites; Jajawal, Chhattisgarh in Paleoproterozoic sheared migmatites of Chhotanagpur gneiss complex and Walkunji, Karnataka in basal quartz-pebble conglomerates of Dharwar Group.

During the mid-seventies, exploration was initiated in several potential geological sectors targeting sandstone-type uranium deposits. The pursuit for sandstone-type uranium mineralisation resulted in establishing a high-grade, medium-tonnage deposit at Domiasiat (Kylleng-Pyndengsohiong Mawthabah) in the Cretaceous sandstones of Meghalaya. Exploration in the contiguous sectors has established a number of small uranium deposits.

During the mid-eighties, a low-grade, stratabound deposit hosted by dolostones of the Vempalle Formation was established at Tummalapalle, Andhra Pradesh in Cuddapah Basin. The dolostone ore was not amenable for the conventional leaching procedures available at that time, and therefore exploration in this sector was discontinued. However, development of an economically viable alkali pressure leaching process rejuvenated the exploration activities in this part of Cuddapah Basin especially targeting carbonate-hosted uranium mineralisation in the Vempalle Formation. In recent years, intensive multi-parametric exploration has been carried out in Tummalpalle and adjacent sectors.

Subsequently, during the early 1990s, a near-surface deposit was discovered adjacent to the unconformity contact between basement granites and overlying Proterozoic Srisailam Quartzite at Lambapur in the Nalgonda district, Andhra Pradesh. These occurrences were further investigated and a number of areas had been identified until 1996. Favourable geological criteria and sustained exploration efforts resulted in establishing deposits at Peddagattu and Chitrial. Exploration in the adjacent Palnad sub-basin has established a small deposit at Koppunuru. Exploration is continuing in these sectors.

Sustained exploration in the North Delhi Fold Belt (NDFB), in parts of Rajasthan and Haryana targeting metasomatite type of uranium mineralisation has established the Rohil uranium deposit, Rajasthan. Recent exploration efforts in this geological domain have resulted in enhancing the tonnage of the Rohil uranium deposit and a few potential sectors have also emerged.

Recent and ongoing uranium exploration and mine development activities

In recent years, exploration activities have been concentrated in the following areas:

- Proterozoic Cuddapah Basin, Andhra Pradesh;
- Mesoproterozoic Singhbhum Shear Zone, Jharkhand;
- Mesoproterozoic North Delhi Fold Belt, Rajasthan & Haryana;
- Cretaceous sedimentary basin, Meghalaya;
- Neoproterozoic Bhima Basin, Karnataka;
- Dharmapuri Shear Zone in the Southern Granulite Terrain, Tamil Nadu;
- Other potential geological domains such as the Kotri-Dongaragarh belt, Chhattisgarh; Lesser Himalayas, Uttarakhand; Chhotanagpur Gneiss Complex, Kaladgi Basin, Karnataka and Siwana Ring Complex, Rajasthan.

Proterozoic Cuddapah Basin, Andhra Pradesh

The Cuddapah Basin (Proterozoic) of Dharwar Craton of Southern Peninsular India is one of the major uranium provinces hosting uranium mineralisation at various stratigraphic levels. Three types of uranium mineralisation/deposits have been established in the Cuddapah Basin: a) carbonate-hosted stratabound type, b) unconformity-related and c) fracture-controlled, carbonate-hosted stratabound uranium deposit.

a) Carbonate-hosted stratabound uranium deposit

The southern part of the Cuddapah Basin hosts a unique, low-grade and large tonnage uranium deposit in dolostone of the Vempalle Formation in the Tummalapalle-Rachakuntapalle sector. This formation occurs at the lower stratigraphic sequence of the Cuddapah Basin. Uranium mineralisation has been traced intermittently over a strike length of 160 km from Reddipalle in the north to Maddimadugu in the southeast. The vast extent of the deposit, its stratabound nature hosted by dolostone, and point to point correlation with uniform grade and thickness of the mineralisation over considerable lengths along the strike and dip, makes the deposit unique. Two ore lodes with an average thickness of 2.30 m and 1.75 m, separated by a lean/unmineralised band of 3.0 m, are under active exploration up to a vertical depth of 825 m. Sustained exploration activities over the 16 km segment within the 160 km long belt has added additional uranium resources. In addition, intensive exploration activities in various sectors of the 160 km long belt (e.g. Rachakuntapalle East, Velamvaripalle, Nandimandalam) substantially increased the uranium potential of this geological domain.

b) Unconformity-related uranium deposits

The north-western margin of Cuddapah Basin comprising Meso to Neoproterozoic Srisailam and Palnad sub-basins are known for their potential for unconformity-related uranium deposits. Intensive exploration over the past few decades in the northern part of Srisailam sub-Basin had established three low-tonnage, low-grade uranium deposits namely Lambapur, Peddagattu and Chitrial. Exploration efforts along the northern margin of Palnad sub-Basin has resulted in locating a low-grade and low-tonnage deposit at Koppunuru. Further exploration has continued in other parts of Srisailam and Palnad sub-basins having a similar lithostructural setup.

c) Fracture-controlled uranium mineralisation

The Gulcheru quartzite of the Cuddapah Supergroup overlying the basement granitoid in the southern parts of Cuddapah Basin is intensely fractured, faulted and intruded by E-W trending basic dykes. Uranium mineralisation is associated with the quartz-chlorite-breccia occurring all along the contact between the Gulcheru quartzite and the basic dykes in the Gandi-Madyalabodu area. Furthermore, the fracture systems within the basement crystallines proximal to the southern margin of Cuddapah Basin, are known to host uranium mineralisation.

Mesoproterozoic Singbhum Shear Zone, Jharkhand

The Singhbhum Shear Zone is a 200 km long, arcuate belt of tectonised rocks fringing the northern boundary of the Singhbhum craton along its contact with the Singhbhum Group of rocks. Exploration efforts since the early fifties have led to the establishment of several low-grade and low to medium tonnage uranium deposits, some of which are under active exploitation. The established uranium deposits are mostly located in the central and eastern sector of the shear zone. Intensive exploration in various sectors in the shear zone has added significant resources to the uranium inventory. Notable among them are Bangurdih and Narwapahar, Singridungri and Banadungri-Geradih sectors.

Mesoproterozoic North Delhi Fold Belt of Rajasthan and Haryana

The metasediments of North Delhi Fold Belt comprising Khetri, Alwar and Bayana-Lalsot sub-basins in the states of Rajasthan and Haryana are the host for a number of uranium occurrences. The 170 km long north-northeast to south-southwest trending “albitite line” passes through the Delhi Supergroup and Banded Gneissic Complex and is the site for extensive sodic metasomatism. This zone holds potential to host metasomatite-type uranium mineralisation. An integrated approach with litho-structural, ground geophysical and drilling inputs have resulted in the discovery of a fracture-controlled vein-type uranium deposit near Rohil, Rajasthan and the entire 170 km long zone holds immense potential for additional uranium resources. Vast inputs of ground and airborne geophysical surveys and drilling is deployed in the contiguous sectors of Rohil. The exploration efforts resulted in establishing promising new sectors along Gumansingh-Ki-Dhani, Narsinghpuri, Hurra-Ki-Dhani, Jahaj-Maota, Diara, etc., in the contiguous area of Rohil with similar geological settings.

Cretaceous sedimentary basin, Meghalaya

The upper Cretaceous lower Mahadek Formation exposed along the southern fringes of Shillong plateau, Meghalaya, is a potential host for uranium mineralisation. This geological domain has been under exploration since the late seventies. Substantial exploration inputs over the years established seven low- to medium-grade and low- to medium-tonnage uranium deposits at Domiasiat, Wahkyn, Wahkut, Gomaghat, Tyrnai, Umthongkut and Lostain. Exploration efforts are presently being continued in Wahkut, Kulang and Umthongkut sectors. The exploration efforts along the southward extensions of the Wahkut deposit have shown positive results.

Neoproterozoic Bhima Basin, Karnataka

The Bhima Basin comprises calcareous sediments with minor arenaceous lithostratigraphic units of the Bhima Group which were deposited over basement granite and have been affected by a number of east-west trending faults. A small-sized, medium-grade uranium deposit has been established at Gogi along the Gogi-Kurlagare-Gundahalli fault. Present exploration efforts are concentrated in the Kanchankayi sector along the north-eastern extensions of Gogi uranium deposit and also along the intervening sector between Gogi and Kanchankayi.

Neoproterozoic alkaline complexes in Southern Granulite Terrain, Tamil Nadu.

The Dharmapuri Shear Zone of Tamil Nadu is emerging as a potential province for multi-metal deposits including uranium. The north-northeast-south-southwest trending shear zone forms part of the Southern Granulite Terrain and is characterised by Neoproterozoic alkaline intrusives including carbonatites. Exploration for uranium, Nb-Ta and rare earth elements in the northern part of the Shear Zone dates back to mid-1960s, resulting in the discovery of significant uranium anomalies associated with quartz-barite veins at Rasimalai, Sevattur, etc. This was followed by a series of prospecting ventures in the zone during the past two decades, leading to the discovery of a number of uranium anomalies in the alkaline emplacements within the Dharmapuri Shear Zone. The Sevattur alkaline-carbonatite complex has been explored for uranium and REE in the past and the alkaline intrusions near Rasimalai and Pakkanadu along the Dharmapuri Shear Zone are under active exploration presently.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

India's known conventional uranium resources (reasonably assured resources and inferred) are estimated to be 181 606 tU hosted in the following deposit types:

Carbonate deposits	42.24%
Metamorphite	31.55%
Sandstone-type	10.33%
Unconformity-type	9.95%
Metasomatite	3.74%
Granite-related	1.99%
Quartz pebble conglomerate	0.19%

As of 1 January 2015, the known conventional in situ resources established so far include 160 033 tU of reasonably assured resources (RAR) and 21 573 tU of inferred resources (IR). This amounts to a substantial increase in RAR and a marginal decrease in IR, compared to what was reported for the 2014 Red Book. These changes are mainly due to appreciable resource additions in the contiguous area of the stratabound deposit in the southern part of the Cuddapah Basin and in the extension areas of known deposits in the Singhbhum Shear Zone, Mahadek Basin and North Delhi Fold Belt. Furthermore, part of the IR reported in 2013 has been converted to RAR.

Undiscovered conventional resources (prognosticated and speculative resources)

In parts of Andhra Pradesh, Meghalaya, Rajasthan, Jharkhand and Karnataka, potential areas for uranium resources were firmed up with a higher degree of confidence. As of 1 January 2015, undiscovered resources increased to 106 000 tU under the prognosticated category and 46 640 tU under the speculative category, both as in situ resources.

The increase in the prognosticated resources category (from 84 800 tU in 2013 to 106 000 tU in 2015) is mainly because of the greater degree of confidence obtained by carrying out multidisciplinary exploration in some of the potential geological domains such as Southern Cuddapah Basin, Andhra Pradesh; Singhbhum Shear Zone, Jharkhand and Bhima Basin, Karnataka.

Similarly, the increase in the speculative resources category (from 42 400 tU in 2013 to 46 640 tU in 2015) is mainly due to the identification of several potential exploration targets in the various geological domains, namely Dharmapuri Shear Zone, Tamil Nadu; Satpura Gondwana Basin, Madhya Pradesh; Southern Cuddapah Basin, Andhra Pradesh.

Uranium production

Historical review

The Uranium Corporation of India Limited (UCIL) was formed in October 1967 under the administrative control of the Department of Atomic Energy, government of India. The UCIL operates six underground uranium mines (Jaduguda, Bhatin, Narwapahar, Turamdih, Bagjata and Mohuldih) and one open-pit mine (Banduhurang in Singhbhum East district of Jharkhand State). The ore produced from the mines is processed in two processing plants located at Jaduguda and Turamdih. All these facilities are located in a multi-metal mineralised sector – the Singhbhum Shear Zone in the eastern part of India. In addition to these, UCIL has also constructed a uranium mine and a processing plant in the YSR district (formerly Kadapa) of Andhra Pradesh.

Status of production facilities, production capability, recent and ongoing activities and other issues

The total installed capacity of UCIL's three operating plants is as follows:

- Jaduguda Plant: 2 500 t ore/day;
- Turamdih Plant: 3 000 t ore/day;
- Tummalapalle Plant: 3 000 t ore/day.

Recent and ongoing activities

Jaduguda mine: The Jaduguda uranium deposit lies within metasediments of Singhbhum Shear Zone. The host rocks are of Proterozoic age. There are two prominent parallel ore lenses – the Footwall lode (FWL) and the Hangwall lode (HWL). These lodes are separated by a 100 m barren zone. The FWL extends over a strike length of about 600 m in a south-east to north-west direction. The strike length of HWL is about 250 m and is confined to the eastern part of the deposit. Both the lodes have an average dip of 40 degrees towards the north-east. Of the two lodes, the FWL is better mineralised. The Jaduguda deposit has been explored up to a depth of 880 m.

Entry to the mine is through a 640-metre-deep vertical shaft. An underground auxiliary vertical shaft, sunk from 555 m to 905 m, provides access to deeper levels. The cut-and-fill stoping method is practised, giving about 80 % ore recovery. De-slimed mill tailings are used as backfill material. Ore is hoisted by the skip in stages through shafts to surface and sent to the Jaduguda mill by conveyor for further processing.

Bhatin mine: The Bhatin uranium deposit is located 4 km north-west of Jaduguda. A major strike-slip fault lies between the Jaduguda and Bhatin deposits. Both the deposits lie in similar geological settings. The Bhatin mine began production in 1986. The ore lens has a thickness of 2 to 10 m with an average dip of 35 degrees and entry to the mine is through an adit, with deeper levels accessed by inclines. Cut-and-fill stoping is practised and deslimed mill tailings from the Jaduguda mill are used as backfill. Broken ore is trucked to the Jaduguda mill. UCIL has planned for increasing underground productivity of this mine by further mechanising its working methods.

Narwapahar mine: The Narwapahar deposit, (about 12 km west of Jaduguda) has been operating since 1995. In this deposit, discrete uraninite grains occur within chlorite-quartz schist with associated magnetite with several lenticular-shaped ore lenses extending over a strike length of about 2 100 m, each with an average north-easterly dip of 30 to 40 degrees. The thickness of the individual ore lenses varies from 2.5 to 20 m. The deposit is accessed by a 355-metre-deep vertical shaft and a 7 degree decline from the surface. Cut-and-fill stoping is also practised using deslimed mill tailings of the Jaduguda plant as backfill. Ore is trucked to the Jaduguda plant for processing.

Turamdih mine: The Turamdih deposit is located about 12 km west of Narwapahar. Discrete uraninite grains within feldspathic-chlorite schist form a number of ore lenses with very erratic configuration. The mine was commissioned in 2003 and three levels (70 m, 100 m and 140 m depth) have been accessed through an 8 degree decline from the surface and a vertical shaft has been sunk to provide access to deeper levels. Ore from this mine is processed at the Turamdih plant. Cut-and-fill stoping is also practised using deslimed mill tailings of the Turamdih plant. Considering the ore geometry, possibilities of adopting sub-level stoping method in specific segments of the orebody is being explored with higher productivity. Trial stoping in one such area has been undertaken.

Bagjata mine: The Bagjata deposit, situated about 26 km east of Jaduguda, has been developed as an underground mine with a 7 degree decline for entry and a vertical shaft to access deeper levels. This mine was commissioned in 2008. Ore from the Bagjata mine is transported by road to the Jaduguda plant for processing. Cut-and-fill stoping is practised in the Bagjata mine and deslimed mill tailings from the Jaduguda mill are used as backfill.

Banduhurang mine: The Banduhurang deposit has been developed as a large opencast mine. The orebody is the western extension of ore lenses at Turamdih. The mine was commissioned in 2009 and ore is transported by road to the Turamdih plant for processing.

Mohuldih mine: The deposit is located in the Seraikela-Kharswan district of Jharkhand, about 2.5 km west of Banduhurang. The mine was commissioned in 2012. The ore from the mine is treated at the Turamdih plant.

Tummalapalle mine: Hosted in carbonate rock, this deposit is located in the YSR district (formerly Kadapa) of Andhra Pradesh. It is the first uranium production centre in the country located outside Jharkhand. This underground mine is accessible by three declines along the apparent dip of the orebody. The central decline is equipped with a conveyor for ore transport and the other two declines are used as service paths. The ore is treated in the plant adjacent to the mine at Tummalapalle. Expansion of the mine and processing plant at Tummalapalle has been planned to augment uranium production.

Jaduguda mill: Ore produced at the Jaduguda, Bhatin, Narwapahar and Bagjata mines is processed in the mill located at Jaduguda. Commissioned in 1968, the mill is capable of treating about 2 500 t/day of dry ore. Following crushing and grinding to 60% (passing 200 mesh), the ore is leached in pachuca tanks using sulphuric acid under controlled pH and temperature. After filtration of the pulp, resin is used in ion exchange to recover the uranium. After elution, the product is precipitated using hydrogen peroxide to produce uranium peroxide containing about 88% U_3O_8. The final product of the Jaduguda mill is uranium peroxide. The treatment of mine water and reclaiming tailings water has resulted in reduced fresh water requirements, as well as increasing the purity of the final effluent. A magnetite recovery plant is also in operation at Jaduguda producing very fine grained magnetite as a by-product.

Turamdih mill: Uranium ore from the Turamdih and Banduhurang mines is being processed in the Turamdih mill. The mill, commissioned in 2009, is capable of treating about 3 000 t/day dry ore. The plant adopts similar processing technology as that of Jaduguda. Presently, this plant produces magnesium diuranate as the final product. Plans to produce uranium peroxide as the final product is under implementation. Expansion of this plant to process 4 500 t/day dry ore has been taken up.

Tummalapalle mill: The uranium process plant at Tummalapalle in the YSR district (formerly Kadapa) of Andhra Pradesh is based on indigenously developed alkali leaching (under high temperature and pressure) technology. The plant to process 3 000 t ore/day is under commissioning. Expansion of this plant to process 4 500 t ore/day has also been planned.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	Jaduguda	Bhatin	Narwapahar	Bagjata	Turamdih	Banduhurang	Mohuldih	Tummalapalle
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Existing
Start-up date	1967	1986	1995	2008	2003	2007	2011	2012
Source of ore:	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore	Uranium ore
Deposit name(s)	Jaduguda	Bhatin	Narwapahar	Bagjata	Turamdih	Banduhurang	Mohuldih	Tummalapalle
Deposit type(s)	Vein	Vein	Vein	Vein	Vein	Vein	Vein	Strata bound
Resources (tU)	-	-	-	-	-	-	-	-
Grade (% U)	-	-	-	-	-	-	-	-
Mining operation:								
Type (OP/UG/ISL)	UG	UG	UG	UG	UG	OP	UG	UG
Size (tonnes ore/day)	650	150	1 500	500	750	3 500	500	3 000
Average mining recovery (%)	80	75	80	80	75	65	80	60
Processing plant:	Jaduguda				Turamdih			Tummalapalle
Type (IX/SX/AL)	IX/AL				IX/AL			ALKPL*
Size (tonnes ore/day)	2 500				3 000			3 000
Average process recovery (%)	80				78			70
Nominal production capacity (tU/year)	200				190			220
Plans for expansion	-				Turamdih mine (1 000 TPD) and Turamdih plant (4 500 TPD) are under expansion			Tummalapalle mine (4 500 TPD) and Tummalapalle plant (4 500 TPD) are under expansion
Other remarks	Ore being processed in Jaduguda plant				Ore being processed in Turamdih plant			

* Pressurised alkali leach. TPD = tonnes per day.

Uranium production centre technical details *(cont'd)*

(as of 1 January 2015)

	Centre # 9	Centre # 10	Centre # 11
Name of production centre	Gogi	Lambapur-Peddagattu	Kylleng-Pyndengsohiong Mawthabah (KPM)
Production centre classification	Planned	Planned	Planned
Start-up date	2020	2024	2022
Source of ore:	Uranium ore	Uranium ore	Uranium ore
Deposit name(s)	Gogi	Lambapur-Peddagattu	KPM
Deposit type(s)	Vein	Unconformity	Sandstone
Resources (tU)	-	-	-
Grade (% U)	-	-	-
Mining operation:			
Type (OP/UG/ISL)	UG	UG/OP	OP
Size (tonnes ore/day)	500	1 250	2 000 (250 days/yr working)
Average mining recovery (%)	60	75	90
Processing plant:	Gogi	Seripally	KPM
Type (IX/SX/AL)	AL	IX/AL	IX/AL
Size (tonnes ore/day)	500	1 250	2 000 (275 days/yr working)
Average processing ore recovery (%)	88	77	87
Nominal production capacity (tU/year)	130	130	340
Plans for expansion	-	-	-
Other remarks	Ore to be processed in the plant at Saidapur	Ore to be processed in the plant at Seripally	

Ownership structure of the uranium industry

The uranium industry is wholly owned by the Department of Atomic Energy, government of India. The Atomic Minerals Directorate for Exploration and Research under the Department of Atomic Energy is responsible for uranium exploration programmes in India. Following the discovery and deposit delineation, the economic viability is evaluated. The evaluation stage may also include exploratory mining. Once a deposit of sufficient tonnage and grade is established, UCIL initiates activities for commercial mining and production of uranium concentrates.

Employment in the uranium industry

About 5 000 people are engaged in uranium mining and milling activities.

Future production centres

The uranium deposit located at Gogi in the Yadgir (former name Gulbarga) district, Karnataka, is planned for development as an underground mine. Exploratory mining work is in progress to establish the configuration of the orebody. The plant at Gogi will utilise alkali leaching technology.

A sandstone-hosted uranium deposit in the north-eastern part of the country at Kylleng-Pyndengsohiong, Mawthabah (formerly Domiasiat) in West Khasi Hills District, Meghalaya State, is planned for development by open-pit mining, with a processing plant to be situated near the mine.

Uranium deposits located at Lambapur-Peddagattu in the Nalgonda district, Andhra Pradesh are also slated for development, with an open-pit and three underground mines proposed. An ore processing plant is being proposed at Seripally, 50 km from the mine site. Pre-project activities are in progress.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

N/A.

Production and/or use of re-enriched tails

N/A.

Production and/or use of reprocessed uranium

N/A.

Environmental activities and socio-cultural issues

There are no environmental issues related to the existing uranium mines and processing plants operated by UCIL. However, provisions are made for the management of environmental impacts. The organisation responsible for this task is the Health Physics Group of the Bhabha Atomic Research Centre, located in Mumbai. It carries out environmental health monitoring for radiation, radon and dust at uranium production facilities. The Health Physics Unit operates an Environmental Survey Laboratory at Jaduguda and has establishments at all operating facilities.

Regulatory regime

In India all nuclear activities, including mining of uranium or other atomic minerals, falls within the purview of the central government and are governed by the Atomic Energy Act, 1962 (AE Act) and regulations made thereunder. The Department of Atomic Energy (DAE) oversees the development and mining of uranium and other atomic minerals. Accordingly, policies of DAE and provisions of the AE Act and regulations framed thereunder play a key role in the prospecting, exploration and mining of uranium. Relevant provisions of the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act) and the Mines Act, 1952 are also applicable in the case of mining of uranium. In addition, all mining activities must comply with environmental regulations. The mining, milling and processing of uranium ore requires a licence under the AE Act. The Atomic Energy (Radiation Protection) Rules (2004) and the Atomic Energy (Working of Mines and Minerals and Handling of Prescribed Substances) Rules (1984) provide procedural details for obtaining a licence and specify conditions required to carry out these activities.

A mining lease for uranium is granted by the state government after the mining plan is approved by the Atomic Minerals Directorate for Exploration and Research as per the provisions of the MMDR Act. The Atomic Energy Regulatory Board (AERB), an independent authority, regulates safety and other regulatory provisions under the AE Act and ensures the safety of workers, the public and the environment. The AERB oversees various aspects of a mining plan that are required to conform to radiological safety, siting of the mill, disposal of tailings and other waste rocks, as well as decommissioning the facility. Opening, operation and decommissioning of uranium mines require compliance with the various provisions under different legislation and regulations.

In India, uranium exploration/prospecting and mining are carried out exclusively by the central government.

Uranium requirements

As of 1 January 2015, the total installed nuclear capacity in India was 5 680 MWe (gross) which is comprised of 18 pressurised heavy water reactors, two boiling water reactors and 1 light water reactor. Construction of four pressurised heavy water reactors (KAPP 3 and 4: 2 x 700 MWe and Rajasthan Atomic Power Station 7 and 8: 2 x 700 MWe), one light water reactor; Kudankulam NPP 2 of 1 000 MWe) and one prototype fast breeder (500 MWe) is in progress. Total nuclear power generating capacity is expected to grow to about 9 380 MWe by 2017 as projects under construction are progressively completed.

The present plan is to increase nuclear installed capacity to about 35 000 MWe by the year 2022 which will be comprised of 11 460 MWe utilising pressurised heavy water reactors, 22 320 MWe by light water reactors, one 500 MWe by fast breeder reactor and 300 MWe by advanced heavy water reactor.

Annual uranium requirements in 2013 amounted to about 1 400 tU and this would increase in tandem with increases in installed nuclear capacity. Identified conventional uranium resources are sufficient to support 10-15 GWe installed capacity of pressurised heavy water reactors operating at a lifetime capacity factor of 80% for 40 years.

With international co-operation in peaceful nuclear energy being opened to India, installed nuclear generating capacity is expected to grow significantly as more international projects are envisaged. However, the exact size of the programme based on technical co-operation with other countries is yet to be finalised.

Supply and procurement strategy

Uranium requirements for pressurised heavy water reactors are being met with a combination of indigenous and imported sources. Two operating boiling water reactors and two light water reactors of VVER-type (one under operation and another under construction) require enriched uranium and are fuelled by imported uranium. Future light water reactors will also be fuelled by imported uranium.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Uranium exploration, mining, production, fuel fabrication and the operation of nuclear power reactors are controlled by the government of India. National policies relating to uranium are governed by the Atomic Energy Act 1962 and the provisions made thereunder.

Imported light water reactors to be built in the future are to be purchased with an assured fuel supply for the lifetime of the reactor.

Uranium stocks

N/A.

Uranium prices

N/A.

Uranium exploration and development expenditures and drilling effort – domestic

(Indian rupee millions)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	2 827.00	2 318.30	2 643.40	2 816.80
Industry* development expenditures	0	0	0	0
Government development expenditures	0	0	0	0
Total expenditures	**2 827.00**	**2 318.30**	**2 643.40**	**2 816.80**
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Industry exploration trenches (m)	0	0	0	0
Industry trenches (number)	0	0	0	0
Government exploration drilling (m)	188 140	224 488	176 654	205 700
Government exploration holes drilled	N/A	N/A	N/A	N/A
Government exploration trenches (m)	N/A	N/A	N/A	N/A
Government trenches (number)	N/A	N/A	N/A	N/A
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Total drilling (m)	**188 140**	**224 488**	**176 654**	**205 700**
Total number of holes drilled	**N/A**	**N/A**	**N/A**	**0**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Proterozoic unconformity	N/A	N/A	N/A	18 072
Sandstone	N/A	N/A	N/A	15 867
Granite-related	N/A	N/A	N/A	3 618
Metamorphite	N/A	N/A	N/A	39 623
Metasomatite	N/A	N/A	N/A	6 134
Carbonate	N/A	N/A	N/A	76 719
Total				**160 033**

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Underground mining (UG)	N/A	N/A	N/A	139 536
Open-pit mining (OP)	N/A	N/A	N/A	20 479
Unspecified	0	0	0	18
Total				**160 033**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Conventional from UG	N/A	N/A	N/A	139 536
Conventional from OP	N/A	N/A	N/A	20 479
Unspecified				18
Total				**160 033**

* In situ resources.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Sandstone	N/A	N/A	N/A	2 890
Paleo-quartz-pebble conglomerate	N/A	N/A	N/A	352
Metamorphite	N/A	N/A	N/A	19 665
Metasomatite	N/A	N/A	N/A	666
Carbonate	N/A	N/A	N/A	0
Total	**N/A**	**N/A**	**N/A**	**23 573**

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Underground mining (UG)	N/A	N/A	N/A	19 479
Open-pit mining (OP)	N/A	N/A	N/A	2 094
Unspecified				2 000
Total	**N/A**	**N/A**	**N/A**	**23 573**

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Cost range unassigned
Conventional from UG	N/A	N/A	N/A	19 479
Conventional from OP	N/A	N/A	N/A	2 094
Unspecified				2 000
Total	**N/A**	**N/A**	**N/A**	**23 573**

* In situ resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	Cost range unassigned
N/A	N/A	106 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	N/A	46 640

Ownership of uranium production in 2015

Domestic				**Foreign**				**Totals**	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
N/A	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	4 962	4 962	4 962	5 000
Employment directly related to uranium production				

Short-term production capability

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A				N/A				N/A			

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A				N/A				N/A			

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	35.33	38.00

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
4 780	4 780	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		N/A	4 780	N/A	7 480	10 080	11 480	N/A	25 000	N/A	N/A	N/A	N/A

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
N/A	N/A	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		N/A	1 400	N/A	1 688	1 800	2 050	N/A	4 400	N/A	N/A	N/A	N/A

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government					
Producer					
Utility					
Total	N/A	N/A	N/A	N/A	N/A

Indonesia

Uranium exploration and mine development

Historical review

Uranium exploration by the Centre for Development of Nuclear Ore and Geology of the National Nuclear Energy Agency of Indonesia (BATAN) started in the 1960s. Up to 1996, reconnaissance surveys had covered 79% of a total of 533 000 km^2 identified for survey on the basis of favourable geological criteria and promising exploration results. Since that year the exploration activities have been focused on the Kalan, Kalimantan, in which the most significant indications of uranium mineralisation have been found. During 1998-1999, exploration consisted of systematic geological and radiometric mapping, including a radon survey carried out at Tanah Merah and Mentawa, Kalimantan in order to delineate the mineralised zone. The results of those activities increased speculative resource estimates by 4 090 tU to 12 481 tU. From 2000 up to 2002, exploration drilling was carried out at upper Rirang (178 m), Rabau (115 m) and Tanah Merah (181 m) in west Kalimantan.

In 2003-2004, additional exploration drilling was conducted at Jumbang 1 (186 m) and Jumbang 2 (227 m). In 2005, exploration drilling was carried out at Jumbang 3 (45 m) and at Mentawa (45 m), in 2006 at Semut (454 m) and Mentawa (45 m) and 2007 at Semut (174 m). In 2008, no exploration drilling was undertaken.

In 2009, exploration drilling was continued in the Kalan sector and detailed, systematic prospection in the Kawat area and its surroundings was carried out. General prospection in Bangka Belitung Province was also undertaken. Plans to extend exploration in Kalimantan and Sumatera by prospecting from general reconnaissance to systematic stages in order to discover new uranium deposits have been adopted. In 2010, efforts were devoted to evaluating drilling data from the Kawat sector to re-evaluate estimates of speculative resources.

Recent and ongoing uranium exploration and mine development activities

Exploration drilling was carried out in the Lemajung sector, Kalan area in 2013. The drilling reached 1 500 m of total depth, targeting on a horizontal extension of the uranium favourable horizon in metasiltstone and metapelite schistose layers. Geological modelling and resources calculation, using recent drilling data combined with the previous data, resulted in delineation of 600 tonnes of U as measured resources, and 169 tonnes U as indicated resources. Exploration drilling continued in 2014 at the Lembah Hitam sector (Kalan area) to a total depth of 375 m.

A general survey was carried out at Mamuju, West Sulawesi Province in 2013 on Miocene ultra potassic volcanic rock over an area of 800 km^2. Significant volcanic-related anomalies of uranium and thorium were detected, which are structure-bound and appear related to hydrothermal and supergene enrichment processes. The survey continued in 2014 and focused on former volcanic craters where significant anomalies were detected. Based on the survey results, the plan is to focus on uranium and thorium exploration in the Mamuju area for the next several years.

A general survey also carried out at Biak Island, Papua Province in 2014. This survey was carried out based on the report from an environmental survey that showed several radiometric anomalies in the area. The survey delineated radiometric anomalies where the anomaly was detected on the top-most and thin soil strata. The bedrock in the anomalous area is Pleistocene coral limestone.

Uranium and thorium exploration surveys in 2015 continue in the Mamuju area, West Sulawesi Province, and the Ella Ilir sector (Kalan area), West Kalimantan Province. Surveys at the Mamuju area will consist of systematic geological and radiometric mapping in Takandeang, Taan, Ahu, Pangasaan, and the upstream of the Mamuju River sectors and geophysical surveys in the Botteng sector. This will be followed up by exploration drilling in the Botteng and Takandeang sectors targeting on 1 600 m total depth to test subsurface uranium occurrences.

A survey at the Ella Ilir sector consisted of detailed radiometric mapping and subsurface uranium mineralisation targeted by exploration drilling to a total depth of 400 m. Based on previous data, the survey will focus on uranium anomalies from metapelite schistose, metatuff and granite.

No mining activity is currently under consideration.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Based on uranium exploration during 2013 in the Lemajung sector, Kalan area, 769 tU has been added to reasonably assured resources (600 tU measured resources and 169 tU indicated resources). Total uranium resources from uranium exploration in present day from the Kalan area (includes 2013 activity) are 1 473 tU as measured resources; 5 558 tU as indicated resources; and 2 540 tU as inferred resources. Measured and indicated resources are 7 031 tU.

Lemajung sector, Kalan area

Uranium mineralisation potential in this area is of the metamorphite type. The Metasiltstone and metapelite schists members of the Melawi Formation contain uranium mineralisation. Non-mineralised metapelite andalusite and metapelite biotite rock surround these favourable areas. Exploration drilling in the Lemajung sector in 2013 reached 1 500 m of total depth targeting on a horizontal extension of a uranium favourable zone in metasiltstone and metapelite schists of the Melawi Formation. Ore body as much as 51 ores has been identified from the correlation. These ores are parallel to the foliation plane or S1. Resources estimation conducted using inverse distance estimation (IDE) statistics method, block model size of 4 x 4 x 2 m and sub-blocks 0.5 x 0.5 x 0.25 m, the radius of influence for the measured and indicated resource set 25 m and 50 m, with cut-off grade of 0.01% U_3O_8. The result of estimation is measured resources of 600 tU, and indicated resources of 169 tU.

Undiscovered conventional resources (prognosticated and speculative resources)

Based on general prospection during 1980 to 2008, 27 617 tU are classified as undiscovered conventional resources in the prognosticated resource category. This includes the Kawat area (15 137 tU) and some sectors in the Kalan area (12 481 tU).

Kawat area

The Kawat area is located in Mahakam River upstream from East Kalimantan. Uranium mineralisation potential is in volcanic-related type structure striking N 90 E and surrounding the volcanic vent. Uranium is hosted in rhyolitic rock of Nyaan Volcanic Formation. The Kawat area is divided into the Kawat sector, Paluq sector and Nyaan sector. Resources calculation from Kawat sector includes 9 247 tU and calculation from the Paluq and Nyaan sectors includes 5 890 tU, all reported as prognosticated resources.

Kalan area

The Kalan area is located in Melawi, West Kalimantan. The uranium mineralisation potential is of metamorphite-type. Metasiltstone and metapelite schists, members of the Melawi Formation are favourable hosts for the uranium mineralisation. Barren metapelite andalusite and metapelite biotite rocks surround these favourable areas. Speculative resources in this area were obtained from the Tanah Merah sector (525 tU), Jumbang sector (3 336 tU), Prembang Kanan (206 tU), Dendang Arai sector (118 tU), Bubu sector (93 tU), Ririt sector (8 tU) and Mentawa sector (8 194 tU).

Unconventional resources and other materials

Based on general prospection to discover new uranium resources, 25 860 tU were added as unconventional resources from the Bangka Belitung and West Kalimantan Provinces.

Bangka Belitung Province

Uranium potential in this area is associated with monazite. Naturally, monazite rich alluvium is together with tin mineral. Because of tin mining, uranium is also found as a slag in tin mineral smelter. Uranium resources from monazite in alluvium deposit have been calculated as much as 22 830 tU, while uranium resources from tin slag have been calculated as much as 2 407 tU.

West Kalimantan Province

Uranium accumulation potential in this area is located in Semelangan, Ketapang area. Uranium resources are associated with monazite in alluvium deposit. The deposit in this area has similarities with the Bangka Belitung deposit. Unconventional uranium resources from this area have been estimated at 624 tU.

Uranium exploration and development expenditures and drilling effort – domestic

(Indonesian rupiah [IDR])

	2012	2013	2014	2015 (expected)
Government exploration expenditures	2 610 215 235	4 850 000 000	1 209 137 000	5 584 420 000
Total expenditures	**2 610 215 235**	**4 850 000 000**	**1 209 317 000**	**5 584 420 000**
Government exploration drilling (m)	-	1 500	375	2 000
Government exploration holes drilled	-	5	2	20
Subtotal exploration drilling (m)	-	1 500	375	2 000
Subtotal exploration holes drilled	-	5	2	20
Total drilling (m)	**-**	**1 500**	**375**	**2 000**
Total number of holes drilled	**-**	**5**	**2**	**20**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Metamorphite	0	2 005	7 031	7 031
Total	**0**	**2 005**	**7 031**	**7 031**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	2 005	7 031	7 031	75
Total	**0**	**2 005**	**7 031**	**7 031**	**75**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	2 005	7 031	7 031	75
Total	**0**	**2 005**	**7 031**	**7 031**	**75**

* In situ resources.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Metamorphite	0	0	2 540	2 540
Total	**0**	**0**	**0**	**2 540**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	0	2 540	75
Total	**0**	**0**	**0**	**2 540**	**75**

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	0	2 540	75
Total	**0**	**0**	**0**	**2 540**	**75**

* In situ resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	27 617

Iran (Islamic Republic of)

Uranium exploration and mine development

Historical review

Exploration

In 1935, the first occurrence of radioactive minerals was detected in the Anarak mining region. In 1959 and 1960, through co-operation between the Geologic Survey of Iran (GSI) and a French company, preliminary studies were carried out in Anarak and Khorassan (central Iran and Azarbaijan regions) in order to evaluate the uranium mineralisation potential.

Systematic uranium exploration in Iran began in the early 1970s in order to provide uranium ore for planned processing facilities. Between 1977 and the end of 1978, one-third of Iran (650 000 km^2) was covered by terrain clearance airborne geophysical surveys. Many surficial uranium anomalies were identified and follow-up field surveys have continued to the present. The airborne coverage is mainly over the central, south-eastern, eastern and north-western parts of Iran. The favourable regions studied by this procedure are the Bafq-Robateh Posht e Badam region (Saghand, Narigan, Khoshumi), Maksan and Hudian in south-eastern Iran and Dechan, Mianeh and Guvarchin in Azarbaijan. Outside of the airborne geophysics coverage area, uranium mineralisation at Talmesi, Meskani, Kelardasht and the salt plugs of south Iran are also worthy of mention.

Mine development

Feasibility studies and basic engineering designs (1994-1995) and mining preparation reports (1996) led to construction of administration and industrial buildings and equipment supply (1997-1998). Shafts No. 1 and No. 2 were sunk (1999 to 2002) and underground development of the Saghand mine began in 2003.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration activities

According to comprehensive planning, exploration activities within recognised favourable areas are being performed in different phases (i.e. reconnaissance to detailed phase). The reconnaissance and prospecting phases are being accomplished in central, southern, eastern, north-eastern and north-western provinces of the country. Since uranium mineralisation with positive indications has been found in various geological environments, uranium exploration activities are being conducted for a number of different types of deposits, such as granite-related, intrusive and surficial types, and an extensive part of the country has been explored as part of a reconnaissance phase with many favourable areas suited for the prospecting phase.

At present, prospecting and general exploration is being undertaken in different parts of the country for granite-related, intrusive and sedimentary-type deposits, for example in the north-eastern, central and Kerman province.

Mine development activities

At present, the development of mines No. 1 and 2 is being carried out in the Saghand ore field. In mine No. 1, based on the basic and detailed design, open-pit method is being used to access orebodies to a specified level, through overburden stripping. Ore at mine No. 2 is being extracted by an underground method. For this purpose two shafts (main and ventilation shafts) have been sunk and the adits are being drilled. Also some stopes are being developed at different levels for ore production.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Based on exploration activities completed during 2013 and 2014, a total of 368 tU has been added to RAR since the last report and total RAR is 1 390 tU. The resources are related to metasomatite, surficial, granite-related and metamorphite-type deposits.

Changes in inferred resources have occurred as a result of new small discoveries, most of which are volcanic-related. Some inferred resources were moved to the RAR category following additional studies. The total inferred resources as of 1 January 2015 is 3 134 tU.

Undiscovered conventional resources (prognosticated and speculative resources)

Kerman-Sistan mineralisation trend

The uranium mineralisation potential in this trend is of volcanic-related, metasomatic and granite-related type and at present, exploration studies are being conducted on favourable areas. Considering the potential of these areas, some of them are expected to be selected for further exploration.

Naiin-Jandagh mineralisation trend

The uranium mineralisation potential is of granite-related and volcanic-related type and is polymetallic. The surficial studies are being undertaken on favourable areas. If results are positive, further exploration will be performed on subsurface.

Birjand-Kashmar mineralisation trend

The uranium mineralisation potential is of sedimentary, granite-related and volcanic-related type. The surficial studies are being conducted on favourable areas. If favourable results are obtained, further exploration, including borehole drilling and logging will be undertaken.

Salt plugs in south of Iran

Exploration of many salt plugs have been performed in south of Iran, favourable findings have resulted in the selection of favourable plugs for further exploration activities. In Band-e Moallem salt plug, the general exploration via geological, geophysical surveys and trenching is being done. In case of obtaining good results from surficial studies, further exploration including shallow borehole drilling and logging will be done.

Unconventional resources

Recent studies have identified favourable areas of the country for investigation of the potential for unconventional resources. This includes phosphate rocks, non-ferrous ores, ferrous ores, carbonatite and black shales. Speculative resources, with an unassigned cost category amount to approximately 53 000 tU.

Uranium production

Historical review

Uranium ore recovered by open-pit mining of the Gachin salt plug has been processed at Bandar Abbas uranium plant since 2006.

Status of production facilities, production capability, recent and ongoing activities and other issues

Iran's only operating production centre (Bandar Abbas uranium plant) began operating in 2006 with an annual production capacity of 21 tU. Operations began at lower production levels processing Gachin ore. A second production facility near the town of Ardakan, with an annual production capacity of 50 tU, is under construction with production expected to begin in 2015. It will be supplied with ore from the Saghand uranium mine.

Ownership structure of the uranium industry

The owner of uranium industry is the government of Iran and the operator is the Atomic Energy Organisation of Iran (AEOI).

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	**Centre #2**
Name of production centre	Gachin	Ardakan
Production centre classification	Existing	Committed
Date of first production	2006	2015
Source of ore:		
Deposit name(s)	Gachin	Saghand
Deposit type(s)	Salt plug	Metasomatite
Recoverable resources (tU)	100	900
Grade (% U)	0.08	0.0553
Mining operation:		
Type (OP/UG/ISL)	OP	10% OP, 90% UG
Size (tonnes ore/day)	70	400
Average mining recovery (%)	80	80
Processing plant:		
Acid/alkaline	Acid	Acid
Type (IX/SX)	SX	IX
Size (tonnes ore/day)	70	400
Average process recovery (%)	90	90
Nominal production capacity (tU/year)	21	50
Plans for expansion	Yes	Yes

Future production centres

In addition to the currently operating Bandar Abbas uranium plant production centre, a production centre in Ardakan is at pre-commissioning stage and is expected to come into operation in 2015. In addition, feasibility studies for the planning of two new production centres for the Narigan and Khoshoumi uranium deposits is underway.

Uranium exploration and development expenditures and drilling effort – domestic

(IRR millions [Iranian rial])

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	635 700	620 000	608 056	1 604 840
Industry* development expenditures	0	0	0	0
Government development expenditures	369 989	450 000	670 500	550 000
Total expenditures	**1 005 689**	**1 070 000**	**1 278 556**	**2 154 840**
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Government exploration drilling (m)	47 010	45 280	29 906	50 000
Government exploration holes drilled	420	763	410	550
Government exploration trenches (m)	583	2 679	406	400
Government exploration trenched (number)	67	140	18	20
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	47 010	45 280	29 906	50 000
Subtotal exploration holes drilled	420	763	410	550
Subtotal development drilling (m)	0	0	0	0
Subtotal development holes drilled	0	0	0	0
Total drilling (m)	**47 010**	**45 280**	**29 906**	**50 000**
Total number of holes drilled	**420**	**763**	**410**	**550**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related	0	0	653	653
Metamorphite	0	0	136	136
Metasomatite	0	0	491	491
Surficial	0	0	110	110
Total	**0**	**0**	**1 390**	**1 390**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	491	491	85-90
Unspecified	0	0	653	653	85-90
Open-pit mining (OP)	0	0	246	246	85-90
Total	**0**	**0**	**1 390**	**1 390**	**85-90**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	491	491	85-90
Conventional from OP	0	0	110	110	85-90
Heap leaching** from OP	0	0	136	136	
Unspecified	0	0	653	653	85-90
Total	**0**	**0**	**1 390**	**1 390**	**85-90**

* In situ resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related	0	0	479	479
Metamorphite	0	0	25	25
Volcanic-related	0	0	120	120
Metasomatite	0	0	2 510	2 510
Surficial	0	0	0	0
Total	**0**	**0**	**3 134**	**3 134**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	876	876	85-90
Open-pit mining (OP)	0	0	0	0	85-90
Unspecified	0	0	2 258	2 258	85-90
Total	**0**	**0**	**3 134**	**3 134**	**85-90**

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	876	876	85-90
Conventional from OP	0	0	0	0	
In situ leaching acid	0	0	0	0	
In situ leaching alkaline	0	0	0	0	
In-place leaching**	0	0	0	0	
Heap leaching*** from UG	0	0	0	0	
Heap leaching*** from OP	0	0	0	0	
Unspecified	0	0	2 258	2 258	85-90
Total	**0**	**0**	**3 134**	**3 134**	**85-90**

* In situ resources.

** Also known as stope leaching or block leaching.

*** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	12 400	12 400

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	32 700

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Metasomatite	0	0	0	0	0	25
Surficial	22.6	24.4	8	11.3	66.3	10
Total	**22.6**	**24.4**	**8**	**11.3**	**66.3**	**35**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	22.6	24.4	8	11.3	66.3	10
Underground mining[1]	0	0	0	0	0	25
In situ leaching	0	0	0	0	0	0
Co-product/by-product	0	0	0	0	0	0
Total	**22.6**	**24.4**	**8**	**11.3**	**66.3**	**35**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	25.5	24.4	8	11.3	66.3	35
In-place leaching*	0	0	0	0	0	0
Heap leaching**	0	0	0	0	0	0
U recovered from phosphate rocks	0	0	0	0	0	0
Other methods***	0	0	0	0	0	0
Total	**25.5**	**24.4**	**8**	**11.3**	**66.3**	**35**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
11.3	100	0	0	0	0	0	0	11.3	100

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	350	500	500	600
Employment directly related to uranium production	150	145	135	350

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	3.89	3.72

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	35	N/A	N/A	90	118

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Installed nuclear generating capacity to 2035

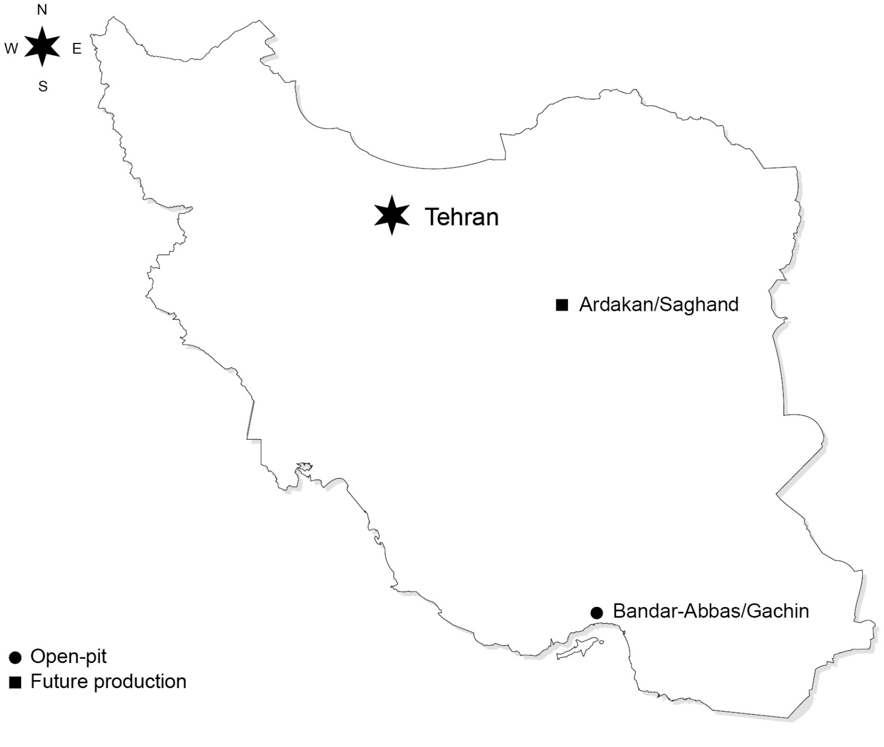
(MWe net)

2013	2014	2015		2020		2025		2030		2035	
915	915	Low	High	Low	High	Low	High	Low	High	Low	High
		915	915	915	915	2 815	5 075	6 975	7 925	N/A	N/A

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
160	160	Low	High	Low	High	Low	High	Low	High	Low	High
		160	160	160	160	490	910	1 230	1 390	N/A	N/A



Iraq

Uranium exploration and mine development

Historical review

Exploration

Uranium resources occur in sedimentary carbonate-hosted mineralisation in the Abu Skhair uranium deposit which was discovered accidently in 1977 when the gamma-log of a well, drilled in the Abu Skhair region for a groundwater survey, showed anomalous radiation at a depth of 70 m within the carbonate rocks of the Early Miocene Euphrates formation.

The Abu Skhair uranium deposit is important for two main aspects: first, it is the only uranium deposit that has undergone systematic exploration, assessment, extraction processing and underground mining and second, it is a unique type of uranium deposit associated with carbonate rocks, both syngenetically and epigenetically. However, being of a very low grade, it is not considered to have economic value.

Uranium also occurs in association with phosphorite. The first discovery was made in the early 1950s with a car-born radiometric survey along the Baghdad-Amman highway. Extensive work on the phosphorites was carried out by GeoSurv Ltd from 1986-1990. The uranium content ranges from 20 to 45 ppm and the corresponding P_2O_5 content ranges from 12 to 23%.

The Akashat phosphorite deposit was discovered by an Iraqi geologist in 1965 and production began in 1983 to feed the fertiliser plant at the Al-Qaim area.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration activities

There have been no exploration or development activities in Iraq since 1990.

Uranium resources

Undiscovered conventional resources (prognosticated and speculative resources)

There have been no calculations made of the conventional resources in the Abu Skhair deposit which is a carbonate-hosted deposit with contains on average 80 ppm U_3O_8.

Unconventional resources

The unconventional resources in Iraq occur in phosphates with total phosphate resources amounting to 9.5 billion metric tonnes with uranium contents ranging from 20 to 45 ppm U.

Uranium production

No uranium production has been reported from Iraq.

Italy

Uranium exploration and mine development

Historical review

The first uranium deposit, the volcanogenic Permian Novazza, was discovered in the Orobic Alps (Lombardia region, province of Bergamo) as a result of exploration from 1954 to 1962. A second deposit, Val Vedello, was also discovered in the same general area (Lombardia region, province of Sondrio) as a result of exploration from 1975 to 1983. Between 1985 and 1987, very limited exploration also took place on three uranium projects over a total area of 25.7 km^2. Agip Miniere also carried out joint venture exploration projects in Australia, Canada, the United States and Zambia prior to 1990. Since then, no exploration has taken place in Italy. Efforts by the Australian company Metex in 2006 to restart exploration of the Novazza deposit were unsuccessful due to local public resistance.

Plans to construct the Valvenova uranium production centre (260 tU/yr) in the 1980s were never realised. No uranium exploration and/or mine development activity is currently underway either domestically or abroad.

Recent and ongoing uranium exploration and mine development activities

Renewed interest in exploration of deposits in the Orobic Alps has been reported by Australian-Italian companies.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

There are no changes to the uranium resource figures presented in the 1991 edition of this publication. These estimates were made in 1987.

Unconventional resources and other materials

None reported.

Uranium requirements

Requirements had been estimated to comply with the national nuclear programme objective of 25% electricity generation from nuclear at 2030, corresponding to some 13 GWe net nuclear power fleet to be installed (reference case). However, following the March 2011 nuclear accident at the Fukushima Daiichi NPP in Japan, the Italian government established a one-year moratorium for the nuclear national programme. In a referendum held on 13-14 June 2011, voters strongly rejected all of the four initiatives promoted by the government, including the 2009 legislation that set up arrangements to build and operate new NPPs in the country. While excluding demand for uranium from the Italian market, the referendum results do not prevent exploration and development of uranium extraction projects.

Supply and procurement strategy

Not defined.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Italy currently has no operating NPPs, having shut down three operational reactors by 1990, following the results of a referendum in 1987. However, in 2004, the government made the first step towards reconsidering nuclear power by issuing a new energy law that opened up the possibility of making joint ventures with foreign companies in relation to NPPs abroad and importing electricity from them.

A second more decisive step was set in May 2008 when the then pro-nuclear Italian government confirmed that it would start building new NPPs within five years in order to diversify the energy mix, reduce the country's great dependence on oil, gas and imported electricity and to curb greenhouse gas emissions. At that time nuclear power was foreseen as a key component of the new energy policy which by 2030 aimed to have 25% of electricity generated by nuclear power together with 50% by fossil fuels and 25% by renewable energy sources.

Comprehensive economic development legislation was passed in July 2009 when the government introduced a complete package of legislation for nuclear power, a fundamental step in the revival of the technology. This package included measures to set up a national nuclear regulatory agency, expedite the licensing of new reactors at existing NPPs and new greenfield sites and to reorganise the national nuclear research and development entity.

In January 2010, provisions for public consultation were announced and the draft decree set out financial benefits for cities and regions hosting NPPs (EUR 3 000/MWe/yr during construction and 40 cm/MWh during operation). Further legislation in February 2010 set out a framework for siting of NPPs, involving local governments. For NPPs and fuel cycle facilities, a so-called "unique authorisation" would be required for construction, as well as an environmental permit. In November 2010, the Constitutional Court had overturned a bid by three regions (Puglia, Campania and Basilicata) to ban nuclear plants from their territory due to strong public opposition.

In January 2011, the Constitutional Court ruled that Italy could hold a referendum on the planned reintroduction of nuclear power, as proposed by an opposition party – www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Italy/#. The question posed in the referendum, held later in the year, was whether voters wanted to cancel most of the legislative and regulatory measures which had been taken by the government over the previous three years to make possible the construction and operation of new NPPs in the country.

Immediately following the Fukushima Daiichi accident, the government declared a one-year moratorium on nuclear development plans and through a law decree stated the abrogation of some specific articles of the nuclear legislation package (approved by parliament at the end of May), with the intent of carrying out a reconsideration of the national energy strategy on the basis of the results from the stress test programme established by the EU and other input from competent international institutions. The referendum was held on 13-14 June 2011 and voters strongly rejected all four initiatives promoted by the government, including the 2009 legislation that set up arrangements to build and operate new NPPs. Although a strong majority voted to cancel plans for building new NPPs, the results of the referendum do not affect plans for the development of a national waste repository, the so-called "Technological Park", the national nuclear research and development entity, the nuclear regulatory agency and mineral exploration activities. The referendum result is binding for five years. This situation is similar to the one following the 1987 referendum that was held in the aftermath of the Chernobyl accident.

A National Energy Strategy (SEN) was submitted for public consultation in 2012, mostly relying on fossil fuels, especially gas, as well as renewable energy sources and enhanced energy efficiency.

While a national nuclear programme is not required for uranium exploration and extraction projects, concerns about impacts on mountain ecosystems have to be taken into account.

A R&D praesidium on "new nuclear fission" was maintained within a three-year (2012 to 2014) Enea Ministry for Economic Development (MSE) programme agreement on electrical system research. This is aimed at knowledge development in system safety and innovations, emphasising lessons learnt from Fukushima Daiichi and co-operation in international programmes for generation IV closed-cycle systems (mostly lead-cooled fast reactor systems).

Research on nuclear safety and generation IV reactors (participation in international co-operation programmes) is planned to continue under the 2015-2017 Enea-MSE contract agreement, which is currently in the process of being approved.

Uranium stocks

None to report. A total of 1 641 tHM of spent fuel from shutdown NPPs has been sent abroad for reprocessing under the national decommissioning programme led by the Sogin management company (963.2 tHM up to 1 978 + 678 tHM after 1978).

Uranium prices

None to report.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Volcanic-related		4 800	4 800	4 800	72
Total		**4 800**	**4 800**	**4 800**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Volcanic-related		1 300	1 300	1 300	72
Total		**1 300**	**1 300**	**1 300**	

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
10 000	10 000	

Installed nuclear generating capacity to 2035*

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
		-	-	1 600	1 600	6 400	6 400	13 000	13 000	13 000	13 000

* Estimates based on nuclear development plans of the previous government that were rejected in a referendum in 2011.

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
		-	-	212	212	1 908	1 908	7 844	7 844	16 324	16 324

Note: Figures are cumulated amounts at end of the reference year in the table. Estimations are based on the following assumptions:

– 13 GWe net online by 2030, of which 1.6 GWe net online by 2020 and 6.4 GWe net online by 2025.

– Fuel burn-up: 60 GWd/t UO_2; fuel enrichment: 4.1% ^{235}U, tails assay: 0.3% ^{235}U; efficiency: 34.2%; capacity factor: 0.9.

Japan

Uranium exploration and mine development

Historical review

Domestic uranium exploration has been carried out by the Power Reactor and Nuclear Fuel Development Corporation (PNC) and its predecessor since 1956. About 6 600 tU of uranium resources were discovered in Japan before domestic uranium exploration activities were terminated in 1988. Overseas uranium exploration began in 1966 with activities carried out mainly in Australia and Canada, as well as other countries such as Niger, the People's Republic of China, the United States and Zimbabwe.

In October 1998, PNC was reorganised into the Japan Nuclear Cycle Development Institute (JNC). The Atomic Energy Commission decided in February 1998 to terminate uranium exploration activities in 2000 and JNC's mining interests and technologies were transferred to the private sector. In October 2005, the Japan Atomic Energy Agency (JAEA) was established by integrating the Japan Atomic Energy Research Institute and JNC.

In April 2007, the Japanese government decided to resume overseas uranium exploration activities with financial support provided by Japanese companies through Japan Oil, Gas and Metals National Corporation (JOGMEC). JOGMEC is carrying out exploration activities in Australia, Canada, Uzbekistan and other countries.

Recent and ongoing uranium exploration and mine development activities

Japan-Canada Uranium Co. Ltd, which took over JNC's Canadian mining interests, is continuing exploration activities in Canada while JOGMEC continues exploration activities in Australia, Canada, Uzbekistan and elsewhere. Japanese private companies hold shares in companies developing uranium mines and also with those operating mines in Australia, Canada, Kazakhstan and Niger.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

About 6 600 tU of reasonably assured resources recoverable at <USD 130/kgU have been identified in Japan.

Uranium production

Historical review

A test pilot plant with a capacity of 50 t ore/day was established at the Ningyo-toge mine in 1969 by PNC. The operation was ended in 1982 with total production amounting to 84 tU. In 1978, a leaching test consisting of three 500 t ore vats with a maximum capacity of 12 000 t ore/year was initiated to process Ningyo-toge ore on a small scale. The vat leaching test was terminated at the end of 1987.

Secondary sources of uranium

Production of mixed oxide fuels

Production facilities

The JAEA plutonium fuel plant consists of three facilities, the Plutonium Fuel Development Facility (PFDF), the Plutonium Fuel Fabrication Facility (PFFF) and the Plutonium Fuel Production Facility (PFPF).

The PFDF, constructed for basic research and the fabrication of test fuels, started operation in 1966. As of December 2014, approximately 2 tonnes of MOX fuel had been fabricated in the PFDF.

The PFFF had two MOX fuel fabrication lines, one for the experimental Jōyō fast breeder reactor (FBR line) with a capability of 1 tonne MOX/yr and the second for the prototype advanced thermal reactor Fugen (ATR line) with 10 tonnes MOX/yr fabrication capability. The FBR line started operations in 1973, producing the initial fuel load for the experimental Jōyō sodium-cooled fast reactor. FBR line fuel fabrication ended in 1988 and Jōyō fuel fabrication was switched to the PFPF. The ATR line started operations in 1972 with MOX fuel fabrication for the Deuterium Critical Assembly in JAEA's O-arai Research and Development Center. Fuel fabrication for ATR Fugen was started in 1975 and ended in 2001. MOX fuel fabrication in both lines amounted to a total of approximately 155 tonnes.

The PFPF FBR line, constructed to supply MOX fuels for the prototype Monju FBR and the experimental Jōyō FBR, has a production capability of 5 tonnes MOX/yr. The PFPF FBR line began operating in 1988 fabricating Jōyō fuel reloads. Fuel fabrication for the FBR Monju was started in 1989. As of December 2014, approximately 16 tonnes of MOX fuels had been fabricated in the PFPF.

Use of mixed oxide fuels

Monju prototype fast breeder reactor

Monju achieved initial criticality in April 1994 and began supplying electricity to the grid in August 1995. However, during a 40% power operation test of the plant, a sodium leak accident in the secondary heat transport system in December 1995 interrupted operation. After carrying out an investigation to determine the cause, a two-year comprehensive safety review and the required licensing procedure, the permit for plant modification (including countermeasures to reduce the likelihood of sodium leak accidents) was issued in December 2002 by the Ministry of Energy, Trade and Industry. JAEA completed a series of countermeasure modifications in May 2007, implemented a modified system function test until August 2007 and then conducted an entire system function test. The existing 78 slightly used and 6 newly fabricated fuel assemblies were loaded by 27 July 2009. Following the system start-up test, Monju was restarted on 6 May 2010. The core confirmation test was completed on 22 July 2010 and 33 freshly fabricated fuel assemblies were loaded by 18 August 2010. However, after refuelling, the in-vessel fuel transfer machine was dropped on 26 August 2010 and removed by 24 June 2011. JAEA is working on countermeasures against tsunami, station black-out and severe accidents on the basis of the severe Fukushima Daiichi accident. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) established the Monju research plan in September 2013. JAEA has also been preparing for the new safety standards that have been determined by the Nuclear Regulation Authority (NRA) in July 2013.

Experimental fast reactor Jōyō

The experimental fast reactor Jōyō attained criticality in April 1977 with the MK-I breeder core. As an irradiation test bed, the Jōyō MK-II core achieved maximum design output of 100 MW in March 1983. Thirty-five duty cycle operations and thirteen special tests with the MK-II core had been completed by June 2000. The MK-III high-performance irradiation core, with design output increased to 140 MW, achieved initial criticality in July 2003. Six duty cycle operations and four special tests with MK-III core were completed. The Jōyō net operation time reached around 70 000 hours and 588 fuel subassemblies were irradiated during MK-I, MK-II and MK-III core operations.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Japan has relatively scarce domestic uranium resources and therefore relies on overseas uranium supply. A stable supply of uranium resources is to be ensured through long-term purchase contracts with overseas uranium suppliers, direct participation in mining development and diversification of suppliers and countries.

With the exception of two reactors that have operated periodically since the severe accident at the Fukushima Daiichi NPP in March 2011, all remaining operational reactors in Japan that normally provide about 30% of electricity production have been progressively taken out of service during scheduled refuelling and maintenance outages. The number of reactor restarts, as well as the timing of the restarts, is uncertain. The establishment of a new, independent regulatory agency, regulations governing the safe operation of reactors and requirements for restart were established by mid-2013, prompting utilities to apply to restart a number of reactors, the first of which are expected to resume operations in 2015. Until the number of reactors to be restarted is better defined, Japanese uranium requirements remain uncertain.

Uranium exploration and development expenditures – non-domestic

(JPY million [Japanese yen])

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	N/A	N/A	N/A	N/A
Government exploration expenditures	426	345	375	375
Industry* development expenditures	N/A	N/A	N/A	N/A
Government development expenditures	0	0	0	0
Total expenditures	**N/A**	N/A	N/A	N/A

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	6 600	6 600
Total	**0**	**0**	**6 600**	**6 600**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	6 600	6 600	85
Total	**0**	**0**	**6 600**	**6 600**	**85**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	6 600	6 600	85
Total	**0**	**0**	**6 600**	**6 600**	**85**

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Sandstone	84	0	0	0	84	0
Total	**84**	**0**	**0**	**0**	**84**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	39	0	0	0	39	0
Underground mining[1]	45	0	0	0	45	0
Total	**84**	**0**	**0**	**0**	**84**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	45	0	0	0	45	0
Heap leaching*	39	0	0	0	39	0
Total	**84**	**0**	**0**	**0**	**84**	**0**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Mixed oxide fuel production and use

(tonnes natural U-equivalent)

Mixed oxide (MOX) fuel	**Total through end of 2011**	**2012**	**2013**	**2014**	**Total through end of 2014**	**2015 (expected)**
Production	684	0	0	0	684	N/A
Use	912	0	0	0	912	N/A
Number of commercial reactors using MOX		0	0	0		N/A

Reprocessed uranium use

(tonnes natural U-equivalent)

Reprocessed uranium	**Total through end of 2011**	**2012**	**2013**	**2014**	**Total through end of 2014**	**2015 (expected)**
Production	645	0	0	0	645	N/A
Use	215	0	0	0	215	N/A

Net nuclear electricity generation*

	2013	**2014**
Nuclear electricity generated (TWh net)	0	0

* Data from the 2015 edition of *OECD Nuclear Energy Data*.

Installed nuclear generating capacity to 2035

(MWe net)

2013	**2014**	**2015**		**2020**		**2025**		**2030**		**2035**	
44 269	42 442	Low	High	Low	High	Low	High	Low	High	Low	High
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Jordan

Uranium exploration and mine development

Historical review

In 1980, an airborne spectrometric survey covering the entire country was realised and by 1988 ground-based radiometric surveys of anomalies identified in the airborne survey were completed. From 1988 to 1990, Precambrian basement and Ordovician sandstone target areas were evaluated using geological, geochemical and radiometric mapping and/or surveys.

During the 1990s, reconnaissance and exploration studies revealed surficial uranium deposits distributed in several areas of the country, as described below:

- Central Jordan: exploration, including 1 700 trenches and over 2 000 samples were analysed for uranium using a fluorometer, revealed the occurrence of uranium deposits as minute mineral grains disseminated within fine calcareous Pleistocene sediments and as yellowish films of carnotite and other uranium minerals coating fractures of fragmented chalk or marl of Mastrichtian-Paleocene age. Results of channel sampling in three areas indicate uranium contents ranging from 140 to 2 200 ppm U_3O_8 (0.014% to 0.22% U_3O_8) over an average thickness of about 1.3 m, with overburden of about 0.5 m.
- Three uranium anomalous areas (Mafraq, Wadi Al-Bahiyyah and Wadi-SahabAlabyad) with promise for hosting uranium deposits were also covered by the reconnaissance studies.

In 2008, the Jordan Atomic Energy Commission (JAEC) was established, in accordance with the Nuclear Energy Law (Law No. 42) of 2007 and amendments of 2008. The JAEC is the official entity entrusted with the development and execution of the Jordanian nuclear power programme. The exploration, extraction and mining of all nuclear materials; including uranium, thorium, zirconium and vanadium is under the authority of JAEC.

The Nuclear Fuel Cycle Commission of JAEC is in charge of developing and managing all aspects of the nuclear fuel cycle; including uranium exploration, extraction, production, securing fuel supply and services, nuclear fuel management and radioactive waste management. The JAEC uranium policy is to maximise sovereignty while creating value from resources and to avoid concessions to foreign companies. To attract investors and operate on a commercial basis, JAEC created Jordan Energy Resources Inc. as its commercial arm.

In September 2008, JAEC signed an exploration agreement with Areva and created the Jordanian French Uranium Mining Company (JFUMC), a joint venture created to carry out all exploration activities leading to a feasibility study of developing resources in the central Jordan area. In January 2009, JAEC signed a Memorandum of Understanding (MoU) entitling Rio Tinto to carry out reconnaissance and prospecting in three areas (north of Al-Bahiyyah, Wadi SahbAlabiadh and Rewashid). Exploration activities by Jordanian teams in co-operation with the Chinese SinoU were carried out in two other areas (Mafraq and Wadi Al-Bahiyyah).

During 2009-2010, JFUMC started the first phase of the exploration programme in the northern part of the central Jordan licence area that included geological mapping, a carborne radiometric survey, drilling, trenching, sampling, chemical analyses, development of an environmental impact assessment and a hydrogeological study and building a database inventory.

Recent and ongoing uranium exploration and mine development activities

During 2013-2014, both Jordan Uranium Mining Company (JUMCO) and Jordan Energy Resources Inc. jointly carried out an exploration programme to evaluate the uranium resources within the top layer (0-5 m depth) in the central Jordan area. The exploration programme included: trenching (4-5 m deep), channel sampling (QA/QC), chemical analyses and JORC compliant resource estimation. During this period, 3 883 trenches were excavated (total length = 15 532 m) and channel samples were collected and chemically analysed (38 150 samples). During 2012, the uranium resources, utilising radiometric method, were estimated by Jordanian French Uranium Mining Company revealing 22 000 tU. The technical audit carried out by an international company indicated that there is an underestimation of the uranium resources especially within the surficial layer 5 m deep from the ground surface.

The radiometry chemical grade correlation formula was recalculated by an international expert.

In April 2014, the first JORC compliant report was prepared by an international team of world renowned experts.

The uranium resources within the surficial layer (0-5 m) were estimated utilising the trenching programme results, obtained from 1 967 trenches, excavated during the period (February 2013 to March 2014) and 19 685 channel samples collected and chemically analysed.

The uranium resources in the deep layer (i.e. deeper than 5 m) were estimated utilising the downhole gamma logs carried out previously by JFUMC (5 691 drill holes and 880 762 eU values) and using the recalculated regression formula.

The estimated tonnages and average grade values at 80 ppm eU cut-off were as follows:

- 9 100 tU at 0.0135% eU in the surficial layer;
- 21 800 tU at 0.0108%eU in the deep layer;
- total estimated tonnage in the central Jordan area: 30 900 tU.

The exploration plan for 2015 will be concentrated on the central Jordan area.

The trenching programme will be continued including trench excavation, channel sampling, chemical analyses of the collected samples and JORC compliant resource estimation. The trenching programme includes two programmes:

- the first programme includes trenching on a 200 m x 200 m grid to complete covering the whole area;
- the second programme includes trenching on 100 m x 100 m grid to cover selected mining areas to upgrade the resource category to conduct a pre-feasibility study;
- both programmes will be carried out simultaneously.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Central Jordan area

JORC compliant resource estimation indicated 30 900 tU as inferred resource (in situ).

Hasa-Qatrana area

In 2012, a preliminary resource estimation carried out in this area, covering seven mineralised zones, indicated a total resource of about 28 700 tU as inferred resource (in situ).

Undiscovered conventional resources (prognosticated and speculative resources)

No change (about 50 000 tU as speculative resources).

Unconventional resources and other materials

No change (about 100 000 tU in the phosphate deposits in the whole country).

Uranium production

Historical review

Jordan does not currently produce uranium. In 1982, a feasibility study for uranium extraction from phosphoric acid was completed by an engineering company (Lurgi A.G. of Frankfurt, Germany) on behalf of the Jordan Fertiliser Industry Company, company subsequently purchased by the Jordan Phosphate Mines Company. One of the extraction processes evaluated was originally found to be economically feasible, but as uranium prices dropped in the 1990s, the process became uneconomic and development of an extraction plant construction was deferred.

In 2009, SNC-Lavalin performed a technological and economic feasibility study, for the recovery of uranium from the phosphoric acid produced at the Aqaba Fertilizer Complex. This study has been performed jointly with Prayon Technologies SA. The profitability was evaluated to be 6.8% in terms of internal rate of return.

JAEC is currently conducting research to develop optimised extraction parameters:

- dynamic alkaline leaching of central Jordan ore revealed more than 80% recovery;
- small alkaline heap demonstration project is also being planned (few tons of ore);
- pilot-scale: 6 m high, 0.5 m diameter, 4-6 column extraction facility being designed and constructed for installation at the camp site.

Status of production capability

Jordan does not have firm plans in place to produce uranium.

Uranium requirements

In 2010, Jordan announced plans to pursue the development of civil nuclear power, stating its intention to have four units in operation by 2040. A number of nuclear co-operation agreements have been signed with a number of countries, including Canada, China, France, Japan, Korea, Russia and the United Kingdom. In 2011, it was reported that Jordan would be receiving bids from nuclear power plant vendors. Currently, the kingdom imports over 95% of its energy needs and disruptions in natural gas supply from Egypt have reportedly cost Jordanians more than USD 1 million a day.

Despite the need to generate electricity by other means, the accident at the Fukushima Daiichi nuclear power plant has created some local resistance to the plan to have one 700-1 200 MWe reactor operating by 2020 and a second unit of similar size by 2025. This has created some issues in site selection for the planned reactor construction.

Rosatom was selected as the preferred bidder to construct, build and commission two 1 000 MWe reactors. Rosatom will also serve as a partner and operator of the NPP, with a stake in the project of 49.9%.

Applying exclusion and discretionary criteria, a country-wide survey was carried out and selected a proposed site (2.5 km^2) for the construction of the NPP. Currently, detailed studies are being carried out to evaluate and characterise the selected site, as well as other studies related to the construction and operation of the NPP. These studies are expected to be finished in 24 months (end of 2016), following conclusion of these studies, a final decision will be made to begin construction.

National policies related to uranium

With Jordan's intention to develop a peaceful atomic energy programme for generating electricity and water desalination, JAEC reactivated uranium exploration in the country with the goal of achieving a degree of energy self-sufficiency.

Uranium exploration and development expenditures and drilling effort – domestic

(JOD [Jordanian dinars])

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	1 022 000	0	0	0
Government exploration expenditures	280 000	2 247 700	2 704 800	2 500 000
Industry* development expenditures	0	0	0	0
Government development expenditures	0	0	0	0
Total expenditures	**1 302 000**	**2 247 700**	**2 704 800**	**2 500 000**
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Industry exploration trenches (m)	36	0	0	0
Industry trenches (number)	9	0	0	0
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Government exploration trenches (m)	798	5 524	10 008	10 000
Government trenches (number)	101	1 381	2 502	2 500

* Non-government.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Surficial			59 600
Total			**59 600**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			59 600	59 600	
Total			**59 600**	**59 600**	

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified			59 600	59 600
Total			**59 600**	**59 600**

* In situ resources.

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	50 000	N/A

Kazakhstan

Uranium exploration

Historical review

Since the beginning of uranium exploration in 1944 in Kazakhstan, about 60 uranium deposits have been identified in six uranium ore provinces – Shu-Sarysu, Syrdarya, Northern Kazakhstan, Caspian, Balkhash and Ili.

By the late 1970s, unique deposits suitable for uranium mining by in situ leaching (ISL), such as Inkai, Mynkuduk, Moinkum, Kanzhugan and North and South Karamurun, were discovered.

Recent and ongoing uranium exploration and mine development activities

During 2013 and 2014, exploration was undertaken at Moinkum, Inkai, Budenovskoye in the Shu-Sarysu Uranium Province and in the Northern Kharasan and Bala-Sauskandykskoye deposits in the Syrdaria Uranium Province.

JV Katco continues exploration at site No. 2 (Tortkuduk) of the Moinkum deposit and has started ISL pilot mining.

JV Inkai continues exploration at site No. 3 of the Inkai deposit including ISL pilot production.

The Akbastau JSC has completed the exploration at sites No. 1 and No. 3 of the Budenovskoye deposit and it continues ISL pilot production at site No. 4 of the Budenovskoye deposit.

The Kyzylkum LLP and the Baiken-U LLP are performing exploration at the Northern Kharasan deposit.

Exploration on Zhalpak deposit was restarted in 2015. In 2014, NAC Kazatomprom JSC and Taukent Mining Chemical Plant LLP started ISL test mining at the site No. 3 (Central) Moinkum deposit.

In 2015, NAC Kazatomprom JSC started exploration on the new part of the Budenovskoye deposit, sites No. 6 and No. 7. Prognosticated resources there are about 70 000 tU.

Because of the absence of a commercial discovery, the current licence JV Zarechnoye JSC has stopped on the South Zarechnoye deposit.

The Volkovgeology JSC renewed geological prospecting of sandstone-type deposits amenable for ISL mining in new perspective areas of the Shu-Sarysu uranium provinces, with funding from the NAC Kazatomprom JSC budget.

The exploration in 2013-2014 resulted in an increase of identified resources by 125 232 tU, including an increase of reasonably assured resources by 34 471 tU and of inferred resources by 90 761 tU because of resources reclassified from prognosticated. These resource increases occurred at the Budenovskoye (sites No. 1, No. 3, and No. 4), Inkai (sites No. 3), Moinkun (site No. 3) and Northern Kharasan (site Kharasan-2) deposits.

The company Balausa LLP discovered a new uranium-vanadium mineralisation, the Bala-Sauskandykskoye deposit, during the reporting period. Inferred uranium resources are reported as 1 874 tonnes U and uranium grade is about 0.0031%.

No uranium exploration and development was performed by Kazakh enterprises outside of Kazakhstan.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2015, identified uranium resources recoverable at a cost less USD 260/kgU amounted to 1 072 933 tU, including 759 886 tU of resources amenable for ISL recovery. The resource estimates are "net" and depletion is taken into consideration.

In 2013-2014, a total of 45 330 tU was produced by ISL. Considering losses during mining (5 778 tU or 11%), 51 108 tU of resources were depleted (45 558 tU – reasonably assured and 5 550 tU – inferred).

Underground mining at the Vostok and Zvezdnoye deposits was stopped.

Identified uranium resources increased by 125 232 tU as a result of geological exploration in sandstone deposits from 2013-2014. An increase of 34 471 tU is reported for reasonably assured resources. A total of 90 761 tU were transferred from prognosticated resources to inferred resources, including 1 874 tonnes of uranium from the associated minerals at the uranium-vanadium deposit.

Although there were no significant changes in cost categories, a change in production cost of sandstone resources occurred because lower cost resources increased.

All of Kazakhstan's RAR plus IR recoverable at <USD 40/kgU are associated with existing and committed production centres, whereas 95% recoverable at <USD 80/kgU are in existing and committed production centres, 86% recoverable at <USD 130/kgU are in existing and committed production centres and 67% recoverable at <USD 260/kgU are in existing and committed production centres.

Undiscovered conventional resources (prognosticated and speculative resources)

Re-evaluation of prognosticated and speculative resources was done in the reporting period.

The majority (234 053 tU) of the total of 235 583 tU of prognosticated resources are related to sandstone deposits, while the remaining 2 000 tU are metasomatite deposits. Of the 300 000 tU of speculative resources, 90% are related to sandstone deposits and 10% to unconformity-related or metasomatite deposits.

Prognosticated resources assessment methodology of uranium sandstone deposits for ISL production is based on a linear productivity (amount of uranium per unit length of the border zone of formation pinching out oxidation) and considering reduction factors that take into account the variability of linear productivity, intermittency and variability of mineralisation width of the ore zone.

Unconventional resources and other materials

Estimates are not made of Kazakhstan's unconventional uranium resources and other materials.

Uranium production

Historical review

The growth of uranium production in Kazakhstan is connected with the discovery of sandstone-type deposits of uranium, suitable for ISL mining, which is one of the cheapest methods of uranium mining and has a minimal impact on the environment.

Uranium production in Kazakhstan over the past 15 years has increased 15-fold from 1 500 to 22 800 tonnes of uranium per year.

Production capability and recent and ongoing activities

In 2013-2014, uranium production was 45 294 tonnes.

Uranium was mined at the Kanzhugan, Moinkum, Akdala, Uvanas, Mynkuduk, Inkai, Budenovskoye, North and South Karamurun, Irkol, Zarechnoye, Semizbay, Northern Kharasan deposits. All uranium deposits were mined by in situ leaching acid.

Northern Kazakhstan uranium province

Stepnogorsk Mining Chemical Complex LLP stopped production at the Vostok and Zvezdnoe deposits and the mine was closed. Semizbay-U LLP operates the Semizbay deposit by in situ leaching acid.

Shu-Sarysu uranium province

The Uvanas, Mynkuduk (Eastern and Central sites), Kanzhugan, Moinkum (the southern part of site No. 1) deposits are operated by NAC Kazatomprom JSC through the Stepnoye Mining Group LLP, Ortalyk LLP and Taukent Mining Chemical Plant LLP enterprises.

JV Katco LLP takes part in the operation of the Moinkum deposit (northern part of sites No. 1 and site No. 2). JV Inkai LLP operates the Inkai deposit (sites No. 1 and 2), and Appak LLP develops the Western site of the Mynkuduk deposit.

JV Akbastau JSC operates deposit Budennovskoye (sites No. 1 and No. 3), Karatau LLP develops the Budenovskoye deposit (site No. 2), and performs processing of solutions extracted from the sites No. 1 and No. 3 of Budennovskoye deposit.

The Akdala and Inkai (site No. 4) deposits are operated by JV South Mining Chemical Company LLP from October 2014, processing is carried out by Betpak-Dala LLP.

Syrdarya uranium province

The North and South Karamurun deposits are operated by NAC Kazatomprom JSC through the Mining Group-6 LLP.

JV Zarechnoye JSC develops Zarechnoye deposit, the licence for the South Zarechnoye deposit ceased operation because of a lack of commercial discovery in November 2013.

The Irkol deposit was developed by Semizbay-U LLP and Baiken-U LLP carries out uranium production at the Northern Kharasan (site Kharasan-2) deposit.

Khorasan-U LLP completed the test production and started commercial production at the Northern Kharasan (site Kharasan-1) deposit. The licence referred to the Khorasan-U LLP in October 2014, processing is carried out by Kyzylkum LLP.

As of 1 January 2015, the total capacity of uranium production centres in Kazakhstan is 24 000 tU/yr.

Uranium production at ISL mines in Kazakhstan is carried out using sulphuric acid to produce pregnant uraniferous solutions. Further processing of pregnant solutions using ion-exchange sorption-elution technologies produces a uranyl salts precipitate that, with further extraction refining, results in the production of natural uranium concentrate.

A number of mining enterprises (Appak LLP, Karatau LLP, JV Betpak-Dala LLP, Inkai LLP, Baiken-U LLP) obtain natural uranium concentrate by sedimentation of uranium using hydrogen peroxide and further calcination without an extraction stage.

The company Balausa LLP is developing the uranium-vanadium Bala-Sauskandykskoye deposit by open-pit mining. By-product uranium from mining amounting to about 0.3 tU is not processed.

Ownership structure of the uranium industry

In 2014, the state share of uranium production in Kazakhstan was 60% (13 601 tU), including 37% from NAC Kazatomprom owing to its partnership in joint ventures and 23% – own production by NAC Kazatomprom, a 100% state-owned company, through the Samruk-Kazyna JSC national wealth fund.

In November 2013, there was a reorganisation of Mining Company LLP by joining the NAC Kazatomprom JSC, all mining licences passed to NAC Kazatomprom JSC.

The NAC Kazatomprom JSC includes the following production centres: Taukent Mining and Chemical Plant LLP, Stepnoye Mining Group LLP, Mining Group-6 LLP, and Ortalyk LLP, all of which produce uranium by ISL.

In 2014, NAC Kazatomprom had shares in 12 joint ventures with private companies from Canada, Japan and Kyrgyzstan (JV Inkai LLP, Appak LLP, Kyzylkum LLP, Khorasan-U LLP, Baiken-U LLP, JV Zarechnoe JSC), and with foreign state companies from China, Russia and France (Semizbai-U LLP, JV Katco LLP, JV Betpak-Dala LLP, YuGHK LLP, JV Akbastau JSC, Karatau LLP, JV Zarechnoe JSC, Kyzylkum LLP, Khorasan-U LLP).

The company Balausa LLP belongs to a foreign private company.

In 2014, the production share of private foreign companies in Kazakhstan amounted to 12%, while the share of state foreign companies in Kazakhstan amounted to 28% of total production.

Employment in the uranium industry

In connection with the reorganisation in 2013-2014, there was a decline in the production centres by 20%, while the employment directly related to uranium production increased by 18-19%.

Training for the uranium industry was conducted in 2013-2014 in two educational centres for skilled staff from the local community in Kyzylorda (Shieli village) and South Kazakhstan (Taukent village) areas in the locations of the production centres. The Kazakhstan Nuclear University, established on the basis of NAC Kazatomprom JSC, conducts training and skills development. The new uranium production centres are involved, as well as students of higher and technical secondary educational institutions of Kazakhstan.

According to the subsoil use licence, annual costs for training and retraining of staff is 1% of the annual cost of exploration in the exploration period and 1% of the annual operating costs for the period of uranium mining.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	Taukent Mining Chemical Plant LLP	Stepnoye Mining Group LLP	Mining Group-6 LLP	South Mining Chemical Company JV LLP	Katco JV LLP	Inkai JV LLP	Zarechnoe JV JSC	Karatau LLP
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Existing
Start-up date	1982	1978	1985	2001	2004	2004	2007	2007
Source of ore:								
Deposit name(s)	Kanzhugan, Moinkum (sites 1, 3)	Mynkuduk (Eastern site), Uvanas	North & South Karamurun	Akdala, Inkai (site 4)	Moinkum (sites 1, 2)	Inkai (sites 1, 2, 3)	Zarechnoye, South Zarechnoye	Budenovskoe (site 2)
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Recoverable resources (tU)	32 654	12 725	21 948	51 709	35 944	267 537	13 400	53 232
Grade (% U)	0.052	0.031	0.080	0.052	0.071	0.056	0.050	0.096
Mining operation:								
Type (OP/UG/ISL)	ISL	ISL	ISL	ISL	ISL	ISL	ISL	ISL
Size (tonnes ore/day)								
Average mining recovery (%)	87	90	91	90	87	80	94	90
Processing plant:								
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX/AL)	IX, SX	IX	IX	IX	IX	IX	IX	IX
Size (kilolitre/day)	85 000	60 000	60 000	160 000	140 000	80 000	80 000	50 000
Average process recovery (%)	98.9	98.7	98.7	98.9	98.9	98.9	98.5	98.9
Nominal production capacity (tU/year)	1 000	1 300	1 000	3 000	4 000	2 000	1 000	3 000
Plans for expansion	Yes	No	No	No	No	Yes	No	No
Other remarks								

Uranium production centre technical details *(cont'd)*

(as of 1 January 2015)

	Centre #9	Centre #10	Centre #11	Centre #12	Centre #13	Centre #14	Centre #15
Name of production centre	Ortalyk LLP	Appak LLP	Khorasan-U LLP	Bayken-U LLP	Akbastau JV JSC	Semyzbai-U LLP	NAC Kazatomprom JSC
Production centre classification	Existing	Existing	Existing	Existing	Existing	Existing	Committed
Start-up date	2007	2008	2008	2009	2009	2007	2016
Source of ore:							
Deposit name(s)	Mynkuduk (Central site)	Mynkuduk (Western site)	North Kharasan (site 1)	North Kharasan (site 2)	Budenovskoe (sites 1, 3, 4)	Semyzbai, Irkol	Zhalpak
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Recoverable resources (tU)	35 916	22 779	31 041	26 330	50 442	39 339	14 525
Grade (% U)	0.047	0.027	0.204	0.117	0.089	0.050	0.033
Mining operation:							
Type (OP/UG/ISL)	ISL	ISL	ISL	ISL	ISL	ISL	ISL
Size (tonnes ore/day)							
Average mining recovery (%)	90	90	90	90	90	87	90
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX/AL)	IX	IX	IX	IX	N/A	IX	IX
Size (kilolitre/day)	70 000	60 000	40 000	60 000	20 000	85 000	0
Average process recovery (%)	98.5	98.9	98.5	98.5	98.9	98.6	N/A
Nominal production capacity (tU/year)	2 000	1 000	1 000	2 000	500	1 200	0
Plans for expansion	No	No	Yes	No	Yes	No	Yes
Other remarks							

Future production centres

In October 2014, two new companies were formed: JV South Mining Chemical Company LLP with equity participation of NAC Kazatomprom JSC and Uranium One, for the development of the deposits Akdala and Inkai (site No. 4) and Khorasan-U LLP with equity participation of the group of Japanese companies, NAC Kazatomprom JSC and Uranium One, for the development of the Northern Kharasan deposit (site Kharasan-2). Processing capacity remained owned by enterprises Betpak-Dala LLP and Kyzylkum LLP. No new production centres have been established.

Once prospecting of promising areas of Shu-Sarysu and Syrdaria Uranium Provinces is completed, new ISL production centres may be established.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Mixed oxide (MOX) fuel is neither produced nor used in Kazakhstan.

Production and/or use of re-enriched tails

Uranium obtained through re-enrichment of depleted uranium tails is neither produced nor used in Kazakhstan.

Environmental activities and social cultural issues

Environmental activities

Subsoil users created a liquidation fund to eliminate the effects of operations on subsoil use in Kazakhstan. Contributions to the liquidation fund during the exploration and extraction of subsurface users are produced annually at a rate of at least 1% of the annual cost of exploration and production in a special deposit account in any bank in the state.

In 2013-2014, liquidation work in the uranium mines in Kazakhstan was not carried out.

In the framework of ecological policy in Kazakhstan, a number of measures to improve environmental protection and encourage rational use of natural resources have been implemented in recent years.

Each uranium venture in Kazakhstan realised a short-term waste management plan, which includes measures to reduce their generation and accumulation.

Environmental safety has a significant role in the effective functioning of the system of industrial environmental monitoring.

Social and/or cultural issues

All contracts for uranium exploration and mining provided by the government require financial contributions to local social and cultural improvements. All subsoil users are obliged to finance the establishment, development, maintenance and support of the regional social sphere, including health care facilities for employees and local citizens, education, sport, recreation and other activities in accordance with the Strategy of JSC NAC Kazatomprom and by an agreement with local authorities.

Contributions from each operator amount to:

- USD 30 000 to 100 000 per year (during the exploration period);

- up to 15% of annual operational expenses or USD 50 000 to 350 000 per year (during the mining period).

Expenditures on environmental activities and social cultural issues in 2013-2014

(KZT million)

	2013	2014	Total
Environmental impact assessments	35.0	51.6	86.6
Monitoring	272.0	299.2	571.2
Tailings impoundment	281.0	384.7	655.7
Waste rock management	219.0	184.7	403.7
Effluent management	66.2	50.2	116.4
Site rehabilitation	22.0	0.1	22.1
Regulatory activities	71.0	56.9	127.9
Social and/or cultural issues	1 961.0	2 508.0	4 469.0

Uranium demand

Internal demand for natural and enriched uranium is not expected in Kazakhstan until 2020. Construction of an NPP is under consideration.

Supply and procurement strategy

At present the entire volume of uranium produced in Kazakhstan is exported to the world market.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Since 2014, Kazakhstan has been working on the development of the Subsoil Use Code, as well as the implementation of standards of international reporting system on Mineral Resources CRIRSCO (Committee for Mineral Reserves International Reporting Standards).

Adoption of the Code allows the transformation of the sphere of subsoil use, bringing it to a qualitatively new level, raising efficiency and providing a comprehensive regulation which is systemic in nature, thus creating the conditions for long-term growth.

In 2015, a formal ceremony was held for the launching of the International Bank of low-enriched uranium in Kazakhstan with the IAEA signing of the Agreement on the establishment of the Bank. The event was held with the participation of the IAEA, including the Director-General, Yukiya Amano, and representatives from China, France, Germany, Russia, the United Kingdom and the United States.

Uranium exploration and development expenditures and drilling effort – domestic

(KZT million)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	13 697	9 154	4 724	8 180
Government exploration expenditures	0	0	0	0
Industry* development expenditures	373	2 442	1 639	238
Government development expenditures	0	0	0	0
Total expenditures	**14 070**	**11 596**	**6 363**	**8 418**
Industry* exploration drilling (m)	1 002 656	1 114 552	222 600	817 419
Industry* exploration holes drilled	2 056	2 230	395	1 896
Industry exploration trenches (m)	0	0	0	0
Industry trenches (number)	0	0	0	0
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Government exploration trenches (m)	0	0	0	0
Government trenches (number)	0	0	0	0
Industry* development drilling (m)	61 519	234 262	129 360	44 470
Industry* development holes drilled	213	601	408	159
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	1 002 656	1 114 552	222 600	817 419
Subtotal exploration holes drilled	2 056	2 230	395	1 896
Subtotal development drilling (m)	61 519	234 262	129 360	44 470
Subtotal development holes drilled	213	601	408	159
Total drilling (m)	**1 064 175**	**1 348 814**	**351 960**	**861 889**
Total number of holes drilled	**2 269**	**2 831**	**803**	**2 055**

* Non-government.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)	0	0	4 179	109 472	83
Open-pit mining (OP)	0	0	47 237	47 237	91
In situ leaching acid	43 206	257 677	257 677	257 677	89
In situ leaching alkaline	0	0	0	0	0
Co-product and by-product	0	0	0	0	0
Unspecified	0	0	0	0	0
Total	**43 206**	**257 677**	**309 093**	**414 386**	**88**

* In situ resources reported with recovery factors provided.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	4 179	109 472	83
Conventional from OP	0	0	47 237	47 237	91
In situ leaching acid	43 206	257 677	257 677	257 677	89
In situ leaching alkaline	0	0	0	0	0
In-place leaching**	0	0	N/A	N/A	N/A
Heap leaching*** from UG	0	0	N/A	N/A	N/A
Heap leaching*** from OP	0	0	N/A	N/A	N/A
Unspecified	N/A	N/A	N/A	N/A	N/A
Total	**43 206**	**257 677**	**309 093**	**414 386**	**88**

* In situ resources reported with recovery factors provided.

** Also known as stope leaching or block leaching.

*** A subset of open-pit and underground mining, since it is used in conjunction with them.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	0	0	0	0
Sandstone	43 206	257 677	271 027	271 027
Polymetallic Fe-oxide breccia complex	0	0	0	0
Paleo-quartz-pebble conglomerate	0			
Granite-related	0	0	0	0
Metamorphite	0	0	0	0
Intrusive	0	0	0	0
Volcanic-related	0	0	0	0
Metasomatite	0	0	8 882	84 742
Surficial	0	0	0	0
Carbonate	0	0	0	0
Collapse breccia-type	0	0	0	0
Phosphate deposits	0	0	29 184	29 184
Lignite-coal	0	0	0	0
Black shale	0	0	0	0
Total	**43 206**	**257 677**	**309 093**	**414 386**

* In situ resources reported.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	0	0	0	0
Sandstone	66 317	492 038	508 957	508 957
Polymetallic Fe-oxide breccia complex	0	0	0	0
Paleo-quartz-pebble conglomerate	0	0	0	0
Granite-related	0	0	0	0
Metamorphite	0	0	0	0
Intrusive	0	0	0	0
Volcanic-related	0	0	0	0
Metasomatite	0	0	10 776	131 671
Surficial	0	0	0	0
Carbonate	0	0	0	0
Collapse breccia	0	0	0	0
Phosphate	0	0	0	0
Lignite-coal	0	0	7 716	17 919
Black shale	0	0	0	0
Total	**66 317**	**492 038**	**527 449**	**658 547**

* In situ resources reported.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	4 896	135 994	83
Open-pit mining (OP)	0	0	18 471	18 471	91
In situ leaching acid	66 317	492 038	502 209	502 209	89
In situ leaching alkaline	0	0	0	0	0
Co-product and by-product	0	0	1 873	1 873	91
Unspecified	0	0	0	0	0
Total	**66 317**	**492 038**	**527 449**	**658 547**	**88**

* In situ resources reported with recovery factors provided.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	4 896	135 994	83
Conventional from OP	0	0	20 344	20 344	91
In situ leaching acid	66 317	492 038	502 209	502 209	89
In situ leaching alkaline	0	0	0	0	0
In-place leaching**	0	0	N/A	N/A	N/A
Heap leaching*** from UG	0	0	N/A	N/A	N/A
Heap leaching*** from OP	0	0	N/A	N/A	N/A
Unspecified	N/A	N/A	N/A	N/A	N/A
Total	**66 317**	**492 038**	**527 449**	**658 547**	**88**

* In situ resources reported with recovery factors provided.

** Also known as stope leaching or block leaching.

*** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
121 372	234 053	235 583

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
266 900	300 000	N/A

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	21 618	0	0	0	21 618	0
Underground mining[1]	42 260	259	30	0	42 549	0
In situ leaching	114 295	20 981	22 483	22 781	180 540	23 500
Co-product/by-product	0	0	0	0	0	0
Total	**178 173**	**21 240**	**22 513**	**22 781**	**244 707**	**23 500**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	41 898	211	0	0	42 109	0
In-place leaching*	0	0	0	0	0	0
Heap leaching**	362	48	30	0	440	0
In situ leaching	114 295	20 981	22 483	22 781	180 540	23 500
U recovered from phosphate rocks	21 618	0	0	0	21 618	0
Other methods***	0	0	0	0	0	0
Total	**178 173**	**21 240**	**22 513**	**22 781**	**244 707**	**23 500**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Proterozoic unconformity	0	0	0	0	0	0
Sandstone	114 295	20 981	22 483	22 781	180 540	23 500
Polymetallic Fe-oxide breccia complex	0	0	0	0	0	0
Paleo-quartz-pebble conglomerate	0	0	0	0	0	0
Granite-related	0	0	0	0	0	0
Metamorphite	0	0	0	0	0	0
Intrusive	0	0	0	0	0	0
Volcanic-related	0	0	0	0	0	0
Metasomatite	42 260	259	30	0	42 549	0
Surficial	0	0	0	0	0	0
Carbonate	0	0	0	0	0	0
Phosphate	21 618	0	0	0	21 618	0
Collapse breccia-type	0	0	0	0	0	0
Lignite and coal	0	0	0	0	0	0
Black shale	0	0	0	0	0	0
Other/unspecified	0	0	0	0	0	0
Total	**178 173**	**21 240**	**22 513**	**22 781**	**244 707**	**23 500**

Ownership of uranium production in 2014

Domestic				**Foreign**				**Totals**	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
13 601	60	0	0	6 445	28	2 735	12	22 781	100

Uranium industry employment at existing production centres

(person-years)

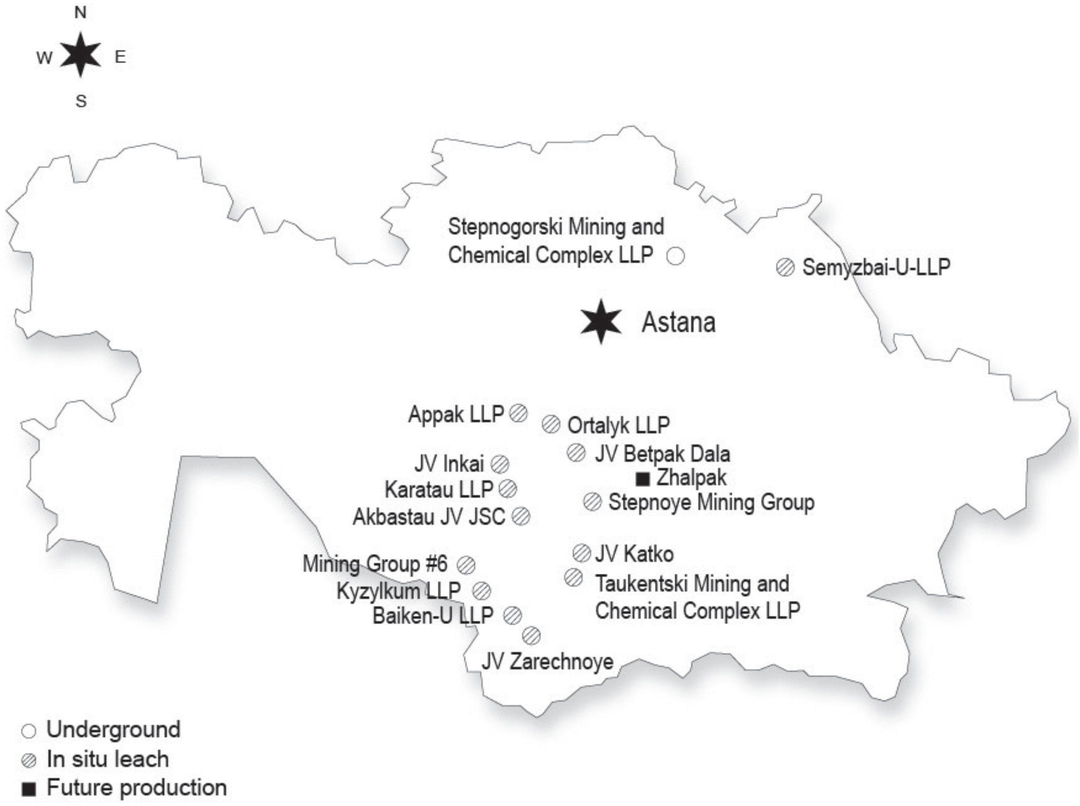
	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	9 760	7 682	7 728	8 010
Employment directly related to uranium production	5 809	6 874	6 915	7 146

Short-term production capability

(tonnes U/year)

2015				2020				2025			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
24 000	24 000	25 000	25 000	22 000	22 000	25 000	25 000	15 000	16 000	19 000	20 000

2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
10 000	11 000	14 000	15 000	4 000	5 000	8 000	9 000



Malawi*

Uranium exploration and mine development

Historical review

In the early 1980s, the Central Electricity Generating Board of Great Britain (CEGB) discovered mineralisation in the sandstones of Kayelekera. Extensive drilling from 1982 to 1988 defined an initial inferred resource of 9 800 tU at an average grade of 0.13% U.

From 1989 to 1992, geotechnical, metallurgical, hydrological and environmental works were conducted, as well as a feasibility study to assess the viability of a conventional open-pit mining operation. This work was completed in 1991 at a total cost of USD 9 million. The CEGB study concluded that the project was uneconomic using the mining model adopted and the low uranium prices of that time and so the project was abandoned in 1992.

In 1998, Paladin Resources Ltd (Paladin Energy Ltd as of 1 February 2000) acquired an interest in the Kayelekera Project through a joint venture with Balmain Resources Ltd, which at that time held exploration rights over the project area. Engineering and financial evaluation work indicated a positive outcome for the project. In 2004, additional drilling was completed to improve confidence in resource estimates, and the pre-feasibility study was updated. Resource drilling and bulk sample drilling for metallurgical test works were completed in 2005 and a bankable feasibility study was then undertaken. Paladin purchased Balmain's remaining stake in the project in 2005 and became the sole owner. The Kayelekera uranium deposit is a sandstone-hosted uranium deposit, located close to the north tip of the North Rukuru Basin. This basin contains a thick (at least 1 500 m) sequence of Permian Karoo sandstones preserved in a semi-graben about 35 km to the west of and broadly parallel to the Lake Malawi section of the East African Rift System.

The Kayelekera mineralisation lies within the uppermost 150 m of the Muswanga Member, which is the upper part of the Karoo Formation. The Muswanga Member consists of a total of eight separate arkose units with intervening silty mudstones in an approximate 1:1 ratio. Such a succession is indicative of cyclic sedimentation within a broad, shallow, intermittently subsiding basin. The arkose units contain most of the uranium mineralisation. They are on average about 8 m thick, are generally coarse grained and poorly sorted, and contain a high percentage of fresh, pink feldspar grains. The basal arkose units are usually a quartz-feldspar pebble conglomerate.

Coffinite has been identified as the principal uranium-bearing species and it occurs together with minor uraninite. Near-surface weathering of primary ore has produced a zone of oxide ore characterised by yellow and green secondary uranium minerals (meta-autunite and boltwoodite). Approximately 40% of the total ore occurs within reduced arkose, 30% within oxidised arkose, 10% in mixed arkose, and 20% is considered of the mudstone type.

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* Report prepared by the NEA/IAEA, based on previous Red Books and company reports.

Historical studies indicate that economically recoverable resources of uranium and coal only occur within the Kayelekera area. Coal is present in the project tenement area in two deposits: the Nkhachira deposit (850 000 tonnes, recoverable by open-pit and underground mining) and in association with the Kayelekera deposit. Coal in the Kayelekera deposit is associated with the uranium resources and is therefore unavailable for commercial extraction. Moreover, this coal is of very low quality.

In Malawi uranium exploration has increased in recent years as a result of expanding resources at the Kayelekera mine and the potential for discovery of additional deposits in a similar geological setting in the Karoo Group sedimentary rocks. Since 2010, Paladin Energy has completed exploration drilling in areas to the north-west and south of the mine area with objectives of extending the existing orebody, as well as identifying and evaluating new ore bodies, including Mpata to the east and Juma to the south.

The Livingstonia uranium project is a joint venture between two Australian companies, Resource Star and Globe Metals and Mining. The geological setting is very similar to that of Kayelekera. In 2006, Globe drilled 94 holes totalling 11 533 m. In July 2010, Resource Star did an additional 1 502 m of drilling in 13 holes to prove up a JORC compliant inferred resource of 7.7 million tonnes ore grading 0.0229% U. In 2013, Resource Star, the operator of the Livingstonia Project, has reported that thickened zones of mineralisation are open to the north-east, and the sparse drilling in the southern zone increases potential for additional mineralisation being defined. The mineralisation is also open to the north where the project adjoins tenements owned by Paladin Energy Ltd.

Another potential uranium resource is the Kanyika Niobium Project held by Globe Metals. Uranium is an important by-product in the complex polymetallic ore in a pegmatite quartz vein, hosted in Proterozoic felsic schists. Niobium and tantalum products would be produced with uranium and zircon as by-products. In 2011-2012, Globe Metals & Mining continued the development of the Kanyiba deposit. Total drilling, reverse circulation and diamond drilling, amounted to 40 540 m. As of December 2012, total resources amount to 68.3 Mt of ore at average grade of 0.28% Nb_2O_5, 0.0135% Ta_2O_5 and 0.0666% U (4 550 tU). Globe Metals & Mining submitted the environmental impact assessment for the Kanyika Niobium Project for public review in May 2012.

Recent and ongoing uranium exploration and mine development activities

The anticipated early approval by the Department of Mines of applications for five exclusive prospecting licences (EPLs), covering areas north, south and east of Kayelekera mine that would have enabled exploration activity to commence in July 2015, did not occur. The government of Malawi has imposed a moratorium on applications and grants of all mining and exploration tenements while it introduces a new cadastral system and a new minerals act. As a result, Paladin has suspended exploration activities in Malawi until there is clarity on the provisions of the new mining code and its EPL applications have been granted.

In 2013, Global Metals & Mining approved a demonstration plant to further optimise process design and reduce project risk of Kanyika Niobium Project. The focus of the pilot plant is to validate bench-scale testing results obtained during the optimisation phase of the Kanyika Definitive Feasibility Study, and also to validate engineering data for plant design. The Kanyika bulk sample is located at the Guangzhou Research Institute of Non-Ferrous Metallurgy (China) and the pilot plant is in progress. The mineral concentrate produced from this pilot plant exercise will be used for further downstream metallurgical testing and production of marketing samples. Preliminary samples have been collected and mineralogical work is currently underway at a metallurgical laboratory in Perth (Australia) to support optimisation efforts.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Malawi's total recoverable identified resource is 14 277 tU. This is based on resources at three locations: Paladin's Kayelekera operating mine (9 725 tU), Resource Star's Livingstonia deposit (1 822 tU) (both sandstone deposits), and Globe Metal's Kanyika niobium deposit (2 730 tU), where uranium will be produced as a by-product.

Uranium production

Historical review

The Kayelekera mine is located in the Karonga district of the northern region of Malawi, about 600 km by road from the capital city of Lilongwe. Transport of the first product to Walvis Bay, Namibia, via Zambia, took place on 17 August 2009. Uranium production is by open pit with an annual production of 1 270 tU planned with a mine life of nine years.

Uranium is recovered using a solvent extraction process, with sulphuric acid as the lixiviant and sulphur dioxide/air mixture as the oxidant. The plant utilises a resin-in-pulp (RIP) process which is a first in the Western world for uranium production. Expected uranium mill recovery is 90%. Production was hampered in 2009 and 2010 by technical problems with the RIP process. In addition, land slip problems in 2010 resulted in remediation work being implemented and made it necessary to relocate certain parts of the plant and machinery.

Kayalekera is the first mine to have produced uranium in Malawi and is currently the only producer. However, Globe Metals and Mining's Kanyika Niobium Project is planned to come on stream in 2014 and will produce about 60 tU/yr as a by-product.

Status of production facilities, production capability, recent and ongoing activities and other issues

In 2013, Kayelekera mine made progress on cost reductions, mainly on the acid supply front, where the project became acid independent through a number of measures. Improvements included increases in on-site acid production and the addition of the nano-filtration plant, which assisted with acid recycle. In addition to acid management, other improvements were realised in the milling, leach and RIP efficiencies, particularly with completion of modifications in the RIP section.

As a result of the sustained low uranium price, it was announced in February 2014 that processing would cease at Kayelekera and that the site would be placed on care and maintenance. Following a period of reagent run-down, processing was completed in early May 2014. This is expected to cost about USD 12 million per year, ongoing, compared with operating losses of double of that. It is expected that production will recommence once the uranium price provides a sufficient incentive (circa USD 75/lb) and grid power supply is available on-site to replace the existing diesel generators with low-cost hydroelectricity.

In 2013 and 2014, the Kayelekera mine produced 1 132 tU and 369 tU, respectively. Once uranium prices offer sufficient incentive for restart, production, with some RIP/elution upgrades, is expected to be up to 1 270 tU per year.

Ownership structure of the uranium industry

Two Australian companies, Paladin Energy and Resource Star, are active in Malawi in the primary uranium sector. Paladin holds an 85% interest in the Kayelekera Project through its subsidiary company Paladin (Africa) Limited. The remaining 15% is held by the Republic of Malawi according to terms of the Development Agreement signed in 2007.

Paladin supplements ongoing mining with extensive exploration activities aimed at growing its resource base in Malawi.

In 2010, Resource Star signed a joint venture agreement with Globe Metals and Mining over their Livingstonia Project, with Resource Star managing work and earning up to 80% equity. In May 2012, Resource Star announced that it would acquire 100% of the Livingstonia Project from Globe. The Malawi authorities approved the transfer of the exploration licence to Resource Star in November 2012 at which time Resource Star applied to the Malawi authorities for a two-year extension to the term of the Livingstonia tenement.

Global Metals is also involved in rare earth exploration with significant uranium by-product potential.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2
Name of production centre	Kayelekera	Kanyika
Production centre classification	Care and maintenance	Planned
Date of first production (year)	2009	N/A
Source of ore:		
Deposit name(s)	Kayelekera	Kanyika
Deposit type(s)	Sandstone	Intrusive
Recoverable resources (tU)	9 725	2 730
Grade (% U)	0.73	0.08
Mining operation:		
Type (OP/UG/ISL)	OP	OP
Size (tonnes ore/day)	4 000	6 000
Average mining recovery (%)	75	N/A
Processing plant:		
Acid/alkaline	Acid	N/A
Type (IX/SX)	SX	N/A
Average process recovery (%)	80	N/A
Nominal production capacity (tU/year)	1 270	60
Plans for expansion (yes/no)	Yes	
Other remarks	Ramp up to 1 460 tU/yr	By-product

Employment in the uranium industry

Paladin employed 759 people at the Kayelekera mine in 2012, of which 118 were expatriates and 68, or 9%, were female.

Future production centres

Globe Metals & Mining submitted the environmental impact assessment for the Kanyika Niobium Project for public review in May 2012. According to Globe, the aim of the project is to produce niobium and tantalum products with potential production of uranium and zircon. Uranium would be produced as a by-product at a nominal rate of 80 t $Na_2U_2O_7$

(ammonium di-uranate) per year (60 tU/yr). Mining will involve the extraction of ore from a single open pit at a rate of 1.5 to 3.0 million tonnes per annum using conventional open-pit drill and blast, followed by truck shovel load and haul. The final open-pit dimensions are expected to be in the order of 300 m wide, 2.2 km long (north-south) and 130 m deep. The project will produce approximately 52 million tonnes of solids to tailings over the mine life (estimated in excess of 20 years).

Environmental activities and socio-cultural issues

Paladin continues to fulfil its social development undertakings under the terms of the Kayelekera Mine Development Agreement. A programme to promote local involvement, economic growth and capacity building in communities is in progress. Opportunities are being explored for skills transfer and technical advice from Kayelekera's experienced workforce to local businesses.

Paladin is supporting the UK-based MicroLoan Foundation by funding an expansion of the foundation's activities in the Karonga region to provide micro-loans to 23 groups totalling around 300 local rural women for small-scale co-operative business ventures which will boost farming family incomes by encouraging expansion of small business initiatives.

Paladin engages formally with the Malawi government and with local communities via committees established for that purpose. These committees include the Government Liaison Committee (GLC), Karonga District Assembly and Kayelekera Village Elders.

Paladin continues to provide technical support and assistance to the Northern Region Water Board (NRWB) in the maintenance of the Water Supply Plant in Karonga. This project was constructed by Paladin in 2010 for a cost of approximately USD 10 million as part of its undertaking under the Development Agreement. Paladin funded a 400 m extension of the runway at Karonga Airport, in conjunction with the Malawi Department of Civil Aviation (DCA). This has enabled Paladin's aircraft to operate safely and has upgraded facilities for third party users by enabling larger aircraft to use Karonga Airport. Two reconditioned fire engines have been donated to DCA for use at the airport.

Karonga District Hospital (KDH) was identified as the local public service institution most in need of support under Paladin's Infrastructure Development Programme. The 187-bed hospital services a regional population of 250 775 and is the main referral hospital in the district. Renovations included replacement of ceilings, windows, screens and plumbing fixtures. Responding to a long-standing request of the Karonga Town Planning Department and local public, Paladin upgraded a guardians' compound adjacent to KDH. It is normal practice in Malawi for rural patients' families to camp near a hospital to provide food and support for their relatives. At KDH, an average of 100 patients' guardians at any time camp in a designated area outside the hospital walls, with minimal support services. Paladin constructed a large, sheltered cooking area, toilets and bathing stalls.

In April 2012, Lab Without Walls founder Prof. Tim Inglis handed over a complete field microscope set to Paladin staff for use in Malawi. This was the latest addition to the community health services provided by Paladin and will be used to confirm malaria, tuberculosis and other infectious diseases.

In addition to supporting a number of employees in their external studies, Paladin also continues to support education for children in Kayelekera and nearby villages through paying for nine teachers, supply of materials and teaching initiatives. In 2012, a teacher's house was completed in Viraule village and two new classrooms were completed at Ipiana village. Repairs were carried out on the Kayelekera Primary School. Paladin also sponsors nine volunteer educators who supplement regular teaching staff at schools in villages near the Kayelekera mine.

Friends and Employees of Paladin for African Children (FEPAC) is a charitable foundation established in 2008 by Paladin employees to fund smaller social projects in Malawi that are outside the scope of the company's programmes. The charity supports six projects that assist orphaned children with educational needs and vocational training courses, such as brick laying, carpentry and tailoring. Sixty teenagers have completed these courses and have been provided with tools to enable them to earn money to support their younger siblings. During the year, FEPAC financed construction of a girls' dormitory, a kitchen/dining building and a teacher's house at the School for Deaf Children in Karonga.

Paladin HIV/AIDS awareness programmes continued in local communities. Four new booklets written by the Paladin Social Development Officer have been translated into three local languages and distributed to employees and the community. A total of 22 booklets have been published, covering social topics including HIV/AIDS prevention; malaria and chest infection management, dealing with alcohol abuse; care of the new born; prevention of diarrhoea; combating deforestation; theft and corruption and wise use of wages.

In the interests of improving access to medical facilities in Kayelekera village, Paladin and the Department of Health entered into discussions to expand upon the Paladin-supported weekly outpatient clinic in the village. The outcome was a commitment from the department to establish a sub-clinic in Kayelekera to provide access to the full range of government programmes. Paladin will facilitate establishing the clinic and provide housing for two clinic staff in the village. Land has been allocated for this purpose.

Uranium requirements

Currently Malawi has no plans for nuclear power.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

All mining activities are under the control of the Department of Mines of the Ministry of Natural Resources with environmental matters falling under the Department of Environmental Affairs in the same ministry. However, in common with many developing countries, Malawi has no specific legislation or a regulation relating to uranium, but it is working in co-operation with the IAEA to develop appropriate legislation. In 2011, the National Assembly passed an atomic energy bill, which is the first step of the introduction of comprehensive legislation to provide for adequate protection of people as well as the environment against harmful effects of radiation, nuclear material and radioactive materials.

The government is committed to putting in place policies that will attract private sector participation in the exploration, exploitation, processing and utilisation of Malawi's mineral resources. To this end, in March 2013, the Mines and Mineral Policy of Malawi was developed by the Malawi government. The government recognises that the minerals sector has significant potential to contribute towards the rapid economic growth and development of the country. The policy seeks to stimulate and guide private mining investment by administering, regulating and facilitating the growth of the sector through a well-organised and efficient institutional framework. The government will also intensify provision of extension services to the artisanal and small-scale miners and women miners. The goal of the Mines and Minerals Policy is to enhance the contribution of mineral resources to the economy of the country so as to move from being an agro-based to mineral-based economy.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Sandstone			4 420	7 464
Intrusive				2 205
Total			**4 420**	**9 669**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Open-pit mining (OP)			4 420	7 464	80
Co-product and by-product				2 205	60
Total			**4 420**	**9 669**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from OP			4 420	7 464	80
Other				2 205	60
Total			**4 420**	**9 669**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Sandstone			1 822	4 083
Intrusive				525
Total			**1 822**	**4 608**

Inferred conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Open-pit mining (OP)			1 822	4 083	80
Co-product and by-product				525	60
Total			**1 822**	**4 608**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			1 822	4 083	80
Other				525	60
Total			**1 822**	**4 608**	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Sandstone	1 613	1 103	1 132	369	4 217	0
Total	**1 613**	**1 103**	**1 132**	**369**	**4 217**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining	1 613	1 103	1 132	309	4 217	0
Total	**1 613**	**1 103**	**1 132**	**369**	**4 217**	**0**

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	1 613	1 103	1 132	309	4 217	0
Total	**1 613**	**1 103**	**1 132**	**369**	**4 217**	**0**

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
55	15	0	0	0	0	314	85	369	100

Uranium industry employment at existing production centres

(person-years)

	2010	2011	2012	2013
Total employment related to existing production centres		766	759	750
Employment directly related to uranium production				

Short-term production capability (tonnes U/year)

2015				2020				2025			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	0	0	0	0	0

2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	1 400	1 460	0	0	1 400	1 460

Mali*

Uranium exploration and mine development

Historical review

Exploration for uranium in Mali was done along the border with Senegal between 1954 and 1956, by the French Atomic Energy Commission in the Adrar des Iforas region. Indications of uranothorianite and thorianite were discovered in large pegmatite lenses enclosed in highly metamorphosed hornblende- and pyroxene-schists of the Suggarian sequence. Numerous granites were also studied in this area but only the younger granites showed anomalous radioactivity, probably because of the presence of monazite as an accessory mineral.

Under an agreement with the government of Mali, Krupp carried out a reconnaissance survey in the eastern part of Mali in 1970 with no positive results. In 1971, the Institute for Geosciences and Natural Resources (BGR) carried out a hydrogeochemical and radiometric reconnaissance survey in the western Kayes region of the country. Some anomalies were found but their character did not encourage further activities. In 1974, Japan's Power Reactor and Nuclear Fuel Development Corporation (PNC) initiated an exploration project in the Adrar des Iforas covering parts of the Taoudeni sedimentary basin.

In 1976, the Compagnie Générale des Matières Nucléaires (COGEMA) started exploration in the areas of Kenieba, Kayes, Bamako, Sikasso, Hombori, Douentza and Taoudenni. This work included airborne radiometric surveys in Kenieba and Taoudenni, and geophysical exploration (including drilling) in Kenieba (Faléa and Dabora). COGEMA ended its exploration project in 1983 and PNC limited its activities to a small area of 20 km^2. PNC continued work through the first quarter of 1985, using emanometry and very low frequency electromagnetics over an area of 14 km^2, and then ended its activities in the second quarter of 1985. From 2007-2008, several companies conducted uranium exploration in Mali.

Recent and ongoing uranium exploration and mine development activities

As of 1 January 2015, seven uranium exploration permits had been granted to five exploration companies. However, because of the rebellion in the north-eastern part of the country, exploration activities are only being undertaken in the western part of the country.

Exploration permits

Western part of Mali

Bala	125 km^2	Delta Exploration Mali Sarl
Madini	67 km^2	Delta Exploration Mali Sarl
Faléa	75 km^2	Rockgate Capital Corp in partnership with Delta Exploration Inc.

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* NEA/IAEA report based on company reports and government data.

Eastern part of Mali

Arafat	1 750 km^2	Earthshore Resources Mali Ltd
Diarindi	150 km^2	Merrea Gold
Dombia	254 km^2	Tropical Gold of Mali Sarl
Kidal	3 980 km^2	Oklo Uranium Ltd Mali Sarl
Tessalit	4 000 km^2	Oklo Uranium Ltd Mali Sarl

In 2007-2008, Australia's Oklo Uranium Ltd conducted uranium exploration over the Kidal area, part of the underexplored north-eastern part of Mali. Exploration covered a large crystalline geological province known as the Adrar des Iforas that is considered prospective for palaeo-channel-hosted uranium, alaskite/pegmatite and vein-hosted uranium and contains occurrences of uranium, gold, copper-lead-zinc and manganese. Target identification has been undertaken in the project area with 47% of an airborne geophysical survey completed in 2007. In 2008, potential uranium anomalies were located and tested with ground spectrometry, geochemical sampling and drilling.

At Faléa, substantial uranium and copper values were first discovered by COGEMA in the late 1970s, but the project has not advanced because of the prevailing low commodity prices. Exploration conducted since 2008 by Rockgate and Delta has focused on defining and expanding these initial results.

The mineralisation at the Faléa Project occurs within the Neoproterozic to Carboniferous sedimentary sequence of the Taoudeni Basin, a shallow interior sag basin with flat to very shallow dips. Faléa is located along the southern edge of the western province of the Taoudeni Basin.

The first event related to ore genesis is believed to have deposited the copper (mostly in the form of chalcopyrite) and silver mineralisation. The copper mineralisation is found to be disseminated primarily within the Kania Sandstones, as halos around the uranium minerals, and thus it acts as a trap for uranium mineralisation which occurs mostly as pitchblende and coffinite.

The uranium mineralisation is believed to be a sandstone-type – roll-front – deposit. With a few exceptions, mineralisation has been confined to the flat-lying KS unit, as well as within the units immediately above and below it. The distance from surface to the mineralised horizon varies between 31.5 m to more than 350 m below surface.

In 2011, a heliborne versatile time-domain electromagnetic/magnetics/radiometrics survey was flown over the central Faléa area. The survey comprised 933 line-km at a 1 100-metre line spacing covering an area of approximately 90 km^2. Drilling data used for the 2009 mineral resource estimate totalled 149 drill holes, 247 in 2011, and 754 in 2012 (virtually all diamond-type drilling). Further drilling is planned, mainly to test potential extensions of high-grade mineralisation on the north zone structures.

In 2014, Denison Mines spent CAD 269 000 on Faléa, with activity being limited to a modest field programme consisting of geological mapping and surficial geochemistry orientation surveys. These programmes were completed during the second quarter of the year. During the fourth quarter of 2013, minimal exploration expenditures of CAD 39 000 were spent on Faléa after acquiring the property from Rockgate. In early 2015, the company submitted an application for a new exploration licence to the authorities in Mali to allow exploration activity to continue at Faléa.

Uranium resources

Identified conventional resources

In December 2012, Minxcon Ltd (Johannesburg, South Africa) developed an NI 43-101 compliant resource estimate of the Faléa deposit, at a cut-off grade of 0.03% U_3O_8 (0.025% U).

Total identified resources amounted to 17 412 tU, which includes 11 377 tU RAR and 6 035 tU inferred.

Recent metallurgical test work and engineering have confirmed recoveries of uranium, silver and copper on a consistent basis, and hence the contribution of all these metals that may be expected from mining. A pre-feasibility study has begun based upon the results above together with an enhanced understanding of the orebody and possible mining and metallurgical solutions.

Environmental activities and socio-cultural issues

On 26 April 2010, Rockgate Capital Corp. announced that it had commissioned Golder Associates to conduct environmental and social baseline studies on the Faléa Project. In January 2014, Denison Mines of Canada took over Rockgate Capital Corp.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	11 377	11 377
Total	**0**	**0**	**11 377**	**11 377**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	11 377	11 377	N/A
Total	**0**	**0**	**11 377**	**11 377**	**N/A**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified	0	0	6 035	6 035	In situ
Total	**0**	**0**	**6 035**	**6 035**	**In situ**

* In situ resources.

Mauritania*

Uranium exploration and mine development

Historical review

The first uranium exploration project in Mauritania was carried out in 1959 by France's Atomic Energy Commission in the area of the Ogmane anticline.

In 1972, following the discovery of surficial-type uranium deposits in Western Australia, uranium exploration was initiated in the Regueibat Range by Total Compagnie Française de Pétrole (in joint venture with the Société Mauritanienne de Recherches Minières, the French Atomic Energy Commission and Tokyo Uranium Development Company). The two exploration permits covered a total area of 164 000 km², divided into four blocks (Chami, Bir Hoghrein, Nouadhibou and Ghallamane). In 1975, the total area was reduced to five blocks totalling 41 000 km², and these joint ventures were modified after the foundation of French Minatome SA and Compagnie Générale des Matières Nucléaires.

These joint ventures held the areas up to 1983. Work on the permits was carried out between 1972 and 1975 and again in 1981 and targeted the evaluation of surficial-type deposits (Reguibat Range), as well as occurrences in the Precambrian basement, where radioactive anomalies were found associated with syenites and granites (Bir En Nar, Tigismat, Tenebdar). In 1983, all uranium exploration activities were suspended.

In December 2007, Australia's Forte Energy NL completed its first drilling programme in Mauritania, a 4 006 m reverse circulation programme of 41 holes of 50-150 m depth. The drilling was carried out in the Bir En Nar area of the Zednes region and followed up on high grade results previously obtained. Downhole radiometric logging results indicated numerous high-grade uranium intersections, including 1.55 m at 1.55% U. The results of drilling a second group of 21 holes yielded up to 6 310 ppm U over 1 m, and 576 ppm U over 19 m.

In November 2006, the UK's Alba Mineral Resources with Mauritania Ventures Limited, started to investigate the uranium potential of areas located in north-east Mauritania. The area is considered to be prospective for unconformity-type uranium mineralisation. The permits cover significant areas of an unconformable contact between Early Proterozoic reworked granitic terrain and overlying sediments of Late Proterozoic-Carboniferous age. Airborne geophysics, flown on behalf of the Mauritanian government, revealed radiometric anomalies within a mapped, organic-rich unit near the base of this sedimentary sequence, and coincident with its intersection with large, deep penetrating crustal shear structures. Uranium mineralisation is known in the north and north-west part of the permit area, hosted in granites and rhyolites cut by these shear structures. On 3 November 2010, Alba Mineral Resources was notified that the mining authorities in Mauritania had withdrawn the licence, citing a lack of additional exploration activity.

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* Report prepared by the NEA/IAEA, based on previous Red Books and company reports.

Recent and ongoing uranium exploration and mine development activities

Forte Energy NL, based in Australia, holds several uranium exploration licences in Mauritania, including the A 238 and Bir En Ar areas.

The A 238 and Bir En Ar uranium prospect are associated to granites near Bir Moghrein in the north of Mauritania. At A 238 prospect, the main zone of mineralisation extends over a strike length of 1.75 km with mineralisation extending down to over 250 m from surface with widths of over 60 m within 50 m of the surface.

Following the positive results of the 2009/10 reverse circulation (RC) drilling, a further RC drilling programme of around 11 300 m commenced in October 2010, focusing initially on Anomaly 238. Preliminary results from A 238 indicated the potential for a shallow, large volume medium-grade deposit. A total of approximately 10 450 m of RC and diamond core drilling has been carried out, resulting in announcement in June 2011 of an initial JORC code compliant U resource for A 238 of 26.5 Mt at 217 ppm U for 5 730 tU (85 ppm U cut-off).

After completing a further 63 holes (8 567 m) of RC drilling in 2011/12, an updated JORC resource was announced in April 2012 for A 238. The deposit remains open along strike.

Deposit	Resource category	Average grade (ppm U)	Tonnes of U
A 328	Inferred	199	9 000
Bir En Nar	Indicated Inferred	751 488	385 385
Total	**Indicated** **Inferred**	**751** **204**	**385** **9 385**

Australia's Aura Energy owns the Reguibat Project which comprises several, laterally extensive developments of calcrete uranium mineralisation in northern Mauritania.

Between November 2010 and February 2011, Aura Energy completed a drilling programme which covered all of Aura's wholly owned permits, as well as its joint venture permits, and totalled over 9 100 m in 2 022 holes.

A JORC code compliant uranium resource, based on these drilling results, was released (85 ppm U cut-off):

Deposit	Resource category	Average grade (ppmU)	Tonnes of U
Reguibat	Indicated Inferred	254 284	770 18 077
Total		**283**	**18 847**

In 2014, Aura Energy conducted a scoping study that confirmed that Reguibat could be a robust project with shallow mineralisation that could be upgraded through simple beneficiation to high-grade leach feed. The study indicated that some 4 200 tU could be produced over an initial mine life of 15 years, using only 20% of the project's known global mineral resource. The project would require a capital investment of about USD 50 million and would have an operating cost of USD 30/lbU_3O_8, and with a mine-life average production of 290 tU/yr.

Additionally, extensive radiometric surveys allowed Aura Energy to estimate an exploration target of an additional 19 000 tU, inferring a global mineral resource target of around 38 000 t of uranium at Reguibat.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

In 2012, Forte Energy NL and Aura Energy released JORC code compliant U resource for the A 328, Bin En Ar and Reguibats deposits.

Based on 85 ppm U cut-off, global resources of Mauritania totalled 1 155 tU in the indicated category, and 27 462 tU in the inferred category (in situ resources).

Undiscovered conventional resources (prognosticated and speculative resources)

Based on extensive radiometric surveys, Aura Energy estimates an additional potential of 19 000 tU in the Reguibat area.

Uranium production

In 2014, Aura Energy achieved the completion of the Reguibat Scoping Study.

Mineralisation occurs largely within 3-4 m of the land surface, in gravels and weathered granite. Most of the mineralisation occurs as single sheets with little or no cover. The material is largely unconsolidated and can be readily excavated by diggers or scrapers without blasting. Overlying waste consists of loose windblown sand. The strip ratio is anticipated to be approximately 0.25:1.

Simple washing and screening tests on the ore have yielded exceptional results. Wet screening at 75 µm resulted in the rejection of 80% by weight with the retention of 91% of the uranium into the screen undersize. This represents a sevenfold upgrade factor from the 334 ppm resource grade. These exceptional results may be explained by the extremely fine size and ready liberation of the uranium mineral, carnotite, and the large difference in particle size distribution between the carnotite and the bulk of the host rock minerals.

Following a series of encouraging small-scale preliminary tests, a standard leach test on -300 µm beneficiated material confirmed exceptional results, with 92% uranium extraction within 4 hours and 95% after 8 hours.

The total estimated initial capital cost for engineering, procurement, construction, commissioning, start-up and the owner's activities for the project is AUD 50 million.

The life of mine unit operating cost estimate for the Reguibat Project is estimated to be USD 30.3/lb U_3O_8.

The planned operation will produce approximately 385 tU per year in years 2 and 3, followed by 250 tU for years 4-11, and 270 tU in years 12-15. The total uranium produced under these assumptions is 4 100 tU over the 15-year mine life.

A feasibility study was undertaken in 2015, with a view to a simple truck and shovel mine on the eastern deposit feeding an AUD 50 million plant and production at about 400 tU/yr from 2017.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1
Name of production centre	Reguibat
Production centre classification	Prospective
Date of first production (year)	N/A
Source of ore:	
Deposit name(s)	Reguibat
Deposit type(s)	Calcrete
Recoverable resources (tU)	4 100
Grade (% U)	0.033
Mining operation:	
Type (OP/UG/ISL)	OP
Size (tonnes ore/year)	1 Mtpa
Average mining recovery (%)	
Processing plant:	
Acid/alkaline	Acid
Type (IX/SX)	Heap leaching
Size (tonnes ore/day)	
Average process recovery (%)	92
Nominal production capacity (tU/year)	400

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite	N/A	N/A	N/A	289
Calcrete	N/A	N/A	670	670
Total	**N/A**	**N/A**	**670**	**959**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	N/A	N/A	670	670	87
Unknown	N/A	N/A	N/A	289	75
Total	**N/A**	**N/A**	**670**	**959**	**83**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching from OP	N/A	N/A	670	670	87
Unknown	N/A	N/A	N/A	289	75
Total	**N/A**	**N/A**	**670**	**959**	**83**

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite	N/A	N/A	N/A	7 039
Calcrete	N/A	N/A	15 727	15 727
Total	**0**	**0**	**15 727**	**22 766**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	N/A	N/A	15 727	15 727	87
Unknown	N/A	N/A	N/A	7 039	75
Total	**N/A**	**N/A**	**15 727**	**22 766**	**83**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Heap leaching from OP	N/A	N/A	15 727	15 727	87
Unknown	N/A	N/A	N/A	7 039	75
Total	**N/A**	**N/A**	**15 727**	**22 766**	**83**

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	N/A	19 000

Mexico

Uranium exploration and mine development

Historical review

Uranium exploration began in 1957, using both ground and aerial prospecting with geological and radiometric methods. Limited technical and financial resources initially hampered national exploration efforts, but these problems were alleviated by government support, particularly from 1972 to 1980.

Until 1979, exploration was performed by the National Institute of Nuclear Energy. In 1979, the responsibility for exploration was vested in Uranio Mexicano (URAMEX). The areas explored, in order of importance, are in the states of Chihuahua, Nuevo León, Tamaulipas, Coahuila, Zacatecas, Queretaro and Puebla.

Uranium exploration was stopped in May 1983 and URAMEX was dissolved in February 1985.

Recent and ongoing uranium exploration and mine development activities

In 2009, the Mexican Geological Survey (SGM) reactivated radioactive exploration in Mexico, in order to validate and re-evaluate the resources reported by URAMEX according to international standards. This involves the analysis of the preliminary information available, as well as complementary studies of geology, geochemistry, geophysics and drilling, simultaneously exploring new locations with uranium potential.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Projects	Tonnes U
Las Margaritas, Chihuahua State	610
El Puerto III, Chihuahua State	178
El Nopal I, Chihuahua State	321
La Coma, Nuevo León State	852
Los Amoles, Sonora State	439
Buenavista, Nuevo León State	1 259
El Chapote, Nuevo León State	844

Past evaluation of these projects by URAMEX did not fulfil the international standards of evaluation. Potential was demonstrated, however, and the Mexican Geological Survey began a programme to evaluate resources following international standards. The first results of this programme are presented here.

Undiscovered conventional resources (prognosticated and speculative resources)

There are 53 uranium occurrences in Mexico that will be evaluated by the Mexican Geological Survey.

Unconventional resources and other materials

The San Juan de la Costa phosphorite deposit is estimated to contain significant uranium resources.

Uranium production

Historical review

From 1969 to 1971, the Mining Development Commission operated a plant in Villa Aldama, Chihuahua. The facility recovered molybdenum and by-product uranium from ores mined in the Sierra de Gomez, Domitilia (Pena Blanca) deposits and other occurrences. A total of 49 tU was produced. At present, there are no plans for additional uranium production.

Uranium requirements

As of 1 January 2015, two boiling water reactors with a total installed capacity of 1.4 GW net were in operation at the Laguna Verde NPP. These two units have been in operation since 1990 and 1995. The two units supply about 4-5% of the country's electricity. In 2014, the Laguna Verde nuclear power plant performed the 17th fuel reload of unit 1 and the 14th reload of unit 2. The requirements for the unit 1 were 24.7 tonnes enriched uranium, 3.9% average enrichment and 0.25% tails assays. For the unit 2, the requirements were 25.2 tonnes enriched uranium, 3.9% average enrichment and 0.25% tails assays.

Supply and procurement strategy

Uranium purchase open bid is under study for six reloads (2018-2022).

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The 1984 Act on Nuclear activities, adopted pursuant to Article 27 of the Constitution, entered in force on 5 February 1985. It specifies that the exploration, exploitation and the benefit of radioactive minerals are the exclusive domain of the government of Mexico. Exploration activities are exclusively delegated to the Mexican Geological Survey.

Uranium stocks

Uranium stocks are maintained at minimum levels in order to reduce costs.

Uranium exploration and development expenditures and drilling effort – domestic

(USD)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures				
Government exploration expenditures	856 383	1 214 572	1 383 248	1 451 841
Industry* development expenditures				
Government development expenditures				
Total expenditures	**856 383**	**1 214 572**	**1 383 248**	**1 451 841**

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	852	852
Volcanic-related	0	1 548	1 548	1 548
Total	**0**	**1 548**	**2 400**	**2 400**

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	844	844	1 259	2 103
Volcanic-related	0	0	0	0
Total	**844**	**844**	**1 259**	**2 103**

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	11.4	9.3

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
1 400	1 400	1 400	1 634	1 620	1 634	1 620	1 634	1 620	1 634	1 620	1 634

Annual reactor-related uranium requirements* to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
385	188	188		386		386		386		386	

* Refers to natural uranium acquisitions, not necessarily consumption during the calendar year.

Mongolia

Uranium exploration and mine development

Historical review

Uranium exploration in Mongolia started immediately after World War II, with investigations directed at the search for uranium contained in other, non-uranium deposits. During the period 1945-1960, numerous uranium occurrences were discovered in the brown coal deposits of eastern Mongolia.

Between 1970 and 1990, under a bilateral agreement between Mongolia and the former Soviet Union, specialised geological surveys were conducted by the Geological Reconnaissance Expedition of the Soviet Ministry of Geology. Full airborne gamma-spectrometric surveys at a scale of 1:25 000 and 1:50 000 were conducted over 420 000 km^2, some 27% of Mongolian territory; at a scale of 1:200 000 over 450 000 km^2, or 28% of the territory; and at a scale of 1:1 000 000 over 224 000 km^2, or 14% of the Mongolian Altai, Khangai mountains and Gobi Desert region. The territory along the border with the People's Republic of China and the central Mongolian mountain area, about 30% of the country, were not included in these surveys.

Metallogenic investigation at the scale of 1:500 000 over a 500 000 km^2 area and more detailed geological exploration at the scale of 1:200 000-1:50 000 over 50 000 km^2 area territory of Mongolia were also completed. This work included 2 684 000 m of surface drilling, 3 179 000 m^3 of surface trenching and 20 800 m of underground exploration.

Based on these surveys, the territory of Mongolia was classified into four uranium-bearing metallogenic provinces: Mongol-Priargun, Gobi-Tamsag, Khentei-Daur and Northern Mongolian. Each of these provinces has different geology and hosts different deposit types. Mineral associations and ages of mineralisation also vary. Within these provinces, 9 uranium deposits, about 100 uranium occurrences and 1 400 showings and radioactive anomalies were identified.

The Mongol-Priargun metallogenic province is located in eastern Mongolia, coinciding with a 70 to 250-km-wide continental volcanic belt tracing along the extension over some 1 200 km, from the Mongolian Altai to the Lower-Priargun. This territory includes mainly deposits and occurrences of fluorite-molybdenum-uranium associations resulting from volcano-tectonic events. Distinct uranium mineralisation districts of the Northern Choibalsan, Berkh, eastern and central Gobi are included in this area. The Dornod ore field of Northern Choibalsan includes the uranium deposits of Dornod, Gurvanbulag, Mardaingol, Nemer, Ulaan (incidental), as well as other polymetallic and fluorite associations. The Choir and Gurvansaikhan basins of the eastern and central Gobi uranium mineralisation district include the Kharaat and Khairkhan uranium deposits, among others.

The Gobi-Tamsag metallogenic province covers a territory 1 400 km long by 60-180 km wide in southern Mongolia. It is characterised by numerous uranium occurrences in grey and motley coloured terrigenous sediments related to stratum oxidation and restoration. The district units include a perspective uranium deposit in the south, near the Dulaanuul and Nars deposits and numerous occurrences, as well as perspective uranium-bearing basins, such as Tamsag, Sainshand, Zuunbayan basins and others.

The Henter-Daur metallogenic province (700 km long by 250 km wide) includes the Khangai and Khentii mountains. In this area, uranium occurrences of light coloured granite fragments can be found, such as the Janchivlan ore field, which shows some promise of becoming a deposit of economic interest.

The Northern Mongolian metallogenic province is the largest (1 500 km long by 450 km wide) of the four. This north-western part of Mongolia is a comparatively old geological province characterised by a variety of minerals such as uranium-thorium rare earth elements related to alkaline mineralisation, uranium-thorium in metasomatites, pegmatite, magmatic and quartz schist uranium host rock.

Recent and ongoing uranium exploration and mine development activities

In 2013-2014, most uranium prospecting was performed in the Zuunbayan basins (south-east Mongolia), with the objective of identifying sandstone-type uranium mineralisation suitable for ISL mining.

Uranium exploration expenditures were MNT 27 940 million (Mongolian tugrik; USD 14.3 million) in 2014, 18.8% higher than the 2013 expenditures (MNT 22 690 million; USD 11.6 million). Uranium prospecting and exploration drilling totalled 24 685 m in 2014, compared to 19 841 m reported in 2013.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2015, recoverable uranium resources in Mongolia attributable to the category identified resources amounted to 141 521 tU. Compared to 1 January 2013, there is no change.

Inferred resources have remained the same at 33 414 tU, but have been moved from the <USD 80/kgU to <USD 130/kgU since the last report in 2013. The majority of such resources may be mined by the conventional underground mining method.

Undiscovered conventional resources (prognosticated and speculative resources)

As of 1 January 2015, prognosticated resources amounted to 21 000 tU and speculative resources totalled 1 390 000 tU.

Unconventional resources and other materials

No unconventional resources have been identified.

Uranium production

Historical review

Uranium production in Mongolia started with the operation of the Dornod open-pit mine in the Mardai-gol district in 1989, based on the known uranium resources at the Dornod and Gurvanbulag deposits. Assuming an ore grade of 0.12%, this equals a mining production capability of 2 400 tU/year. Mongolia has no processing facilities. The ores mined in the Mardai-gol district were transported by rail 484 km to Priargunsky mining and processing combinate in Krasnokamensk, Russia, for processing. Because of political and economic changes both in Mongolia and neighbouring areas of Russia, uranium production at Erdes was terminated in 1995.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2				Centre #3	
Name of production centre	Emeelt mines	Gurvansaikhan				Coge-Gobi	
Production centre classification	Planned	Planned				Planned	
Start-up date	2018	2018				2019	
Source of ore:							
Deposit name(s)	Gurvanbulag	Kharaat	Khairkhan	Gurvansaikhan	Ulziit	DulaanUul	Zoovch Ovoo
Deposit type(s)	Volcanic	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Resources (tU)	8 580	7 288	8 406	2 479	2 611	6 259	67 706
Grade (% U)	0.162	0.026	0.071	0.034	0.036	0.022	0.022
Mining operation:							
Type (OP/UG/ISL)	UG	ISL	ISL	ISL	ISL	ISL	ISL
Size (tonnes ore/day)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average mining recovery (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	IX	IX	IX
Size (kilolitre/day)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average process recovery (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nominal production capacity (tU/year)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Plans for expansion							
Other remarks	No	No	No	No	No	No	No

Status of production facilities, production capability, recent and ongoing activities and other issues

Currently, no uranium is being produced in Mongolia. However, a number of mines are in the planning stage of development.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Mongolia has not produced or used mixed oxide fuels.

Production and/or use of re-enriched tails

Mongolia currently does not have a uranium enrichment industry. Re-enriched tails are not used or produced.

Production and/or use of reprocessed uranium

There is no production or use of reprocessed uranium.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The new Mongolian government is attaching great significance to the mining of uranium deposits that would positively influence and improve the national economy. It has developed a special programme on uranium and is committed to implementing this programme.

The programme covers the following policies and guidelines:

- Geological exploration and the mining of uranium deposits, processing and marketing of uranium ores on the territory of Mongolia; the direction here is to reduce Mongolian government investment and to encourage foreign investment.
- Conducting surveys on the potential hazards of uranium exploration and mining and to protect the environment, people, fauna and flora.
- Developing intensive and effective co-operation with international organisations involved in the prospecting, mining and sale of uranium and other raw materials for nuclear energy.
- Developing all the necessary regulations, instructions and recommendations for activities related to uranium mining.
- Starting uranium geological surveys of sandstone-type deposits or occurrences on the territory of Mongolia.
- Studying possibilities of recovering uranium from phosphate and brown coal deposits and developing alternative extraction techniques.
- Training national personnel for uranium studies and production and to introduce advanced technology, instruments and tools of high precision.
- Setting up a government enterprise responsible for monitoring and co-ordinating uranium exploration and production, as well as developing and implementing government policy and strategies in the field of uranium exploration based on mobilising efforts of national uranium specialists.

The programme defines actions and activities necessary for training national personnel in uranium prospecting and production, introducing advanced and efficient technologies and supplying high-capacity equipment, instruments and tools. The programme also lists achievements in this field and highly appreciates the impact of IAEA projects.

Uranium exploration and development expenditures and drilling effort – domestic

(MNT million)

	2010	2011	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	25 022	38 074	34 842	22 690	27 940	N/A
Government exploration expenditures	0	0	0	0	0	0
Industry* development expenditures	0	0	0	0	0	0
Government development expenditures	100	0	0	0	0	0
Total expenditures	**25 122**	**38 074**	**34 842**	**22 690**	**27 940**	**0**
Industry* exploration drilling (m)	82 925.2	202 930	183 476	19 841	24 685	0
Industry* exploration holes drilled	670	-	-	0	0	0
Government exploration drilling (m)	0	0	0	0	0	0
Government exploration holes drilled	0	0	0	0	0	0
Industry* development drilling (m)	0	0	0	0	0	0
Industry* development holes drilled	0	0	0	0	0	0
Government development drilling (m)	0	0	0	0	0	0
Government development holes drilled	0	0	0	0	0	0
Subtotal exploration drilling (m)	82 925.2	202 930	183 476	19 841	24 685	0
Subtotal exploration holes drilled	670	-	-	0	0	0
Subtotal development drilling (m)	0	0	0	0	0	0
Subtotal development holes drilled	0	0	0	0	0	0
Total drilling (m)	**82 925.2**	**202 930**	**34 842**	**19 841**	**24 685**	**0**
Total number of holes drilled	**670**	**-**	**-**	**0**	**0**	**0**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	92 837	92 837	92 837
Volcanic-related	0	15 270	15 270	15 270
Total	**0**	**108 107**	**108 107**	**108 107**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)	0	15 270	15 270	15 270	75
In situ leaching acid	0	92 837	92 837	92 837	75
Total	**0**	**108 107**	**108 107**	**108 107**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from UG	0	15 270	15 270	15 270	75
In situ leaching acid	0	92 837	92 837	92 837	75
Total	**0**	**108 107**	**108 107**	**108 107**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Volcanic-related	0	33 414	33 414	33 414
Total	**0**	**33 414**	**33 414**	**33 414**

Inferred conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)	0	0	33 414	33 414	75
Total	**0**	**0**	**33 414**	**33 414**	**75**

Inferred conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from UG	0	0	33 414	33 414	75
Total	**0**	**0**	**33 414**	**33 414**	**75**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
21 000	21 000	21 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
1 390 000	1 390 000	0

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Volcanic-related	535	0	0	0	535	0
Total	**535**	**0**	**0**	**0**	**535**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	535	0	0	0	535	0
Total	**535**	**0**	**0**	**0**	**535**	**0**

[1] Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Namibia*

Uranium exploration and mine development

Historical review

Uranium was first discovered in the Namib Desert in 1928 by Captain G. Peter Louw in the vicinity of the Rössing Mountains in the Namib Desert. Over many years he tried to promote the prospect, but it was not until the late 1950s that the Anglo-American Corporation of South Africa prospected the area by drilling and limited underground exploration. As a result of erratic uranium prices and limited economic prospects for uranium, Anglo-American abandoned its work.

As a result of an upswing in the uranium market demand and prices, extensive uranium exploration started in Namibia in the late 1960s. Several airborne radiometric surveys were conducted by the geological survey and numerous uranium anomalies were identified. In 1966, after discovering a number of uranium occurrences, Rio Tinto acquired the rights to the low-grade Rössing deposit, 65 km inland from Swakopmund. During the same exploration period, Trekkopje, a near-surface calcrete deposit, was discovered just north of Rössing and Langer Heinrich, another calcrete deposit, was discovered in 1973 by Gencor, 50 km south-east of Rössing.

Mining commenced in 1976 at Rössing and exploration intensified as uranium prices increased sharply. However, in the early 1980s the combined effects of political uncertainty and the decline of uranium prices caused the rapid curtailment of exploration and development work. This was unfortunate as the refinement of exploration techniques, which had proved to be successful in the Namib Desert, appeared poised to potentially locate a number of new deposits.

The upward trend in uranium prices that began in 2003 once again stimulated extensive exploration activity, mainly in the Namib Desert. Based on earlier successes, two major types of deposits were targeted; the intrusive-type associated with alaskite, as at Rössing, and the surficial, calcrete-type, as at Langer Heinrich. Exploration activities continue but declining uranium prices since 2011, partly as a result of the Fukushima Daiichi accident, have slowed activities to a certain extent. Despite this recent slowdown, substantial growth in uranium exploration already took place in the Erongo area of west-central Namibia, focusing mainly on previously known deposits with considerable historical data. Over 60 exploration licences were issued up until early 2007, when a moratorium on new licences was imposed by the Namibian government pending development of new policies and legislation given concerns about water and energy requirements for uranium mining.

The state-owned Epangelo Mining Company, created by the Namibian government in 2008, was given exclusive rights to all future uranium exploration and mining licences in April 2011. It was created to effect direct state participation in the Namibian mining industry, combining characteristics of an instrument of public policy and those of a business.

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* Report prepared by the NEA/IAEA, based on previous Red Books, government data and company reports.

To appease concerns among companies currently active in Namibia, the government stated that existing licences held by private companies would be honoured and that private companies were welcome to negotiate for a share of interest in ventures. However, Epangelo would maintain a majority shareholding at the outset of new strategic mineral developments, including uranium. Through “earn-in” agreements, joint venture private partners can increase shareholding by achieving key milestone targets as the project develops.

Recent and ongoing uranium exploration and mine development activities

During 2013 and 2014, the two operating uranium mines in Namibia (Rössing and Langer Heinrich) focused efforts on expanding the resource base and increasing production.

Rössing Uranium Limited

A positive evaluation of the possibility of extending the mine life to 2016 and later to 2023 led to efforts to expand the existing pit to expose more of the steeply dipping SJ orebody. Between 2007 and 2010, exploration at Rössing focused on extensions of the main SJ ore body, as well as the adjacent SK and SH deposits. However, the SK deposit contains largely refractory mineralisation (betafite) for which the existing process plant is not suitable.

Since 2010, the main exploration focus has been on the southernmost Z20 deposit that extends across the lease boundary into the adjacent lease held by Swakop Uranium Limited. A total of 24 000 m of drilling was completed on Z20 to declare an inferred resource by the end of 2012. The third phase of drilling on the Z20 ore body was completed during 2013. Data from the drilling indicated a significant uranium resource in Z20. In 2013, in situ resources for the Z20 orebody amounted to 46 012 tU at higher grades (0.023% U) than the main orebody. No additional exploration activities were undertaken in 2014. As of December 2014, the Rössing mine identified in situ resources amounted to 107 897 tU at an average grade of 0.024% U.

Langer Heinrich

Langer Heinrich is a surficial, calcrete-type uranium deposit located in the Namib Desert, 80 km from the major seaport of Walvis Bay. The ore occurs over 15 km in a palaeochannel system, some 50 m deep.

The exploration prospecting licence, EPL3500, covers the western extension of the mineralised Langer Heinrich paleo channel. An application to convert the EPL to a mining lease is currently in place and progressing through the regulatory process. An environmental impact assessment has been submitted to the Ministry of Environment and Tourism supporting the mining lease application and this has been accepted with the certificate being forwarded to the Ministry of Mines and Energy.

As of June 2015, the Langer Heinrich identified in situ resources amounted to 46 474 tU at an average grade of 0.047% U.

Trekkopje

The Trekkopje uranium project is located approximately 65 km north-east of the coastal town of Swakopmund, which is approximately 30 km north of the major deep water port of Walvis Bay. The project area contains the Klein Trekkopje resource, a broad, surficial uranium deposit (80% of mineralisation is contained in the top 15 m) hosted in calcium carbonate cemented (calcrete) conglomerates of Tertiary age which lie on a peneplaned surface of Precambrian/Cambrian age meta-sedimentary rocks and intrusive granite. The basal channels in the Trekkopje area follow the northeast-trending structural grain of the underlying basement rocks.

In 1974, an airborne radiometric survey, commissioned by Rio Tinto, identified a uranium anomaly in the south-west of the property over what is now known as the Klein Trekkopje deposit. Sporadic exploration was undertaken by different companies between 1974 and 1999. In December 1999, UraMin Inc, the parent company of UraMin Namibia, was granted licences over the project area. In 2006, UraMin initiated a programme of exploration drilling and in November that year announced resources for the Klein Trekkopje and Trekkopje deposits. In July 2007, UraMin Inc. was purchased by Areva with its 100%-owned subsidiary, Areva Resources Namibia, responsible for exploration and development activities.

As at 1 January 2013, the resource inventory for Klein Trekkopje equated to26 000 tU (250 Mt at 105 ppm U).

Husab

The main part of the Husab Project is the Rössing South orebody, about 5 km south of the Rössing mine. The Husab area was targeted as an exploration area of interest in 2006-2007. The geological reasoning behind this was that similar rock formations (alaskites) to those hosting the Rössing mine to the north were interpreted to be concealed beneath the desert plain in the northern part of Swakop Uranium's EPL area. The discovery holes were drilled in late 2007; the chemical assay results for the three discovery holes were returned from the laboratory in early 2008 and released to the market in February 2008. Cementing its place as one of the largest resource drilling projects globally, Swakop Uranium has completed over 800 000 m of combined reverse circulation and diamond core drilling from April 2006, when the drilling programme started.

The mineralisation is present for a length of approximately 8 km, in the form of secondary uranium vanadate. The deposit lies under a shallow, 50 m, alluvial sand cover. Only 10 km of 15 km strike on the company's lease, contiguous with Rössing, had then been drilled. Recent exploration activities focused more on the satellite deposits in the vicinity of the Husab mine. Waste stripping commenced in May 2014. A 1 500 t/day sulphuric acid plant was expected online at the end of 2015. Additional acid may be imported. Uranium production is expected to begin sometime in 2016.

Estimated resources for all deposits currently licensed to Swakop Uranium, reported by the Mineral Resource Department on 31 August 2014, are summarised in the following table.

Resources reported by Swakop Uranium (as of August 2014)*

	Measured resources			Indicated resources			Inferred resources		
	Ore (Mt)	Grade (ppm U)	U (tU)	Ore (Mt)	Grade (ppm U)	U (tU)	Ore (Mt)	Grade (ppm U)	U (tU)
Husab Zone 1	44.32	323	14 330	167.20	344	57 506	70.63	318	22 476
Husab Zone 2	50.94	508	25 882	112.21	466	52 282	49.30	358	17 654
Total Husab	**95.26**	**422**	**40 212**	**279.41**	**393**	**109 788**	**119.93**	**335**	**40 130**
Husab Zone 3							46.10	204	9 270
Husab Zone 4							19.80	475	9 424
Husab Zone 5							44.58	239	10 663
Salem							36.16	131	4 742
Middel Dome							25.90	334	8 654
Total Husab Ext							**172.54**	**248**	**42 753**
Garnet Valley				2.10	199	423	83.70	165	13 847
Ida east							5.20	144	754
Holland's Dome							4.00	132	538
Total Ida Dome				**2.10**	**199**	**423**	**92.90**	**163**	**15 139**
Total Swakop	**95.26**	**422**	**40 212**	**281.51**	**391**	**110 211**	**385.37**	**254**	**98 022**

* The resources for Husab mine were estimated by Coffey Mining at a cut-off grade of 100 ppm U_3O_8, and are supported by competent persons reports.

Etango

The Etango uranium project is located in the Erongo uranium province which lies to the south-west of Rio's Rössing uranium mine and China Guangong General Nuclear Power Company's Husab Project, and to the west of Paladin Energy's Langer Heinrich mine. The Etango mine consists of three prospects named Anomaly A, Oshiveli and Onkelo. These prospects contain uraniferous sheeted leucogranite bodies or alaskites, which have intruded into metasediments of the Nosib (Khan and Etusis formations) and Swakop groups (Chuos formation) of the Damara Sequence. The alaskite ore is very similar to that at Rössing, and although extensions continue to 400 m below the surface, two-thirds of the resource base is located less than 200 m below the surface.

The Etango mineral resource estimate (in situ resources) was prepared for Bannerman in accordance with the Aus IMM JORC Code 2004 by Coffey Mining Pty Ltd ("Coffey"). The resource estimate incorporates all new drilling to September 2010 and was announced in October 2010.

The mineral resource is based on the area of highest drilling density in the Anomaly A, Oshiveli and Onkelo prospects. Oshiveli and Onkelo are contiguous with and immediately to the north of Anomaly A. The resource estimate was prepared using cross-sectional interpretations to generate 3D solids of the geology and mineralisation. Geostatistics and variography has been utilised in the iteration of uranium grades into a 3D block model using Ordinary Kriging.

The resource estimate is based on a block size of 25 m (north-south) by 25 m (east-west) by 10 m (elevation). This block size is assumed to include an allowance for internal dilution but not edge dilution.

Total in situ resources for Etango (as of October 2010)

	Measured resources			Indicated resources			Inferred resources		
	Tonnes (Mt)	Grade (ppmU)	Uranium (tU)	Tonnes (Mt)	Grade (ppm U)	Uranium (tU)	Tonnes (Mt)	Grade (ppm U)	Uranium (tU)
Etango	62.7	174	10 900	273.5	170	46 300	45.7	171	7 800

Bannerman is also investigating potential satellite pit opportunities at Ondjamba and Hyena. These resources (in situ) have been included in the following table:

	Inferred resources		
	Tonnes (Mt)	Grade (ppmU)	Uranium (tU)
Ondjamba	85.1	141	12 000
Hyena	33.6	141	4 700
Total	**118.7**	**141**	**16 700**

Bannerman Mining Resources (Namibia), a subsidiary of Bannerman Resources, is the operator of the mining project. Bannerman originally held 80% of the Etango project, but in December 2015 it acquired the balance of it and has been seeking a development partner.

Omahola

The Omahola Project consists of three deposits, the Ongolo and MS7 alaskite deposits and the Inca uraniferous magnetite deposit. Ongolo mineralisation is primarily uraninite type. MS7 is a mineralised zone of about 600 m along strike and up to 400 m wide about 2 km west of Ongolo while Inca hosts unique high-grade uranium, magnetite and pyrite mineralisation. It is envisaged that the project would consist of a processing plant located close to the Ongolo Alaskite deposit, treating a blend of primary ore from these three deposits.

Following the first discovery hole at Ongolo South in late 2010, the extent of the deposit was confirmed in follow-up drilling late in 2012. Further in-fill and extension drilling at Ongolo was included in an updated mineral resource estimate. The JORC mineral resource of the Ongolo deposit is 11 366 tonnes U_3O_8 (9 638 tU) at a 250 ppm cut-off.

Omahola's JORC Mineral Resource base, the majority of which will be mineable by open-pit methods, currently amounts to 20 462 tonnes U_3O_8 (17 352 tU) at a 250 ppm cut-off. The 2013 exploration programmes at Ongolo focused on in-fill drilling and resource extension at Ongolo South.

Reptile Uranium Namibia (Pty) Ltd (RUN) is a wholly owned subsidiary of Australia's Deep Yellow Ltd, an Australian Securities Exchange-listed entity which also has a listing on the Namibian Stock Exchange. To date, RUN's Omahola Project was predicated on open-pit mining and conventional tank acid leach extraction. However, recent testwork indicated that a heap leach option may also be viable. Recent preliminary economic assessments and trade-off studies indicate that the project is more economically viable as a heap leach process. It is envisaged that the project would consist of a processing plant located close to the Ongolo Alaskite deposit treating a blend of primary ore from these three deposits.

Total in situ resources for Omahola Project

	Measured resources			Indicated resources			Inferred resources		
	Ore (Mt)	Grade (ppmU)	U (tU)	Ore (Mt)	Grade (ppm U)	U (tU)	Ore (Mt)	Grade (ppm U)	U (tU)
Inca				7.0	399	2 800	5.4	441	2 400
Ongolo	7.7	374	2 500	9.5	315	3 000	12.4	328	4 100
MS7	4.4	349	1 700	1.0	367	370	1.3	381	500
Total Omahola	**12.1**	**347**	**4 200**	**17.5**	**353**	**6 170**	**19.1**	**366**	**7 000**

The Tumas Sand Project

Formerly referred to as the Tubas Red Sands (TRS) Project, it was originally discovered and explored in the 1970s and 1980s. The Tubas Sand Project consists primarily of low-grade secondary uranium mineralisation (carnotite) in well-sorted aeolian sediments. Since 2006, RUN has conducted two in-fill drilling campaigns which lead to an update of the Mineral Resource Estimate (MRE) in early 2014. This MRE comprises approximately 1/3 of the area explored previously and is a subset of the entire deposit. The updated 2012 JORC compliant MRE totals 34.0 Mt at an average grade of 170 ppm U_3O_8 for 5 800 tonnes U_3O_8 (4 918 tU) at a 100 ppm cut-off.

	Indicated resources			Inferred resources		
	Ore (Mt)	Grade (ppmU)	U (tU)	Ore (Mt)	Grade (ppm U)	U (tU)
Tumas Sand	10.0	160	1 600	24.0	137	3 300

Preliminary economic analysis and trade-off studies show that the project is not viable as a standalone yellow cake producing facility. A physically beneficiated concentrate could be transported and successfully treated at a nearby processing facility within a 100 km radius. Efforts are continuing to secure an off-taker for the concentrate or a toll-treat arrangement at a nearby processing plant.

Tubas-Tumas paleochannel

RUN's exclusive prospecting licences also include extensive surficial (palaeodrainage calcrete and sand-hosted) uranium deposits along the Tubas-Tumas drainage. The palaeochannel system extend cover some 80 km, and contain secondary uranium mineralisation (carnotite) hosted predominantly by fluviatile sheetwash sands and gravels with some deeper incised palaeochannel development.

	Indicated resources			Inferred resources		
	Ore (Mt)	Grade (ppmU)	U (tU)	Ore (Mt)	Grade (ppm U)	U (tU)
Tumas	14.4	310	4 500	0.4	305	100
Tubas calcrete				7.4	324	2 400
Total	**14.4**	**310**	**4 500**	**7.8**	**320**	**2 500**

The Tumas-3 exploration target could contain 20 Mt at 300 ppm U_3O_8, 6 000 tU_3O_8 (5 100 tU) of prognosticated and speculative resources.

Aussinanis

The Aussinanis Project is a palaeochannel deposit, located near the coast. Uranium mineralisation is present from the surface to an average depth of 6 m as carnotite-hosted in sediments and calcrete. It has 6 900 tU indicated and inferred resources at about 0.02% U. In January 2013, Deep Yellow agreed with Namibia's Epangelo to transfer its Aussinanis and Ripnes projects into a new company, Yellow Dune Uranium Resources Ltd. Epangelo acquired a 5% stake in Yellow Dune to fund test work and confirm that the Aussinanis deposit can be upgraded by beneficiation. Reptile holds 85% and Oponona Investments 10%. If the test work at Aussinanis is successful, Epangelo will become the operator of the joint venture and would earn up to 70% in Yellow Dune by funding the project through to a bankable feasibility study. Reptile's holding would then shrink to 20%.

Total in situ resources at Aussinanis Project

	Indicated resources			Inferred resources		
	Ore (Mt)	Grade (ppm U)	U (tU)	Ore (Mt)	Grade (ppm U)	U (tU)
Aussinanis	5.6	179	1 000	29.0	203	5 900

Marenica

Marenica is situated in a paleochannel approximately 40 km north of Trekkopje. Carnotite uranium mineralisation occurs in both the paleochannel and weathered basement rock. The regional geology of this area consists of basin and dome tectonic features, where massive marbles of the Karibib Formation form three prominent domal structures, while steeply dipping biotite schists (Kuiseb Formation) form the basins similar to that of the Rössing mine. Potential to find a hard rock deposit is therefore encouraging. The recent discovery of uraninite-bearing alaskites on the Marenica Project further enhances the hard rock potential of the area.

In November 2011, Marenica Energy Ltd reported a resource estimate, based on historical and new data, totalling 23 483 tU at an average grade of 0.008% U.

The EPL3287 was extended to 30 November 2014. As the deposit is a relatively well-known, large, low-grade resource, Marenica Energy recently suspended all drilling activities, focusing on metallurgical testing and on an upgrade process to increase the grade of mined material prior to leaching. The upgrade process has proven successful and has reduced the leach feed to about 1% of the plant feed because of a rejection of the major gangue mineral of calcite. Calcite rejection has also enabled the proposed leach circuit to be changed from an alkali leach (with higher operating temperatures and slower kinetics) to acid (at ambient temperature and rapid kinetics), thereby reducing expected capital and operating costs.

Marenica Energy has a 75% interest in the project, with Xanthos Mining Limited (20%) and Millennium Minerals (5%).

Happy Valley/Zhonghe resources

EPL3602, which was located in Happy Valley area in Namibia some 110 km north-east of Swakopmund and near the east of Rössing Uranium, was granted to Zhonghe Resources on 1 August 2006. Zhonghe Resources (Namibia) Development P/L is a Namibian registered company founded in 2008 by China Uranium Corporation Ltd (SinoU) (58%), a wholly owned subsidiary of China National Nuclear Corporation (CNNC), and a private company, Namibia-China Mineral Resources Investment and Development P/L (Nam-China) (42%).

A 1:50 000 scale airborne radiometric survey was done by South West African Geological Survey in 1975, and a surface radioactivity survey was carried out by Rio Tinto but was interrupted by a downturn in uranium price.

The exploration work, including the geological survey, the radioactive survey, the geophysical survey, the geochemical survey, drilling, trenching and so on, was started in this area by Zhonghe Resources in 2007, with a total of 372 drill holes and 89 512 m drilled as of end of 2012.

Deposits No. 18, No. 2 and No. 15 were found in Happy Valley area. In 2012, according to JORC estimation by MicroMine Company, at a 100 ppm U_3O_8 cut-off grade, indicated resources were 67 M lbs U_3O_8 (25 700 tU) and inferred resources 39 M lbs U_3O_8 (15 100 tU) in the No. 18 deposit. The inferred resources were 30 M lbs (11 500 tU) in the other deposits (No. 2 and 15).

Total in situ resources for Happy Valley (as of 2012)

	Indicated resources			**Inferred resources**		
	Tonnes (Mt)	Grade (ppm U)	Uranium (tU)	Tonnes (Mt)	Grade (ppm U)	Uranium (tU)
N° 18	135	190	25 700	82	184	15 100
N°2, 15						11 500
Total	**135**	**190**	**25 700**			**26 600**

A feasibility study for mine development of the No. 18 deposit was undertaken from 2011 to 2012.

Engo Valley

The Engo Valley Project comprises a series of uranium anomalies exposed in and adjacent to Karoo sedimentary rocks. The project is located 600 km north of Swakopmund, on the Skeleton Coast of northern Namibia. The licence falls in the Skeleton Coast National Park. In July 2012, Metals Australia limited received an Environmental Clearance and Access Permit allowing exploration to proceed in the area.

An extension application was lodged prior to the expiry of the licence in June 2013. The delay in granting the environmental permit resulted in limited work on the tenement. The company is currently awaiting the decision of the ministry on the licence extension.

Nova Energy Namibia

RUN is the operator and holds a 65% interest in Nova Energy Namibia, which holds three EPLs for nuclear fuel, base and rare metal exploration. The licences cover areas adjacent to RUN's Omahola Project and are considered prospective for primary Rössing-type mineralisation and surficial Langer Heinrich-type mineralisation.

RUN lodged the appropriate applications to renew the environmental clearance letters for different EPLs or projects. The Environmental Management Plan is continuously improved to ensure that exploration impacts are mitigated.

- Baseline surveys were conducted prior to drilling and weekly inspections were undertaken.
- As part of mitigating impacts, three archaeological sites - namely QRS 122/6, QRS 122/12 and QRS 122/26 - are protected by RUN. These sites were declared as no-go areas by RUN and awareness was raised with regard to the sites and sign boards were erected at the respective sites.
- Ongoing climate and plant monitoring.
- Progressive site rehabilitation is ongoing and NAD 183 198 was spent on rehabilitation in 2013 and 2014.
- Environmental impact assessments envisioned for Tumas and Ongolo projects in support of mining licences to be lodged with the Ministry of Mines and Energy.
- Quarterly and biannual reporting to authorities.

Reptile Uranium Namibia's radiation management plan was updated in June 2014 and is awaiting approval from the National Radiation Protection Authority (NRPA). Regular liaising and reporting requirements are fulfilled. Radiation monitoring includes environmental dose rate, personnel radon exposure, surface contamination and Alpha-in-Air monitoring. RUN also contributed to and participated in strategic environmental assessment (SEA) for the Erongo region and therefore has and maintains ownership of the resultant Strategic Environmental Management Plan (SEMP).

Identified conventional resources (reasonably assured and inferred resources)

Identified, recoverable conventional resources in Namibia amounted to 462 987 tU as of June 2015, an increase of 7 396 tU from the last report in 2013 resulting from updated resource estimates for Langer Heinrich and Husab. Deposits in Namibia are typically large and low grade. In 2015, about 75% of the recoverable identified uranium resources were classified in the <USD 130/kgU cost category with no resources reported in the <USD 80 kg/U category.

Undiscovered conventional resources (prognosticated and speculative resources)

Undiscovered resources are estimated in areas adjacent to deposits with identified resources in Happy Valley, Etango, Tumas, Husab and Ida. As of 1 January 2015, prognosticated resources amounted to 57 000 tU and speculative resources totalled 110 700 tU (unchanged from 1 January 2013).

Uranium production

Historical review

Rössing Uranium Limited was formed in 1970 to develop the deposit. RTZ was the leading shareholder with 51.3% of the equity at the time of the formation of the company (69% in 2013). Mine development commenced in 1974 and commissioning of the processing plant and initial production took place in July 1976. In 1977, a full design capacity of 5 000 short tons of U_3O_8/year (3 845 tU/year) was established, but because of the highly abrasive nature of the ore, an aspect not identified during the pilot plant testing stage, the production target was not reached until 1979 following plant design changes. From the date of first production in July 1976 to 2015, the Rössing mine produced a cumulative total of over 104 000 tU.

Full-scale development of the Langer Heinrich mine proceeded after licensing and commissioning began in late 2006. A bankable feasibility study had confirmed that a large body of uranium mineralisation could be mined by open pit with a minimum mine life of 11 years and a process plant life of 15 years. The study showed 1 000 tU/yr could be produced for the first 11 years at a head feed grade of 0.074% U and that an additional 340 tU could be produced over an additional 4 years using the accumulated low-grade (0.027% U) stockpile. Commercial production began at Langer Heinrich in 2007 and as outlined above, the Langer Heinrich project has been expanded three times in recent years to achieve a production capacity of just over 2 000 tU/yr.

Status of production facilities, production capability, recent and ongoing activities and other issues

Total uranium production in Namibia declined from 4 239 tU in 2012 to 4 264 tU in 2013, and to 3 246 tU in 2014.

Rössing

Production at Rössing declined in recent years (2 289 tU in 2012, 2 043 tU in 2 013 and 1 308 tU in 2014) as a result of planned maintenance shutdowns, but also because of low ore grades and challenges with recovery. Various efforts are ongoing to improve the recovery rates.

The objective in 2014 was to establish the development pathway for the economical extraction of ore from the Z20 deposit. This included establishing a new pit and overland conveyor for transporting ore for processing through a modified plant at the mine. Although this major investment was discussed with potential funding partners, because of the poor uranium price, it did not come to fruition. The Z20 deposit remains part of Rössing Uranium's resource for further development at a point when market conditions improve sufficiently.

Expansion studies progressed in parallel with exploration activities and ultimately focused on heap leaching as the preferred process expansion route because of the potential lower costs and the ability to treat low-grade ore. Following initial column test work, a pilot plant was commissioned in 2010 that operated until the end of 2012 when a pre-feasibility study was completed. Further development is dependent on increased uranium prices and increases in the resource base required to support the scale of expansion under consideration.

In 2014, Rössing Uranium initiated a study to develop a desalination plant that would supply fresh water to the mine, considering the current constraints on the supply of aquifer water, as well as the high costs associated with alternative desalination supplies. Consulting teams were appointed to conduct detailed engineering, costing and environmental impact assessments of such a plant. The last quarter of 2014 saw the environmental impact assessment process completed. The envisaged location will be approximately 6 km north of Swakopmund, at the existing Swakopmund Salt Works.

Langer Heinrich

At Langer Heinrich, the initial planned production level of 1 040 tU/yr was achieved in 2008-2009. This was followed by the Stage 2 expansion to 1 350 tU/yr in 2010. Stage 3 expansion to 2 030 tU/yr was completed in 2012. A Stage 4 expansion feasibility study and environmental impact assessment were submitted to the government, but subsequently the project was put on hold because of low uranium prices. The Stage 4 expansion plan is aimed at achieving a production level of 3 850 tU/yr.

After an increase of the production in 2013, production performance was affected by plant availability and utilisation (1 699 tU in 2012, 2 035 tU in 2013 and 1 938 tU in 2014). Recovery in late 2014 was 84.5%. A heap leach to produce about 400 tU/yr from low-grade ore by mid-2014 was proposed, moving towards a 3 850 tU/yr production level. Amec Minproc was undertaking a definitive feasibility study on this. However, in April 2014, new plant investment was put on hold for at least two years. Expected production for 2016 is 1 900 to 2 100 tU, with a planned 11% reduction in milled ore grade to 580 ppm U.

In January 2014, China National Nuclear Corporation's subsidiary CNNC Overseas Uranium Holding Limited bought a 25% joint venture equity stake in the Langer Heinrich mine for USD 190 million, entitling it to that share of output.

Trekkopje

In October 2007, Areva commenced phase 1 trial mining (250 000 t of ore) and processing operations at Klein Trekkopje. The phase 2 pilot test commenced in October 2008 and resulted in an additional 3 Mt of ore being mined and stacked on a heap leach pad. The trials involved the extraction of uranium using a sodium carbonate/bicarbonate heap leach process and represent the first commercial scale application of alkaline heap leach technology in the world.

In 2009, a geotechnical site investigation and the engineering design were completed for a new 30 million tonne, on-off uranium heap leach pad covering 2.5 km^2. Construction of the main production pad began in 2010. A final production level of 3 000 tU_3O_8/yr (2 545 tU) was envisaged.

In 2012, as a direct consequence of the low uranium price, a decision was taken by Areva to place the project on care and maintenance.

Production in 2012 and 2013 was limited to 251 tU and 186 tU, respectively, demonstrating the feasibility of the technical solutions adopted and confirming the production cost targets.

Klein Trekkopje was placed on care and maintenance in mid-2013 following completion of the phase 2 pilot tests on extraction.

Since 2010, the operation has been supplied with water from a coastal desalination plant set up by Areva with about 55 000 m^3/day (20 million m^3/yr) output. Some of this water is available to other mines.

Husab

Swakop Uranium is responsible for developing and constructing a world-class uranium mine, called the Husab mine, in the Erongo region in western-central Namibia.

The main part of the Husab Project is the Rössing South orebody, located 5 km south of the Rössing mine and 45 km north-east of Walvis Bay port. The project received environmental clearance from the Namibian Ministry of Environment and Tourism in

January 2011. By the end of 2011, it had obtained a mining licence from the Ministry of Mines and Energy.

Based on the positive results of a definitive feasibility study, Husab is being developed as a conventional, large-scale open-pit mine, feeding ore to a conventional agitated acid leach process plant. The process is estimated to recover approximately 88% of the uranium. With the Husab Project seen as one of the most important uranium discoveries of recent years, Swakop Uranium is planning to develop and construct what will likely be the third largest uranium mine in the world with the potential to produce 15 million pounds uranium oxide per annum (5 700 tU). This is more than the total current uranium production of Namibia and will potentially elevate Namibia past Niger, Australia and Canada to the second rung on the world leader of uranium producers. The forecast ore grade at Husab Zones 1 and 2 is 0.0518% U. The feasibility study showed a production cost of USD 32/lb U_3O_8 including royalties, marketing and transport, with capital cost of USD 1.66 billion. The study envisages mining of 15 million tonnes of ore per year from two separate open pits to feed a processing plant producing 5 700 tU per year. Water supply and labour agreements were signed in April 2014. Construction began in February 2013. Husab uranium mine is scheduled to start uranium production in 2016, with a 24-month ramp up to full production capacity of 5 700 tU/yr by the end of 2018. The project will create more than 6 000 temporary jobs during construction and about 2 000 permanent operational job opportunities.

Until April 2012, Swakop Uranium was a 100% subsidiary of Extract Resources, an Australian company listed on the Australian, Canadian and Namibian stock exchanges. During April 2012, Taurus Minerals Limited of Hong Kong became the new owners following a successful takeover of Extract Resources. Extract Resources has subsequently been delisted. Taurus is an entity owned by CGNPC Uranium Resources Co., Ltd and the China-Africa Development Fund. In November 2012, the Namibian state-owned mining company, Epangelo, and Swakop Uranium finalised an agreement for the subscription of a 10% stake in Swakop Uranium.

Future production centres

Etango

Bannerman Resources have received environmental approvals to proceed with development of the Etango mine. A scoping study for the mine's development was completed in September 2007, followed by a preliminary feasibility study (PFS). Results of the PFS were announced in December 2009. A definitive feasibility study (DFS) was completed by Amec in April 2012. The DFS confirmed the viability of the project with a long-term uranium price of about USD 61/lb U_3O_8 (USD 159/kgU) with pre-production capital costs estimated to amount to USD 870 million. As currently planned, Etango has a projected life of 16 years at a production rate of 2 700 tU/yr. The Etango mine will be developed as a conventional open-pit mine. Tests conducted on the ore samples recovered from the mine revealed that the ore is free from clay and acid consuming carbonates. In addition, the majority of the mineralisation is available at coarse crush size. These results led to the conclusion that heap leaching is the most suitable method for optimal recovery.

Production at 2 700-3 500 tU/yr is now envisaged over the first five years, then decreasing to 2 300-3 100 tU/yr for the remaining mine life. In September 2014, the company awarded contracts to construct and operate a heap leach demonstration plant, which was commissioned in March 2015. A further three phases of leach and SX testing will run to mid-2016.

Norasa Project

The Norasa Project is a proposed development involving both deposits, Valencia and Namibplaas. A March 2015 feasibility study estimates annual production of about 2 000 tU over a 15-year mine life. Costs are estimated at USD 32.96 per lb U_3O_8 over the first five years of production and USD 34.72 per lb U_3O_8 over the mine life. Test work has improved uranium recovery from 85% to 91% by using hydrogen peroxide rather than pyrolusite (MnO_2) as the leach oxidant. Environmental approval for an open-pit mine was granted in June 2008 and a 25-year mining licence was granted in August 2008 to Valencia Uranium P/L (a wholly owned subsidiary of Forsys). Uranium production is planned to start by mid-2018.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6
Name of production centre	Rössing	Langer Heinrich	Husab	Trekkopje	Norasa	Etango
Production centre classification	Existing	Existing	Committed	Care and maintenance	Prospective	Prospective
Date of first production (year)	1976	2006	2016	2013	N/A	N/A
Source of ore:						
Deposit name(s)	SJ, SK, SH and N20	Langer Heinrich	Zones 1 and 2	Trekkopje, Klein Trekkopje	Valencia and Namibplaas	Etango
Deposit type(s)	Intrusive	Calcrete	Intrusive	Calcrete	Intrusive	Intrusive
Recoverable resources (tU)	77 956	31 185	134 000	29 287	39 600	65 346
Grade (% U)	0.025	0.045	0.033	0.012	0.017	0.016
Mining operation:						
Type (OP/UG/ISL)	OP	OP	OP	OP	OP	OP
Size (tonnes ore/day)	40 000	20 000	42 000	30 800	33 000	55 000
Average mining recovery (%)	85	90	88	90	77	78
Processing plant:						
Acid/alkaline	Acid	Alkaline	Acid	Alkaline	Acid	Acid
Type (IX/SX)	IX/SX	IX	IX/SX	HL/IX	IX/SX	HL/SX
Size (tonnes ore/day)						
Average process recovery (%)	85	85	88	80	89	85
Nominal production capacity (tU/year)	4 000	2 030	5 700	3 200	2 000	2 700
Plans for expansion (yes/no)	Yes	Yes		No	No	
Other remarks				On hold		

Employment in the uranium industry

At Rössing, because of volatile market conditions, an organisational redesign exercise resulted in a change from continuous operations to a five-day operating model. This led to 204 employees being retrenched. By the end of 2014, staff totalled 850 employees, compared with 1 141 at the end of the previous reporting year. The average number of contractors at the mine for the reporting period was 686.

At Langer Heinrich, the number of employees decreased from 402 in 2013 to 363 in 2014.

At Husab, by the end of 2014, about 4 000 people were employed on the plant's construction with another 600 on mining operations. The 4 000 will be phased out once construction of the mine is completed. However, 600 more employees will be employed for mining operations.

At Trekopje, 40 people are employed for care and maintenance operations.

Environmental activities and socio-cultural issues

In 2004, Namibia adopted "Vision 2030", a document that clearly spells out the country's development programmes and strategies to achieve its national objectives. Vision 2030 focuses on eight themes to realise the country's long-term vision. It is a vision that will take Namibia from the present into the future, a vision that will guide the nation to make deliberate efforts to improve the quality of life of the Namibian people. It is a unifying vision which will provide direction to government ministries, the private sector, NGOs and civil society, as well as regional and local government authorities. Rössing Uranium's community engagement is geared towards this vision, and the mine is supporting education, science and technology, health and development, sustainable agriculture (i.e. through work undertaken by the Rössing Foundation) and the peace and social justice components of this partnership.

Environmental Management Act, Act No. 7 of 2007

Namibia committed itself to sound environmental management and this is reflected in the Environmental Management Act, Act No. 7 of 2007 and Regulations, gazetted on 6 February 2012. The object of the act is prevention and mitigation, on the basis of the principles of environmental management that:

- ensure that the significant effects of activities on the environment are considered in time and carefully;
- ensure that there are opportunities for timely participation of interested and affected parties through the assessment process and that the findings of an assessment are taken into account before any decision is made with respect to the activities.

Atomic Energy and Radiation Protection Act, Act No 5 of 2005

The Atomic Energy and Radiation Protection Act, 2005 (Act No.5 of 2005) was gazetted on 16 January 2012. It is administered by the National Radiation Protection Authority and provides for the regulation of all activities associated with radiation sources, radioactive or nuclear material.

The primary purpose of the act is to:

- protect people against the harmful effects of radiation;
- minimise environmental pollution that may be caused by radiological contamination;
- ensure the safety of facilities and radiation sources;
- guarantee that Namibia meets its obligations within the context of international legal instruments in the sector of radiation or nuclear technologies.

In 2014, the former Uranium Institute (under the Chamber of Mines of Namibia) was reconstituted and the new industry body was formed as the Namibian Uranium Association (NUA). A key mission of the Association's Uranium Stewardship programme is to "earn public trust for the global nuclear fuel cycle through the continued replacement of standard practice with best practice". Reptile Uranium Namibia is an active member of the Stewardship programme and the Communication Technical Advisory Committee (CTAC). CTAC advises and assists the Uranium Stewardship Committee on communication and liaison with interested and affected parties, the communities and the general public at large. The NUA also assists its members with the co-ordination and training of radiation protection officers and compliance with applicable legislation in the country.

The Rössing Foundation was established in 1978 by Rössing Uranium through a Deed of Trust to implement and facilitate corporate social responsibilities within the communities of Namibia. The foundation currently has a strong presence in the Erongo region, but support has extended to other regions (Oshana, Omahaheke and Khomas).

The foundation's Deed of Trust stipulates that education of all Namibians should be furthered in order to achieve greater national productivity and to enhance lifelong learning, creating opportunities for Namibian people to use their education in employment, promoting the advancement of the living standards of all the people in Namibia and doing any act or practice which, in the opinion of the trustees, shall benefit Namibia.

In the Erongo region (75% of the resources), the focus of foundation activities from 2006 to date has been on education, the Arandis sustainable development plan, small-scale miners, community-based natural resource management (CBNRM) and the Erongo development fund. Activities in Oshana include education and CBNRM, and in Omaheke, an outreach programme.

Throughout 2012, Rössing Uranium continued to provide financial and/or technical support to the Uranium Institute, an organisation launched in 2009 to improve the quality of healthcare, environmental management and radiation safety in the uranium industry. It also provides support to the Arandis town council, the Arandis out of school youth skill development programme (youth unemployment is one of the main challenges in Arandis), small-scale mining in the Erongo region, the CBNRM and local biodiversity programmes.

At the end of 2012, the total closure cost projected for the Rössing mine in 2023 stood at just over NAD 1 486 million (about USD 175 million). This includes retrenchment and retraining costs, plant demolition and site rehabilitation, long-term seepage control and post-closure monitoring costs. The provision for closure in the independent Rössing Environmental Rehabilitation Trust Fund stood at NAD 256 million (about USD 30 million) at the end of 2012, and will be increased in the coming years to provide fully for the time of mine closure. A new mine plan is being developed to extend the life of the mine beyond 2023, and this closure cost projection will be updated in line with the new plan.

During 2011 and 2012, continuous rehabilitation activities were carried out and a redundant plant was demolished and historical waste sites rehabilitated. The disturbed area at the Z20 exploration site in the Namib Naukluft National Park was fully rehabilitated. The various rehabilitation programmes will continue into 2013 and beyond. The mine's footprint was extended minimally to amount to a total of 2 531 ha at the end of 2012. This was due to the extensions of the rock disposal facilities.

Paladin Energy, owner and operator of the Langer Heinrich production facility, continued its support and participation in Uranium Institute's activities. It has also established a stakeholder register that was originally developed during an environmental assessment process in order to maintain contact with interested individuals and organisations. During 2011 and 2012, 45 formal stakeholder meetings were held with communities, environmental organisations, government, indigenous and other groups to discuss project expansion plans and to develop an appropriate focus for its social development programme. The main issues raised by stakeholders in these consultations were education, youth development, community needs, water extraction and use. Biannual environmental reports and annual reports on project-specific issues, such as water, are submitted to the government. An environmental database was established to better evaluate and assess accumulating monitoring data (including a comprehensive surface and groundwater monitoring) in order to detect any potential issues that may arise as early as possible. The reuse and recycling of water is maximised as much as possible using water returned from the tailings storage facility and recovery bores and trenches, as well as treated effluent from the sewage treatment plant.

Swakop Uranium, also a contributing member to the Uranium Institute, has committed itself to social aspects such as local procurement, recruitment and employment, involvement in social responsibility programmes, training, education and sound environmental management practices. The Swakop Uranium Foundation was established to support the Erongo region and Namibia. Since Swakop Uranium will operate within the Namib Naukluft National Park, it is responsible for minimising impacts on this fragile ecosystem and along infrastructure routes to site. Water requirements have been met with the supply of desalinated water via a temporary pipeline through an agreement between Swakop Uranium, NamWater and Areva.

Projects have been initiated to address some of the research needs of Swakop Uranium's Environmental Management Plan. Groundwater monitoring in both the Khan and Swakop rivers has been undertaken to collect baseline water-level and water-quality data. Groundwater monitoring wells are being established around the planned locations of the open pits, waste rock dump and the tailings storage facility to measure the effect that pit groundwater drawdown will have in the area. Water quality in drawdown wells will be used as additional baseline data and monitoring throughout the life of the mine will provide an early warning system of potential impacts. As early as 2009, Swakop Uranium began assessing the amount of particulate matter (dust in the air) to contribute to baseline environmental data collection. A dust suppressant will be used at Husab on the pit and dump haul roads and other gravel roads. This will reduce the dust produced to acceptable levels, as well as potentially save up to 90% of the water that would be required to achieve the same level of control if no suppressant is used.

Uranium producers and most of the major exploration companies operating in Namibia created the Namibian Uranium Association to promote industry adherence to sustainable development performance, product stewardship and compliance with the Namibian legislative framework. The association was also created to be the leading contact point in the industry for governments, media and others interested in the positions and policies of the Namibian uranium industry.

In 2009, the South African Institute for Environmental Assessment was contracted by the government to undertake a strategic environmental assessment of the so-called central Namibian uranium rush. Funding was also provided by the German government. The report was submitted to the Namibian government in early 2011. In January 2013, the Geological Survey of Namibia released the first annual report produced under the Strategic Environmental Management Plan developed in response to the SEA.

Positive impacts noted in the SEA include stimulating the Namibian economy, skills development and infrastructure development. A number of constraints to development were also identified, such as possible water shortages, lack of skills, capacity of physical infrastructure and environmental protection. The SEA noted that a uranium rush could have a number of negative impacts in the areas of natural physical resources, biodiversity, health, infrastructure and tourism. Good governance will be critical in minimising these impacts.

The SEMP operational plan sets out several environmental quality objectives (socio-economic development, employment, infrastructure, water, air quality and radiation, health, effect on tourism, ecological integrity, education, governance, heritage and future, closure and land use) that are to be continuously monitored as a collective proxy for measuring the extent to which uranium mine development activities are moving the Erongo region towards a desired future state. An SEMP office has been established to administer the programme. The SEMP document notes that Uranium Institute has worked as a contact point with the uranium industry and supplied much of the data used in the first annual report. It also noted that the uranium industry in Namibia has voluntarily increased its application of the SEA and SEMP to guide mining and exploration plans in order to minimise and manage potential environmental impacts.

One of the key aspects of the SEMP is water supply. Since 2010, water has been supplied to Trekkopje from a coastal desalination plant built by Areva in the Erongo region. This plant will supply 20 million m^3/year output, requiring 16 MWe from the grid. Approximately half of the water will be available to other mines and agreements have been signed with Namibian Water Corp for Rössing, Langer Heinrich and Husab. The plant is jointly owned by Areva and a local company, the United Africa Group. In 2014, the government planned to start building a second plant with a 60 million m^3/year capacity. The first report on implementing the SEMP notes that uranium mining, mine development and exploration have not compromised community access to water supplies of acceptable quality.

Regulatory regime

The constitution provides for the protection of the environment and the welfare of humankind. The Minerals Policy of Namibia of 2003 is aimed at attracting investors by creating a conductive environment for mining activities; however one of its objectives is also to ensure compliance with the national environmental policy and legislation in order to develop a sustainable mining industry.

Furthermore, the Minerals (Prospecting and Mining) Act 1992 (No. 33) requires every licence holder to conduct environmental impact assessments before they start exploration. Namibia's Environmental Management Act of 2007 (Act No. 7 of 2007) came into effect in 2012 and stresses the importance of consultation with interested and affected parties. The act promotes the sustainable management of the environment and the use of natural resources by establishing principles for decision-making on matters affecting the environment, as well as the Environmental Impact Assessment Regulation.

Uranium mining is regulated under the Minerals (Prospecting and Mining) Act No. 33 of 1992 and Environmental Management Act of 2007.

In 2007, the Namibian government instituted a moratorium on uranium exploration licences for an indefinite term in order to develop a nuclear fuel cycle policy and subsequent regulatory framework for effective development, regulation, monitoring and management of the industry.

At the time, the price of uranium had reached a level that had stimulated exploration for the mineral worldwide, in particular in Namibia. The government stated that the moratorium would give it time to reconsider national policies towards uranium following an upswing in demand.

The Epangelo Mining Company was established in July 2008 to participate in the mining sector as per the provisions of the Minerals (Prospecting and Mining) Act and acquire mining rights and equity by concluding joint ventures with existing companies. The Namibian government is the sole shareholder. Namibia has identified uranium as a strategic mineral and potential source of energy production within the nuclear fuel cycle.

The government has expressed its desire to increase beneficiation to enhance economic development and has considered nuclear power programme to augment its energy needs.

Uranium requirements

Namibia has no nuclear generating facilities. Namibia's electricity supply of some 3 billion kWh per year is half supplied by South Africa, which faces serious supply constraints itself.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The government has designated its uranium resources as strategic and controlled minerals that must be treated differently from other minerals, among other reasons, because of the risk of proliferation, its characteristic as material for production of nuclear weapons, its use as fuel for energy production and its associated radiological risks.

In consideration of the special nature of uranium ore and its products, and the radiological and fissile properties of uranium, the government is prompted to develop a responsive regulatory framework which will address health, safety, research and development applicable to the nuclear fuel cycle. In addition, Namibia is considering the development of commercial nuclear power to promote energy security and meet its increasing energy needs while reducing greenhouse gas emissions in accordance with international climate change obligations.

Namibia is party to the Nuclear Non-Proliferation Treaty and has had a comprehensive safeguards agreement in force since 1998, and in 2000 signed and ratified the Additional Protocol.

Uranium exploration and development expenditures and drilling effort – domestic

(NAD – Namibian dollars)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	458 690 351	123 062 784	51 542 657	40 400 000
Industry* development expenditures	185 714 370	66 318 296	11 060 556 911	81 138 309
Total expenditures	**644 404 721**	**189 381 080**	**11 112 099 568**	**121 538 309**
Industry* exploration drilling (m)	169 499	18 023	5 428	9 845
Industry* exploration holes drilled	1 187	320	186	377
Industry* development drilling (m)	205 493	282 701	241 098	378 497
Industry* development holes drilled	4 334	N/A	N/A	380
Subtotal exploration drilling (m)	169 499			
Subtotal exploration holes drilled	1 187			
Subtotal development drilling (m)	205 493			
Subtotal development holes drilled	4 334			
Total drilling (m)	**374 992**			
Total number of holes drilled	**5 521**			

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Intrusive			159 531	244 942
Metasomatite			2 016	2 016
Surficial			24 040	51 452
Total			**189 587**	**298 410**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			189 587	298 410	74.4
Total			**189 587**	**298 410**	**74.4**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			178 880	204 276	75.2
Heap leaching* from OP			0	62 724	73.2
Unspecified			10 707	31 410	72.1
Total			**189 587**	**298 410**	**74.4**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Intrusive			67 544	132 912
Metasomatite			1 728	1 728
Surficial			8 185	29 937
Total			**77 457**	**164 577**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			77 457	164 577	74.6
Total			**77 457**	**164 577**	**74.6**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			70 617	93 085	76.1
Heap leaching* from OP			0	27 152	72.0
Unspecified			6 840	44 340	73.4
Total			**77 457**	**164 577**	**74.6**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	0	57 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	110 700

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Intrusive	103 785	2 289	2 043	1 308	109 425	1 000
Surficial	4 884	1 950	2 221	1 938	10 993	2 000
Total	**108 669**	**4 239**	**4 264**	**3 246**	**120 418**	**3 000**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	108 669	4 239	4 264	3 246	120 418	3 000
Total	**108 669**	**4 239**	**4 264**	**3 246**	**120 418**	**3 000**

[1] Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	108 669	3 988	4 078	3 246	119 981	3 000
Heap leaching	0	251	186	0	437	0
Total	**108 669**	**4 239**	**4 264**	**3 246**	**120 418**	**3 000**

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
39	1.20	0	0	327	10.07	2 880	88.73	3 246	100

Uranium industry employment at existing production centres

(Person-years)

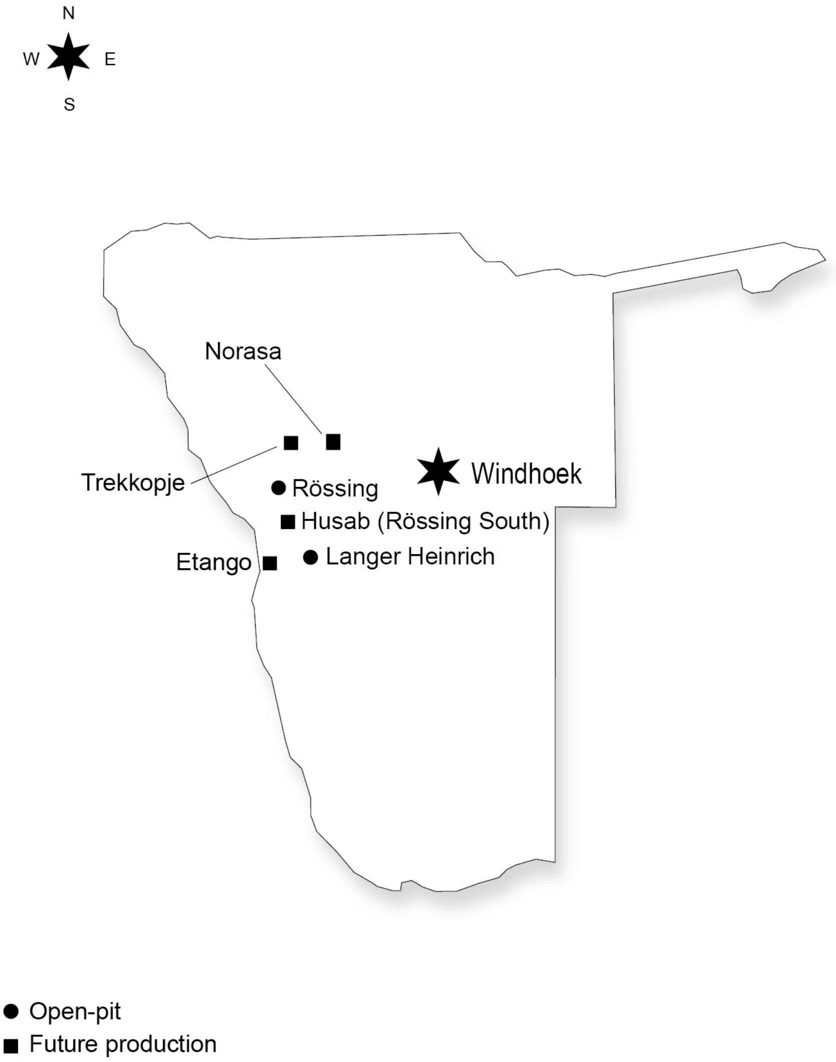
	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	2 786			
Employment directly related to uranium production	2 628	1 583	1 853	2 453

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	3 000	3 000	0	0	7 000	7 000

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	7 700	7 700	0	0	10 400	10 400	0	0	12 400	12 400


N
W
E
S
Norasa
Trekkopje
Rössing
Windhoek
Husab (Rössing South)
Etango
Langer Heinrich
● Open-pit
■ Future production

Niger*

Uranium exploration and mine development

Historical review

Uranium exploration began in 1956 in the Arlit area of Niger within the Tim Mersoï sedimentary basin, and uranium was first discovered in sandstone at Azelik in 1957 by the French Bureau de Recherches Géologiques et Minières (BRGM). The French Atomic Energy Commission initiated further studies of the sandstone which were taken over by the Compagnie Générale des Matières Nucléaires (COGEMA) and resulted in the discoveries of Abokurum (1959), Madaouela (1963), Arlette, Ariege, Artois and Taza (1965), Imouraren (1966) and Akouta (1967).

The Société des mines de l'Aïr (Somaïr) was formed in 1968 and started production from the Arlette deposit in 1971 by shallow (60 m depth) open-pit mining. From 1971 to 1988, acid heap leaching was used at Arlit, producing 200-600 tU per year, for a total of 5 900 tU over this 17-year period. The uranium recovery rate achieved was low at 50% or less and from 1988 to 2009 more than 10 Mt of low-grade ore (0.08% U average grade) has been stockpiled. In 2009, after conducting tests over several years, Somaïr restarted heap leaching using an improved process to achieve recovery rates above 85%.

The Compagnie Minière d'Akouta (Cominak) was set up in 1974 and started production from the Akouta and Akola deposits, near the town of Akokan. This is an underground operation at a depth of about 250 m. Production has now switched to the deposit of Ebba/Afasto, south of Akouta and Akola.

In 2004, COGEMA and the government of Niger signed an agreement to undertake a major exploration programme. In subsequent years, both Somaïr and Cominak were involved in exploration solely for the purpose of better evaluating previously discovered deposits. Somaïr delineated the Taza Nord deposit, while Cominak evaluated a mineralised area south-east of the Akola deposit.

Development of the large Imouraren deposit about 80 km south of Arlit was confirmed in January 2008, after an agreement was signed in 2006 to increase royalty payments by 50%. In 1974, a joint venture agreement was signed to develop Imouraren, but it was shelved because of unfavourable economics.

In 2006, the CNNC signed an agreement to develop the Azelik-Abokurum deposit and a new company, Société des Mines d'Azelik (Somina), was created in 2007 for this purpose. First production was announced at the end of December 2010.

All uranium deposits in Niger are located within the Tim Mersoï basin in close proximity to the main Arlit-In-Azaoua fault. Uranium is mined close to the twin mining towns of Arlit and Akokan, 900 km north-east of the capital Niamey (more than 1 200 km by road) on the southern border of the Sahara Desert and the western range of the Aïr Mountains. The concentrates are trucked to ports in Benin and the majority are exported to the Comurhex conversion facility in France.

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* Report prepared by the NEA/IAEA, based on company reports and government data.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration in Niger was revitalised in 2006. A total of 6 new exploration permits were granted that year and by 2011 uranium exploration activities were being carried out on 160 concessions by foreign companies. However since 2011, there have been increasing geopolitical tensions in the region, resulting in foreign companies like Paladin and URU Metals ceasing exploration activities in Niger.

Development of the Imouraren deposit about 80 km south of Arlit and 160 km north of Agadez was confirmed in January 2008, after Areva agreed to increase royalty payments to the government by 50%, following a 2006 agreement. In January 2009, Areva was awarded a mining licence. The Imouraren SA mining company was established, with Areva NC Expansion (86.5% Areva, 13.5% Kepco) holding a 66.65% interest and Sopamin of Niger holding the remaining 33.35%.

The Imouraren project is a EUR 1.9 billion investment, and Areva has also agreed to spend EUR 6 million per year on health, education, training, transport and access to water and energy for local people. Production is expected to be 5 000 tU/yr for 35 years. The deposit covers 8 km by 2.5 km and Areva lists 213 700 tonnes of uranium reserves at 0.07% U, plus 62 500 tU indicated resources. Average depth is 110 m and maximum thickness 60 m. At full production, the project's heap leaching facility will process 20 000 tonnes of ore per day with an expected 85% rate of recovery. Excavation of the first pit started in mid-2012. In May 2014, with current uranium prices not sufficient to allow profitable mining of the deposit, the government and Areva agreed to set up a joint strategic committee which will determine when mining should start, which may not be until 2020.

GoviEx Uranium holds exploration properties of 2 300 km^2 near the Arlit mine, including the Madaouela deposit, as well as 2 000 km^2 near Agadez. Trendfield (25 %) and UK-based GoviEx Uranium Inc formed the GoviEx Niger JV in 2007 to explore the Madaouela and Arnou Melle deposits, but Trendfield then exchanged this equity for a 10% share of GoviEx. GoviEx is a private company and the major shareholder is Govind Friedland. In August 2008, Cameco bought an 11% share in the company for USD 28 million, with option to increase to 48%. The Niger government holds a 10% carried interest and has the option to purchase a further 30% share when the mining licence is issued.

The GoviEx drilling programme commenced in August 2008, after the permission to start field works in the vicinity of the Madaouela Army Base was obtained. The GoviEx work programme was based on three objectives: i) Resource definition drilling of Marianne and Marilyn deposits; ii) Exploration and resource definition drilling on the Madaouela South deposit area; and iii) Exploratory drilling between the known deposits. As of 14 January 2010 for Marianne-Marilyn and 15 February 2010 for Madaouela South, a project wide total of 2 256 holes have been drilled by GoviEx for a total of 197 400 m, including outlying exploration holes and water well testing holes.

GoviEx has developed an NI 43-101 Integrated Development Plan (IDP) for five deposits (Marianne, Marilyn, Miriam, MSNE and Maryvonne). The IDP is based on detailed pre-feasibility geological studies, metallurgical testing and processing options, mine design, infrastructure, rock mechanics, tailings and heap leach, hydrogeological and environmental impact. In April 2015, NI 43-101 compliant resources of the Madaouela Uranium Project were 42 700 tU measured and indicated resources and 10 660 tU inferred resources. An open-pit mine on at least part of the deposit with conventional processing is expected to produce 975 tU/yr over 18 years, with potential for expanding the resource. Production is expected to begin in 2017 or 2018. Output is expected to reach its peak capacity of over 1 000 tU/yr in 2020. The environmental and social impact assessment for the project was filed with the Nigerien government in March 2015, and the company submitted a mining permit application in June 2015.

Global Atomic Fuels Corp., a private Canadian company, has six exploration permits north of Agadez, four at Tin Negouran (the "TN permits") and two at Adrar Emoles (the "AE Permits").

The Adrar Emoles permit hosts the Dasa deposit. The Dasa deposit occurs at the intersection between the Adrar Emoles flexure and the east-northeast trending Azouza Fault. The Azouza Fault comprises several steep east-northeast faults characterised by significant vertical displacement and forming a regional graben structure. The Dasa deposit can be described as a roll-front style deposit, a meandering stream depositional environment, a basal sheet and basal conglomerate depositional environment with secondary remobilisation possibly being due to a methane event, a hydrothermal event or a groundwater event.

From 2010 to 2014, Global Atomics Fuels Corp had drilled 969 holes (867 rotary drill holes and 102 diamond drill holes), for a total of 119 120 m. In January 2014, SRK Exploration Services released an initial resource estimation which totalled 43 850 tU grading 540 ppm U, using an 85 ppm U cut-off. The Dasa inferred resource occurs within a 500 m wide corridor along a 1.2 km long trend. In June 2014, Global Atomic announced an internal update. Estimates range from 64 600 tU at 490 ppm U (85 ppm U cut-off), to 29 600 tU grading 0.29% U (0.127% U cut-off). The base case appears to be the 36 500 tU grading at 0.222% U (0.085% U cut-off).

In addition to Dasa, two other deposits are located on the Adrar Emoles permits, Dajy and Isakanan. The Dajy deposit is located along the same major NE-SW trending Azouza Fault which hosts the Azelik and Dasa deposits, 30 km SE of Imouraren. Whereas Dasa can be traced to surface, Dajy occurs at depth. Dajy uranium mineralisation is hosted in three sandstone units over a 3.5 km long and 400 m wide area, the Tarat sandstone, the Guezouman sandstone and the Madouela sandstone. The Dajy deposit hosts 6 400 tU grading 584 ppm U (inferred resources). The Isakanan deposit is located 15 km south of the Dasa and Dajy deposits. It hosts 13 000 tU grading 760 ppm U. The Tin Negouran Permits 1-4 host the Tagadamat deposit. This deposit strikes for 3 km. The mineralisation occurs within surface paleochannels with potential for open-pit, heap leach mineralisation. The Tagadamat deposit hosts 3 500 tU grading 150 ppm U. An environmental baseline study was completed in 2009, but the project is today on hold.

URU Metals Limited reported a SAMREC (South African Mineral Resource Committee) compliant inferred resource of 1 654 tU on their In Gall deposit and in 2011 continued to drill the Aboye, Akenzigui and Fagochia targets within their Irhazer and In Gall permits. Project commitments elsewhere and security risks in Niger caused URU Metals to take steps to terminate activities in Niger by 2014.

In December 2010, Paladin completed the takeover of NGM Resources Ltd, the owner of the local company Indo Energy Ltd that held concessions in the Agadez region. NGM Resources had announced an inferred mineral resource of 4 320 tU. In early 2011, Paladin carried out a drilling programme that further defined targets for follow-up and information from the drilling was used to plan a 15 000 m follow-up drilling campaign. However, this was put on hold because of security concerns. All fieldwork has ceased and *Force Majeure* has been requested from the government authorities for an indefinite suspension of further expenditures.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The total recoverable identified conventional resources for Niger, as of the end of 2014, amounted to 411 387 tU, compared to 404 914 tU in 2012. All uranium deposits in Niger are sandstone-hosted, with average grades of 0.07 to 0.40% U.

Undiscovered conventional resources (prognosticated and speculative resources)

Total speculative and prognosticated resources in Niger, as of the end of 2014, amounted to 64 900 tU (unchanged from 2011).

Uranium production

Historical review

Uranium has been produced from sandstone deposits in Niger since 1970 by Somaïr and 1978 by Cominak.

The Société des Mines d'Azelik SA (SOMINA) was established in 2007 to mine the Azelik/Teguidda deposits. Azelik has been developed by the CNNC and came into production at the end of 2010, with the aim to ramp up to 700 tU/yr. It is an open-pit and underground operation using alkaline leach.

Uranium production in Niger has been increasing in recent years as efficiencies have been introduced. In 2010, production amounted to 4 197 tU, then increased to 4 264 tU in 2011 and 4 822 in 2012 as Azelik increasingly added to the national total. However, production declined in 2013 to 4 528 tU following the attack on the Somaïr mine on 23 May 2013 which forced Areva to suspend operations for two months while repairs were completed, and 4 057 tU were produced in 2014.

Status of production facilities, production capability, recent and ongoing activities and other issues

In May 2013, a terrorist car bomb damaged the Somaïr plant and killed 1 employee, also injuring 14. Production partially resumed four weeks later, in mid-June, and was fully restored in August. Four French nationals including an Areva employee, among a group of seven who were kidnapped from Arlit in 2010, were released in October 2013.

Somaïr and Cominak were licensed to the end of 2013, and in mid-December 2013 both were shut down for maintenance, pending resolution of negotiation on licence renewal. The mines resumed operation at the end of January 2014 under the terms of a government decree. In May 2014, the government and Areva signed a new five-year agreement for the two mines based on the 2006 mining law and expressing what both sides said was a balanced partnership. The royalty rate will increase potentially to 12% of market value, but this increase depends on profitability.

In August 2014, CNNC announced that Azelik has experienced prolonged project delays, overruns in its construction budget, and low production. In February 2015, CNNC announced that the mine would be closed and put on care and maintenance because of "tight cash flow".

Ownership structure of the uranium industry

The ownership structure of Niger's four uranium production companies are set out in the table below:

Somaïr	Cominak	Somina	Imouraren
36.6% Sopamin (Niger)	31% Sopamin (Niger)	37.2% CNUC (China)	33.35% Sopamin (Niger)
63.4% Areva NC	34% Areva NC (France)	33% Sopamin (Niger)	57.65% Areva
	25% OURD (Japan)	24.8% ZXJOY invest (China)	9% KEPCO
	10% ENUSA (Spain)	5% KORES	

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1		Centre #2	Centre #3	Centre #4	Centre #5	Centre #6
Name of production centre	Arlit (Somaïr)		Akouta (Cominak)	Azelik (Somina)	Imouraren	Madaouela	Dasa
Production centre classification	Existing		Existing	Care and maintenance	Planned	Planned	Prospective
Date of first production	1970	2009	1978	2010	Unknown*	N/A	N/A
Source of ore:							
Deposit name(s)	Tamou-Artois-Tamgak	Low-grade stockpiles	Akouta-Akola-Ebba	Azelik-Teguidda-Abokurum	Imouraren	Miriam-Marianne-Marilyn -MSNE-Maryvonne	Dasa/Dajy
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Recoverable resources (tU)	48 642	N/A	20 817	15 900	228 530	37 470	32 175
Grade (% U)	0.14	0.069	0.35	0.20	0.07	OP 0.40 UG 0.15	0.22
Mining operation:							
Type (OP/UG/HL)	OP	HL	UG	OP/UG	OP	OP/UG	OP/UG
Size (tonnes ore/day)		1 800 kt/yr				4 200 kt/yr	
Average mining recovery (%)							
Processing plant:							
Acid/alkaline	Acid	Acid	Acid	Alkaline	Acid		
Type (IX/SX)	SX	SX	SX				
Size (tonnes ore/day)							
Average process recovery (%)	95	75	92	87	89	85	
Nominal production capacity (tU/year)	1 900	1 000	1 800	700	5 000	1 040	770
Plans for expansion							1 130
Other remarks							

* Start-up date uncertain due to political and market conditions.

The Madaouela deposits are owned by GoviEx Niger Holdings Ltd (a wholly owned subsidiary of GoviEx Uranium Inc., Toronto, Canada). The government of Niger holds a 10% carried equity interest in the project through state-owned Société du Patrimoine des Mines du Niger (Sopamin), with an option to purchase an additional 30% share once a mining licence is issued.

Employment in the uranium industry

Approximately 1 175 are employed at the Somaïr mine and 1 140 at the Cominak mine. It is reported that 99% of the workers at these two mines are Nigerien. About 680 workers are employed at the Azelik mine. The Imouraren project has employed about 300 during the development stage and is expected to create about 1 400 permanent and up to 3 000 indirect jobs when the facility is in full production.

Future production centres

In May 2009, development of the Imouraren mine was launched with an initial investment of more than USD 1.6 billion. Once up to full production capacity, production of 5 000 tU/yr for 35 years is expected. Production, originally scheduled to start mid-2015, was delayed owing to security risks and poor market conditions.

GoviEx has completed a preliminary economic assessment and proposed an open-pit /underground mine development at the Madaouela project, which could go into production at 2020 horizon with a capacity to produce 1 040 tU/yr.

Global Atomic Fuels plans to construct its first mine at Dasa. It is targeting a 770 tU annual capacity with potential to ramp up to 1 900 tU production per year. Global Atomic has spent approximately CAD 50 million on exploration and development to date on its Niger projects and expects to apply for its mining licence for the Dasa project.

Environmental activities and socio-cultural issues

Both mining operations at Somaïr and Cominak have maintained their ISO 14001 certification for environmental management for many years (certification is renewed every three years). Areva maintains that environmental issues, including water preservation is fundamentally important to their operations. The mandate of the AMAN project, established in 2004, is to study the existing aquifers in the Arlit and Akokan areas to ensure an adequate supply of potable and industrial water is available and not being compromised. Areva has initiated ways to conserve and reduce water consumption and reports that over the past 15 years the annual consumption of water at the mines has been reduced by 35% while uranium production at Somaïr has doubled in the past 10 years.

In April 2010, Areva and local authorities signed a series of protocols and procedures to implement multipartite radiological control of materials and equipment in the streets of Arlit and Akokan, including more stringent monitoring of used materials being taken from the industrial sites.

Somaïr and Cominak manage two hospitals in Arlit and Akokan with technical support centres. First created to provide medical care for the miners and their families, the centres are now largely open to the public free of charge. Imouraren also recently opened a medical centre that treats local residents for free.

As the country's largest private employer, Areva has been contributing to the improvement of living conditions in local communities. In 2010, Areva initiated an ambitious societal policy and committed EUR 6 million per year for the next five years to implement it. Mining activity has resulted in the construction of housing and a modern network of water distribution and contributes to the funding of public services and the construction of educational facilities (schools, libraries, lunch rooms, etc.).

Uranium requirements

There are currently no uranium requirements in Niger. However, it has been reported that Niger is considering a civilian nuclear reactor to meet domestic energy requirements and assist in national economic development.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

One of the main objectives of Niger's national uranium policy is to achieve a higher degree of international competitiveness in the industry. In July 2011, President Issoufo stated that he would seek a better price for the country's uranium exports to maximise their value to support economic and social development. About one-third of Niger's export revenue comes from uranium.

In May 2014, the government and Areva signed a new five-year agreement for the two mines based on the 2006 mining law and expressing what both sides said was a balanced partnership. The royalty rate will increase potentially to 12% of market value, but this increase depends on profitability. The deal stipulates for the first time that the firms' boards will include Nigerien managing directors – appointed this year for Somaïr, and in 2016 for Cominak. Also, Areva will provide EUR 90 million (USD 122 million) to support constructing a road from Tahoua to Arlit, near the uranium developments, as well as a further EUR 17 million (USD 23.1 million) for development in the surrounding Irhazer Valley. Areva will also build a new headquarters building for the two operations in the capital Niamey at a cost of EUR 10 million (USD 13.6 million). The government expects more than USD 39 million in additional tax revenues annually from the new agreement. In October 2014, the government formally approved the agreement.

Production of each year is sold to joint venture partners, usually in proportion to their equity, at a set transfer price known as *prix Niger*. The quantities not sold to joint venture partners, if any, are sold to trading companies at prevailing spot price.

Uranium prices

The price of uranium sold to joint venture partners (prix Niger) is proposed by mining companies to the Ministry of Mines which ultimately decides on its level and duration of validity, which usually corresponds to one year. This price is officially published in the *National Gazette* (Journal Officiel de la République du Niger) and posted on its website. In case the price determination is made in the course of the year, it is retroactively applicable to already made deliveries.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Sandstone		17 746	235 279	316 038
Total		**17 746**	**235 279**	**316 038**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)		11 265	16 194	25 160	89
Open-pit mining (OP)		6 481	219 085	289 132	82
Unspecified				1 746	80
Total	**0**	**17 746**	**235 279**	**316 038**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG		11 265	16 194	25 160	89
Conventional from OP		6 481	44 889	62 741	82
Heap leaching from OP			174 196	226 391	82
Unspecified				1 746	80
Total		**17 746**	**235 279**	**316 038**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone			56 188	95 349
Total			**56 188**	**95 349**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)			892	15 256	76
Open-pit mining (OP)			55 296	59 819	79
Unspecified				20 274	76
Total	**0**	**0**	**56 188**	**95 349**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG			892	15 256	76
Conventional from OP			52 895	57 418	79
Heap leaching from OP			2 401	2 401	82
Unspecified				20 274	76
Total	**0**	**0**	**56 188**	**95 349**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
	13 600	13 600

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	51 300	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Sandstone	118 610	4 822	4 528	4 057	132 017	4 100
Total	**118 610**	**4 822**	**4 528**	**4 057**	**132 017**	**4 100**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	55 214	3 318	3 020	2 556	64 108	2 500
Underground mining*	63 306	1 504	1 508	1 501	67 819	1 600
Total	**118 610**	**4 822**	**4 528**	**4 057**	**132 017**	**4 100**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	N/A	N/A	N/A	N/A	N/A	N/A
Heap leaching*	N/A	N/A	N/A	N/A	N/A	N/A
Total	**118 610**	**4 822**	**4 258**	**4 057**	**132 017**	**4 100**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
1 392	34.31	0	0	2 290	56.45	375	9.24	4 057	100

Uranium industry employment at existing production centres

(person-years)

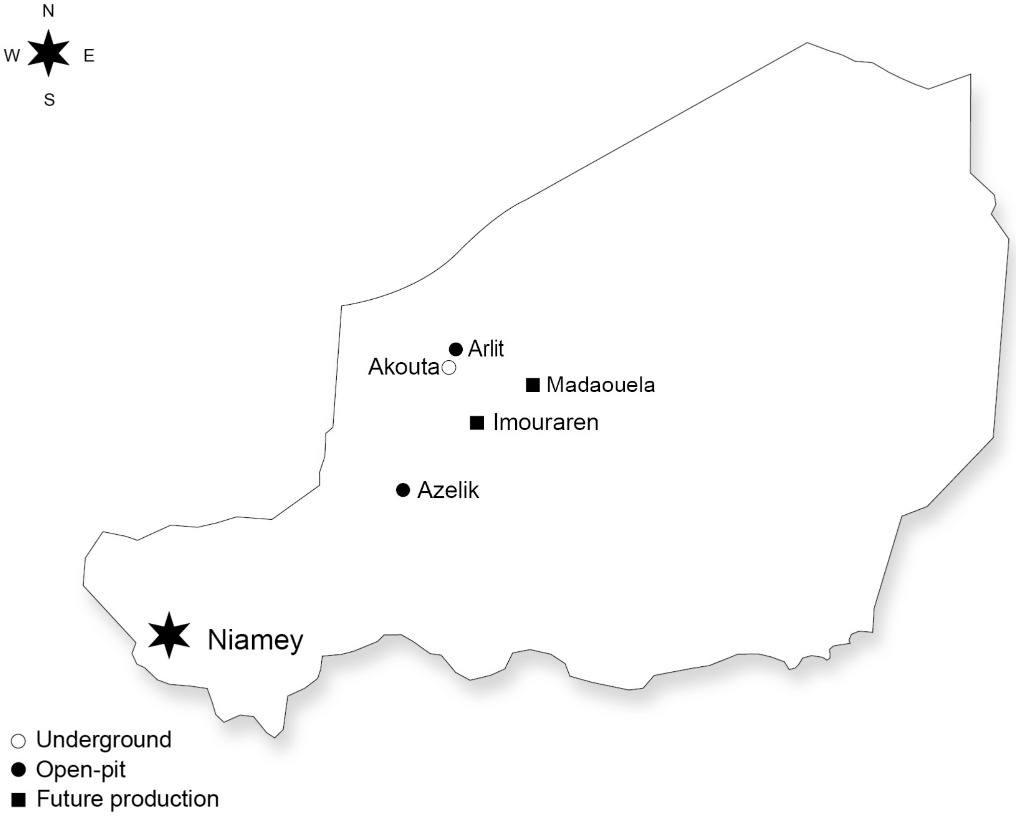
	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	2 915	N/A	N/A	N/A
Employment directly related to uranium production	N/A	N/A	N/A	N/A

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 000	1 000	4 200	4 200	1 000	2 000	5 000	5 000

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	1 000	5 000	5 000	N/A	1 000	5 000	6 000	N/A	1 000	5 000	7 500



Peru

Uranium exploration and mine development

Historical review

Macusani Uraniferous District (Department of Puno) is located in south-east Peru. The uraniferous mineralisation is found in acid volcanic Mio-Pliocene rocks (10 to 4 Ma).

Radiometric prospecting revealed over 40 uraniferous areas, the most important of which are Chapi, Chilcuno-VI, "Pinocho", Cerro Concharrumio and Cerro Calvario.

Uranium mineralisation consists mainly of autunite, meta-autunite and weeksite filling sub-vertical to sub-horizontal fractures, with impregnation on both sides of the fracture. The host rocks are rhyolites of the Quenamari Volcanic Formation.

Considering all the areas surveyed, historically, Chapi is the most important site, and detailed radiometry, emanometry, trench and gallery work, as well as diamond drilling have been carried out. The mineralisation is in sub-vertical fractures distributed in structural lineaments 15 to 150 m wide and 20 to 30 m thick. The grades vary between 0.03% U to 0.75% U, with an average of 0.1% U. Based on the exploration results, as well as the geological and emanometry information, a minimum potential of 10 000 tU has been assigned to the Chapi site and 30 000 tU to the whole Macusani Uraniferous District.

Since 2003, private companies restarted the exploration in both Macusani and the Santa Lucia-Rio Blanco area, 250 km from Macusani, also in the Tertiary volcanic environment. The uranium potential of the remainder of the country is important. The Peruvian Institute of Nuclear Energy (IPEN), through its promotional activities, has proposed highlighting new areas of interest such as San Ramón (Oxapampa and Corongo) in the central region of Peru, where some work has been conducted to identify potential uraniferous regions.

Several companies have focused on the area of Macusani in order to further develop uranium resources through drilling in different prospects within the uraniferous district of Macusani, Puno. Since 2003, exploration restarted in Macusani, Santa Lucia-Rio Blanco and Pampacolca (Arequipa), and also in the Tertiary volcanic environment.

Recent and ongoing uranium exploration and mine development activities

Macusani uraniferous district (Department of Puno) is located in south-east Peru. The uraniferous mineralisation is hosted by young acidic rocks, namely rhyolites of Upper Miocene age (8-6 Ma). There are in excess of 70 radiometric anomalies depicted to date on surface along the Macusani plateau, of which less than 20 have been drilled to date.

Recent studies on mineralisation in the Macusani district indicate that the uranium mineralisation cropping out at elevations of between ~4 100 and 4 400 m around the Quenamari Meseta, west and northwest of the town of Macusani, Puno, south-eastern Peru, comprises stockworks and associated disseminations of two coarse-grained yellow minerals, meta-autunite (hydrous calcium-uranyl phosphate), and subordinately, weeksite (hydrous potassium-uranyl silicate). From a mining standpoint, the mineralised zones are mantos, but are neither strictly stratiform nor stratabound. There is no evidence for the occurrence of precursor uraninite/pitchblende, and the thorium content of the ore is negligible.

The deposits are hosted almost entirely by the Upper Miocene Macusani Formation, about 500 m thick, gently dipping succession of subaerial, exceptionally-reduced, peraluminous sillimanite-andalusite-muscovite-biotite rhyolites which, through crystal fractionation, were intensely enriched in alkali (Li, Rb, Cs) and lithophile metals (Sn, W, Nb, Ta, Be), as well as in F, B and P. The rhyolites lack ash-flow petrographic features and were erupted as crystal-charged frothy debris-flows, with the absence of explosive degassing permitting the exceptional retention of ore metals. The background, whole-rock, uranium contents of the younger lava flows averages 28 ppm U, and attains 120 ppm U and 270 ppm U in coeval hypabyssal intrusions and residual glasses (obsidian), respectively.

Uranium potential in other parts of Peru is important and IPEN has proposed to highlight new areas of interest. In 2012, IPEN discovered new uranium occurrences in the San Ramón-Oxapampa region, where initial results demonstrate important uraniferous potential.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As a result of a series of corporate mergers and acquisitions that took place over the last six years, all the drilled uranium resources at Macusani (124 M lbs U_3O_8 or 47 709 tU) are under the umbrella of Plateau Uranium Inc., a new company derived from Macusani Yellowcake Inc. Another active company on the plateau is Fission Uranium, also from Canada but with no registered resources.

Macusani Uranium District (tU, in situ*)*

Uranium resources (tonnes U)

Prospect	**RAR**	**IR**	**Total**
Corachapi	1 931	733	2 664
Chilcuno	7 608	9 117	16 725
Quebrada Blanca	1 538	3 616	5 154
Tantamaco	1 409	6 148	7 557
Isivilla	1 354	2 182	3 536
Colibri II-III	5 651	1 577	7 228
Nuevo Corani	479	678	1 157
Tuturumani	0	482	482
Calvario I-Real	0	554	554
Puncopata	0	1 277	1 277
Tupurumani	0	1 375	1 375
Total	**19 970**	**27 739**	**47 709**

Undiscovered conventional resources (prognosticated and speculative resources)

Macusani Uranium District	
Corachapi	6 610 tU
Remainder of Macusani Uranium District*	19 740 tU
Total	**26 350 tU**
Unconventional resources and other materials **At country level**	
Permo-triasic granites**	20 000 tU
Bayovar phosphates***	16 000 tU
Thirty-nine locations****	5 600 tU
Total	**41 600 tU**

* Extension of 1 000 km^2, distribution of Tertiary volcanic rocks with associated uranium.

** Granites with radioactive anomalies and uranium occurrences located in the departments of Junín and Pasco, average of 50-80 ppm U.

*** Currently, only exploited rock phosphate concentrate; the evaluated content is 46 ppm U.

**** Others in the rest of the country, uranium deposits associated with hydrothermal deposits (Cu Pb-Ni-W).

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Mining activities, formerly conducted by the government, entered into a privatisation process with passage in 1992 of the Law of Mining Investment Promotion. This legislation aims to provide stability and a guaranteed framework for long-term investments in mining, including uranium. In recent years, the reactivation of interest in uranium exploration has resulted in permitting several foreign private companies to conduct exploration and evaluation programmes in the zones where IPEN had previously performed prospecting and exploration work.

The state, in the promotion of investment in uranium mining, plans to evaluate the potential for uranium in the country in areas other than Macusani. One such area is in the Eastern Cordillera, where occurrences of uranium in granite-type rocks also have thorium potential.

The Technical Office of the National Authority (OTAN) is responsible for policy and regulatory issues. A new law involving the promotion and development of nuclear energy for electricity generation is being developed.

Currently, Macusani Yellowcake formed as a result of the amalgamation of Global Gold Company with other local companies in Peru, a subsidiary of Macusani Yellowcake Inc. of Canada has acquired all properties from other companies that explored in the Macusani district, having thus integrated an increased uranium resource, which now makes exploitation more viable.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related	0	19 970	19 970	19 970
Total	**0**	**19 970**	**19 970**	**19 970**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Open-pit mining (OP)	0	19 970	19 970	19 970
Total	**0**	**19 970**	**19 970**	**19 970**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Heap leaching** from OP	0	19 970	19 970	19 970
Total	**0**	**19 970**	**19 970**	**19 970**

* In situ resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Volcanic-related	0	27 739	27 739	27 739
Total	**0**	**27 739**	**27 739**	**27 739**

Inferred conventional resources by production method

(tonnes U*)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Open-pit mining (OP)	0	27 739	27 739	27 739
Total	**0**	**27 739**	**27 739**	**27 739**

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Heap leaching** from OP	0	27 739	27 739	27 739
Total	**0**	27 739	**27 739**	**27 739**

* In situ resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
6 610	20 000	20 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
19 740	19 740	0

Poland

Uranium exploration and mine development

Historical review

Prospecting for uranium concentration in Poland began in 1948. An industrial plant in Kowary (Lower-Silesian area) was established that was involved in the exploitation and processing of local uranium deposits.

Research beginning in 1956 by the Polish Geological Institute involved the exploration of Carboniferous formations of the Upper Silesian Coal Basin, phosphorite formations and the analysis of drill cores from the Polish Lowlands. As a result of this research, signs of uranium mineralisation were discovered in lower Ordovician formations of the Podlasie Depression (the "Rajsk" deposit) and in Triassic formations of the Perybaltic Syneclize and the Sudetes (Okrzeszyn, Grzmiąca, Wambierzyce). In the Ladek and Snieznik Klodzki metamorphic rocks small occurrences of uranium mineralisation and the Kopaliny-Kletno deposit were discovered.

Recent and ongoing uranium exploration and mine development activities

There are no current (up-to-date) uranium deposits documented in Poland. There are some prospective indications of uranium resources and currently some small prospects for the discovery of uranium that could potentially be economically exploited.

In 2009, the Polish government decided to introduce nuclear into the energy mix and the Polish Nuclear Energy Programme is being prepared. One of the topics covered is potential mining of domestic uranium resources. Initiatives connected to this topic will be undertaken in the coming years.

In 2014, Poland completed geological and technological analysis and modelling of the process of uranium extraction from low-grade Ordovician Dictyonema shale (black shale-type). Analysis has shown that the costs of obtaining raw material for production of 1 kg of uranium would be several times higher than the current market price of that metal. In addition, reserves of uranium in waste heaps from prospecting and extractive operations in the Sudety Mts in the years 1948-1967 are estimated at 10 to 30 tU.

In May 2012, September 2013 and October 2013, three concessions for prospecting for polymetallic uranium deposit for a private company were granted ("Radoniów" area, "Wambierzyce" area and "Dziećmorowice" area in southern region of Lower Silesia).

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The data presented in the table below summarises information from historic geological documentation that does not fulfil current requirements for resource reporting and the potential for mining under current economic conditions. Reinterpretation of geological data in 2009-2010 shows that Poland has no identified conventional uranium resources that could be mined under current market conditions. Modelling of uranium extraction by underground mining from the Rajsk deposit related to the low-grade Ordovician

Dictyonema shale (black shale-type) showed that the costs of obtaining raw material for the production of 1 kg of uranium would be far too high. A comparison of these costs with market prices from the last 25 years implies that the extraction of uranium from those rocks will remain uneconomical in the foreseeable future.

Region	Resources in place (t)	Uranium content (%)
“Rajsk” deposit (Podlasie Depression)	5 320	0.025
Okrzeszyn (Sudetes)	937.6	0.05-0.11
Grzmiąca (Sudetes)	792	0.05
Wambierzyce (Sudetes)	217.5	0.0236

Undiscovered conventional resources (prognosticated and speculative resources)

Historical research also led to the identification of 20 000 tU of speculative resources. However, as with the identification of uranium occurrences noted above, the speculative resource identification needs to be done using modern methods to confirm results.

Region	Speculative resources for depth to 1 000 m (tU)
Perybaltic Syneclise	20 000

Uranium production

Historical review

In 1948, a government-operated industrial plant was established in Kowary (Lower-Silesian area) to process ore mined from local uranium deposits. Exploitation of vein deposits in the Karkonosko-Izerski Block and metamorphic deposits in the Ladek and Snieznik Klodzki continued until 1967. Production data from these uranium deposits is presented below.

	Deposit name	Uranium resources (tU)	Exploited (tU)
1	Wolnosc	94.0	94.0
2	Miedzianka	14.7	14.7
3	Podgorze	280.0	199.0
4	Rubezal	0.5	0.5
5	Mniszkow	4.5	4.5
6	Wiktoria	0.28	0.28
7	Majewo	0.96	0.0
8	Wolowa Gora	2.5	2.5
9	Radoniów	345.0	214.0
10	Wojcieszyce	14.4	12.3

Exploitation of vein deposits in the Karkonosko-Izerski Block (Wolnosc, Miedzianka, Podgorze, Rubezal, Mniszkow, Wiktoria, Majewo, Wolowa Gora, Radoniów, Wojcieszyce) and of metamorphic deposits of Ladek and Snieznik Klodzki (where some small uranium occurrences and the Kopaliny-Kletno deposit were discovered) took place until 1967, at which time the deposits were almost completely depleted. In the Ladek and Snieznik Klodzki metamorphic rocks, a few occurrences of uranium mineralisation and the "Kopaliny-Kletno" deposit were discovered, from which approximately 20 tonnes of uranium were extracted.

During this period, all uranium produced was exported to the former Soviet Union. It is estimated that between 1948 and 1967 approximately 650 tU were mined in the Sudetes of Poland. Chemical treatment of low-grade ores started in Kowary in 1969 and continued until 1972. The activity produced a significant volume of waste that was left in a tailings pond.

Status of production facilities, production capability, recent and ongoing activities and other issues

Currently in Poland, no licences for uranium production have been granted.

However, in 2012-2013, three concessions for prospecting for polymetallic uranium deposits were granted ("Radoniów" area, "Wambierzyce" area and "Dziećmorowice" area in southern region of Lower Silesia). For these concessions, the company intends to perform surface geophysics studies, three control boreholes and take into account the possibility of further drilling in the case of positive results in earlier work.

Environmental activities and socio-cultural issues

All exploitation activities associated with uranium mining and processing in Poland were performed between 1948 and 1976. Although the companies associated with this activity no longer exist, there remains a need to remediate the environment in the area around the sites where the mines operated. The Geological and Mining Law stipulates that the State Treasury is accountable for liabilities from all past uranium production activities in Poland. Therefore, the government is responsible for funding the remediation, using either the national or the district Environmental Protection Fund.

The regional authorities of the voivodship (local administration area) and its special inspectorates or officers are responsible for different aspects of the remediation. The local authorities approve remediation plans and supervise their execution and impacts. The inspectorates of the Environmental Protection of a particular voivodship are responsible, in general, for environmental monitoring. Radiological monitoring is considered a part of this overall monitoring effort and it is being performed under the responsibility of the President of the National Atomic Energy Agency.

Since 1996, Poland has taken part in the PHARE Multi-country Environmental Sector Programme on "Remediation Concepts for the Uranium Mining Operations in Central and Eastern European Countries" (CEEC). In the framework of this programme, an inventory and a common database for the CEEC have been created. According to this inventory, the situation in Poland is characterised by a large number of small-scale liabilities from uranium exploration, localised over several places in the country and generally causing minor environmental impacts.

Only a limited number of issues related to mining and milling are considered to be causing serious impacts and the most important is the tailings pond in Kowary. The 1.3 ha hydrological construction is closed on three sides by a dam that has been modified a number of times in the past. The dam itself is 300 m long (the sum of three sides) and has a maximum height of 12 m. As a result of uranium processing activities, the tailings pond has been filled with about 250 000 tonnes of fine-grained gneisses and schists with average uranium content of 30 ppm (0.003% U). In the early 1970s, the Wroclaw University of Technology (WUT) received, by governmental decision, the ownership of both the area and the facilities of the former uranium mining company. Subsequently, a company owned by the WUT has continued to use the existing chemical plant for various experimental processes on rare earth metals, chemical production and galvanic processes. As a result, about 300 tonnes of remnants of rare earth metal processing and 5 000 m^3 of post-galvanic fluids, with up to 30 tonnes of solids with a high content of aluminium, nickel, zinc and sodium sulphates, have been deposited in the pond.

The remediation programme of the tailings pond was prepared in 1997 by the WUT and successfully carried out under PHARE programme until 2003. The specific objectives of this programme are related to the construction of drainage systems, the design and construction of the tailings pond cover and the final site reclamation.

Three abandoned uranium mines in the Sudetes Mountains of southwest Poland have been successfully adapted for use as tourist attractions and for educational purposes.

The National Atomic Energy Agency conducts regular monitoring of radiation. The monitoring covers the area degraded by extraction and processing of uranium ore in the Lower Silesia region. The monitoring programme consists of the following measurements:

- Total alpha and beta radioactivity in surface waters and groundwater.
  The water is sampled from the natural outflow of the former uranium mine workings, including surface watercourses and reservoirs, dug wells and natural springs discharge (a total of 30 sampling points).
- Total alpha and beta radioactivity in drinking water.
  The water is sampled from the surface and underground public drinking water intakes (a total of 37 sampling points).
- The level of gamma radiation on the surface.
  The measurements of gamma dose rate in the area of former mine workings: drifts, shafts, dumps and in their immediate surroundings (a total of 62 objects).
- Radon concentration in the atmosphere.
  The instantaneous radon Rn-222 concentration measurements (radon emanation) in the atmosphere in the open mine workings such as shafts and tunnels (a total of 22 objects).
- Radon concentration in water.
  The water is sampled from public drinking water intakes, natural outflow from former mine workings, springs and dug wells (a total of 58 objects).

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The approximate amount of uranium required has been determined assuming the use of light-water reactors as outlined in the Polish Nuclear Energy Programme, beginning with the first 1 200 MWe or 1 650 MWe (net) unit expected to be in operation in 2025. The second nuclear power unit is planned to be in operation by 2029 (1 000 MWe to 1 650 MWe). The third and the fourth units are planned to be in operation by 2032 and 2035, respectively.

Uranium exploration and development expenditures and drilling effort – domestic

(PLN)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures				
Government exploration expenditures				
Industry* development expenditures				
Government development expenditures	5 000 0000	2 400 000	700 000	0
Total expenditures	**5 000 000**	**2 400 000**	**700 000**	**0**
Industry* exploration drilling (m)				
Industry* exploration holes drilled				
Government exploration drilling (m)				
Government exploration holes drilled				
Industry* development drilling (m)				
Industry* development holes drilled				
Government development drilling (m)				
Government development holes drilled				
Subtotal exploration drilling (m)				
Subtotal exploration holes drilled				
Subtotal development drilling (m)				
Subtotal development holes drilled				
Total drilling (m)				
Total number of holes drilled				

* Non-government.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Granite-related	445	0	0	0	445	0
Metamorphite	215	0	0	0	215	0
Total	**650**	**0**	**0**	**0**	**650**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	**Total through end of 2011**	**2012**	**2013**	**2014**	**Total through end of 2014**	**2015 (expected)**
Open-pit mining*	0	0	0	0	0	0
Underground mining*	650	0	0	0	650	0
In situ leaching	0	0	0	0	0	0
Co-product/by-product	0	0	0	0	0	0
Total	**650**	**0**	**0**	**0**	**650**	**0**

*Pre-2011 totals may include uranium recovered by heap and in-place leaching.

Short-term production capability

(tonnes U/year)

2013				**2015**				**2020**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	0	0	N/A	N/A	N/A

2025				**2030**				**2035**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Installed nuclear generating capacity to 2035

(MWe net)

2013	**2014**	**2015**		**2016**		**2020**		**2025**		**2030**		**2035**	
0	0	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	0	0	0	0	1 000	1 650	3 000	4 000	6 500	7 500

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	**2012**	**2013**		**2015**		**2020**		**2025**		**2030**		**2035**	
0	0	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	0	0	0	0	160*	264*	480*	640*	1 040*	1 200*

* First core load is not included.

Portugal*

Uranium exploration and mine development

Historical review

The first uranium-radium deposits in Portugal were discovered in 1907, and the first mining concession (Rosmaneira) was granted in 1909, although Urgeiriça became the first producing mine in 1913. Radium was mined at Urgeiriça until 1944 (50 g of estimated radium production and 500 tonnes of lost uranium), and uranium mining began in 1951. Between 1945 and 1962 a foreign, privately owned enterprise, Companhia Portuguesa de Radium (CPR) extracted and processed ores from Urgeiriça and several other mines in the Beira Alta region of central Portugal. CPR also carried out radiometric surveys, detailed geological mapping, trenching and extensive core drilling with gamma ray logging. All targets were located in Hercynian-age Beiras granitic formations.

In 1954, the Portuguese government created the Junta de Energía Nuclear (JEN) under the supervision of the Prime Minister and in 1955 started an extensive and systematic exploration programme of the territory based on geological mapping, car borne and ground radiometric surveys, geophysics (resistivity), trenching and core and percussion drilling. This programme successfully increased the resource inventory. Metasediments surrounding granitic formations proved to be a good target for hosting uranium mineralisation of economic interest. By the end of the exploration programme in 1959, JEN had discovered about 100 deposits of medium and small size in Hercynian granitic and perigranitic formations in Beiras and Alto Alentejo. The Beiras deposits together with Urgeiriça ore mill treatment plant were managed as an integrated uranium production centre. The Alto Alentejo deposits, which include the larger national ore body (Nisa, with roughly 3 500 tU) were considered sufficient to support another production centre but remain untouched. The last attempt to start production in this area was abandoned in 1999 after a positive environmental assessment but a negative economic appraisal.

Since 1976 until the mid-1990s, exploration in crystalline regions continued, successfully identifying sufficient resources to replace those depleted by mining. Exploration in sedimentary formations from 1971 to 1982 (geological mapping, geochemistry, emanometry and drilling surveys in the western Meso-Cenozoic fringe of the Lusitanian Basin) did not result in the identification of resources of economic interest.

Recent and ongoing uranium exploration and mine development activities

No activity at home or abroad.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Portugal hosts an estimated 4 500 tU of reasonably assured resources recoverable at costs of <USD 80/kgU and 6 000 tU RAR recoverable at costs of <USD 130/kgU (according to the

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* Report prepared by the NEA/IAEA, based on previous Red Books and company reports.

2007 edition of the Red Book). Additionally, 1 000 tU are reported as inferred resources recoverable at costs <USD 130/kgU. Processing plus mining losses of ~25% have been applied in all resources estimate categories.

Undiscovered conventional resources (prognosticated and speculative resources)

As reported in the 2007 edition of the Red Book, undiscovered conventional resources are estimated to include 1 500 tU of prognosticated resources. Speculative resources are not reported, because only one out-dated appraisal is available.

Uranium production

Historical review

In 1950-51, a uranium mill facility processing 50 000 t/y was built at Urgeiriça, and underground extraction continued until 1973, followed by in-place leaching between 1970 until 1991. The mine reached a depth of 500 m with a 1 600 m extension.

Between 1951 and 1962, CPR produced a total of 1 123 tU from 22 concessions, of which 1 058 tU were milled at the Urgeiriça plant and 65 tU at other mines by heap leaching. A low-grade concentrate was obtained by precipitation using magnesium oxide. During the period 1962 to 1977, the JEN took over the mining and milling activities from CPR, introducing organic solvent extraction in 1967 and expanding ore treatment capacity to 100 000 t/y to produce a rich ammonium uranate concentrate. In July 1985, a new capacity expansion to 200 000 t/y was implemented. A total of 825 tU were produced under JEN management from the Urgeiriça plant and the pilot plant at Senhora das Fontes. Between 1977 and 2001, Empresa Nacional de Urânio, SA (ENU) produced 1 772 tU. Of the total historical concentrate production, 25% came from Urgeiriça mine.

The Urgeiriça mill stopped conventional ore processing in 1999 and was decommissioned in March 2001. In this interim period only exchange ion resins charged in heap and in-place leaching plants located in Bica e Quinta do Bispo mines were processed in Urgeiriça plant and yellow cake produced thereafter. Globally, 57 ore bodies have been mined, 29 by underground methods, 24 by open pit and 4 by mixed underground/open-pit methods. In 18 of these mines, local ore treatment was used, but only at Urgeiriça were uranium concentrates produced at industrial scale. Two pilot treatment plants (Forte Velho and Sr^{a} das Fontes) produced limited amounts of concentrates (sodium uranate).

Ownership of Urgeiriça mill plant evolved over its operational history and after CPR concluded the agreement with the Portuguese government in 1962, JEN took over until 1977 when ENU, a publicly owned enterprise, acquired exclusive rights to uranium concentrate production and sales. In 1978, JEN exploration teams joined the Direcção-Geral de Geologia e Minas (DGGM). In 1992, ENU was integrated into the Portuguese state mining holding, Empresa de Desenvolvimento Mineiro. In March 2001, Empresa de Desenvolvimento Mineiro decided to liquidate ENU by the end of 2004.

Status of production facilities, production capability, recent and ongoing activities and other issues

Former production centres have been demolished and reclaimed. No future production centres are planned.

Environmental activities and socio-cultural issues

Site rehabilitation

In Portugal, Empresa de Desenvolvimento Mineiro, the state-owned company responsible for dealing with mining legacy in general, has carried out remediation work on several sites. The work developed on former uranium and radium mine sites has required expenditures amounting to a total of more than EUR 12.2 million (2011-2012).

In this respect, the most important works performed have been the beginning of rehabilitation of the industrial area of Urgeiriça mine site and its more recent tailing ponds, as well as the remediation of Bica and Cunha Baixa. Rosmaneira, a smaller mine site related to radium exploitation in the first quarter of 20th century, has also been remediated. Field work for remediation was also developed at Barroco open-pit and Freixiosa underground and open-pit mine sites.

Monitoring of the radioactive impact has continued for the main sites, and Euratom has inspected the ongoing activity and checked the quality of work done on-site.

Uranium requirements

Portugal has no uranium requirements.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Energy policy in the government programme follows the same main lines as previously, and a new energy strategy (Energia 2020) reaffirms the importance of renewable energy (mainly wind and hydropower) and energy efficiency as a means of reducing the external energy dependence and its impact on the trade balance, and of meeting commitments made with respect to the Kyoto Protocol agreement. Once again, nuclear energy is not considered in the energy mix until 2020.

Uranium stocks

No change of stocks since the 2009 edition of the Red Book.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Vein	0	4 500	6 000	6 000	75
Total	**0**	**4 500**	**6 000**	**6 000**	

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	500	500	80
Open-pit mining (OP)	0	4 500	5 500	5 500	75
Total	**0**	**4 500**	**6 000**	**6 000**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from UG	0	0	500	500	80
Conventional from OP	0	4 500	5 500	5 500	75
Total	**0**	**4 500**	**6 000**	**6 000**	

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Vein	0	0	1 000	1 000	75
Total	**0**	**0**	**1 000**	**1 000**	

Inferred conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Open-pit mining (OP)	0	0	1 000	1 000	75
Total	**0**	**0**	**1 000**	**1 000**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from OP	0	1 000	1 000	1 000	75
Total	**0**	**1 000**	**1 000**	**1 000**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
1 000	1 500	1 500

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	N/A	N/A

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Vein	3 720	0	0	0	3 720	0
Total	**3 720**	**0**	**0**	**0**	**3 720**	**0**

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	1 810	0	0	0	1 810	0
Underground mining*	1 326	0	0	0	1 326	0
In situ leaching	584	0	0	0	584	0
Total	**3 720**	0	0	0	**3 720**	0

* Pre-2011 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrate)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	3 136	0	0	0	3 136	0
In-place leaching*	250	0	0	0	250	0
Heap leaching**	321	0	0	0	321	0
Other methods***	13	0	0	0	13	0
Total	**3 720**	0	0	0	**3 720**	0

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	168	0	0	0	168
Total	**168**	**0**	**0**	**0**	**168**

Russia

Uranium exploration and mine development

Historical review

Since the beginning of uranium exploration in 1944, more than 100 uranium deposits have been discovered within 14 districts in Russia. The most significant deposits are located within four uranium-bearing districts:

- the Streltsovsk district, which includes 19 volcanic, caldera-related deposits where the mining of some deposits is ongoing;
- the Trans-Ural and Vitim districts, where basal-channel sandstone-type deposits are being developed for uranium production by in situ leach mining;
- the Elkon district that contains large metasomatite-type deposits prospective for future mining.

Recent and ongoing uranium exploration activities

There are two types of uranium exploration activities in Russia, one involves prospecting aimed at new deposit discovery and the second involves exploration at earlier discovered deposits with a view to estimate resource and delineate deposit.

Uranium prospecting in Russia is financed from the state budget by the Federal Agency for Subsoil Use (Rosnedra). In 2012, the budget amounted to RUB 0.9 billion (Russian rubles) and in 2013/2014, it increased to approximately RUB 1.0 billion. The Republic of Buryatia and the Trans-Baikal region were the main areas for prospecting, followed by the Republic of Kalmykia and Irkutsk region.

These activities were focused on two main objectives: the resource increase near operating Khiagda and Priargunsky production centres and large deposits discovery in new areas for either conventional or in situ leach mining.

The activities of 2013-2014 resulted in identification of prognosticated uranium resources of category P_1 – 56 400 tU, speculative resources of P_2 – 26 600 tU, and P_3 – 400 000 tU.

The opportunities for heap leaching mining were established for phosphorus-rare-earth-uranium mineralisation of Shargadyk and Bagaburul deposits within Ergeninsky uranium district in Kalmykia. The total prognosticated uranium resources of P_1 category in Shargadyk and Bagaburul deposits within Shargadyk-Troitsk ore field are estimated at 29 500 tU.

The methodology of ore preparation for uranium recovery via heap leaching method was elaborated at Khushidin and Eravnin deposits located within South-Vitim and Eravnin districts in Buryatia Republic. It was estimated that zinc and rare earth metals may be extracted into solution along with uranium. The P_1 prognosticated resources of Khushidin deposit are estimated at 3 000 tU, at Eravnin district P_1 – 11 800 tU, speculative P_2 resources – 5 000 tU. The deep buried prospective paleovalleys were identified in the Paleoamalat and Severoamalat areas based on geological and geophysical survey and drilling results. The prognosticated resources of P1 category identified in Paleoamalat area amount to 4 400 tU, in Severoamalat – 6 100 tU of P_1 and 16 100 tU of P_2 category.

In the Trans-Baikal region, prospecting at Sirotinka deposit (Vitim-Karenga district) resulted in 1 600 tU of P_1 prognosticated resources identification and 4 000 tU of P_2 category. The speculative P_2 resources of Torgoi area in Irkutsk region were estimated at 1 500 tU.

A number of perspective areas and structures for future uranium exploration were determined in Priargun uranium ore district (Trans-Baikal region) by means of implementation of a set of geological, geophysical and airborne-gamma-geochemical criteria. The prognosticated resources of the area are estimated at 400 000 tU in P_3 speculative category.

Exploration of existing deposits

The subsidiaries of uranium holding company "Atomredmetzoloto" (ARMZ), which is incorporated within the Russian State Corporation, Rosatom, continued exploration and resource estimation of uranium deposits which are being prepared for development.

In 2013-2014:

- the main exploration and resources estimation were completed for the group of Khiagda ore deposits in Vitim district (Republic of Buryatia);
- the exploration continued at Khokhlovskoe deposit in Kurgan region;
- the exploration activities focused on new high-grade deposits discovery continued within the Streltsovsk uranium district (Trans-Baikal region).

In 2013, ARMZ's uranium exploration budget was RUB 403 million and in situ resources were increased by 28 000 tU (for Khiagda ore field deposits). In 2014, investments amounted to RUB 266 million. Most exploration and drilling activities were performed through ARMZ's geologic exploration company, Rusburmash.

Uranium exploration abroad

Russia, through the Canadian company Uranium One Inc. (a State Corporation Rosatom subsidiary), performed geologic exploration in Kazakhstan and feasibility studies to start a new uranium deposit development in Tanzania.

In Kazakhstan, the geologic exploration was performed at five ventures jointly owned with Kazatomprom and other shareholders: Karatau, Akbastau, Southern Mining-Chemical Company (prior to October 2014 – Betpakdala, including Akdala and Southern Inkai mines), Khorasan (prior to October 2014 – Kyzylkym), and Zarechnoye. The main exploration at Karatau and Akbastau mines was completed in 2013 and resulted in the anticipated resources growth which was confirmed by approved technical reports. In 2015, the exploration continued at the Kharasan and Zarechnoe mines and restarted at Akdala and Southern Inkai mines in order to convert resources to the identified category and supply long-term production programmes with a reliable resource base. The 2012 expenditures also included investments in Khorasan mine development, commercial operation which began in 2014. Nowadays all mines are in commercial production stage.

In Tanzania, Mantra Recourses Company performed feasibility studies, detailed engineering and exploration for the Mkuju River uranium project development. Uranium One Inc. was appointed as the project operator. In recent years, activities were focused on technical optimisation, mining plan improvement, necessary licences and obtaining permits. In 2011-2012, Mantra Resources continued geological exploration aimed at new favourable zones identification and resources reassessment. In 2013, the technical report on resources and feasibility study was updated, and in 2014 the front-end detailed engineering was completed. In addition, in 2012-2013, the research activities were performed with the purpose of optimising the ore processing flow sheet and of evaluating potential for partial resources extraction by the in situ leach mining method.

Recent mine development activities

The activities for uranium deposits development in Russia were performed in two main areas: pilot operations at existing or under construction mines and feasibility studies or engineering works at planned mines.

In 2013, the Dalur mine (Kurgan region of Russia) started advanced pilot in situ leach mining at the Khokhlovskoe deposit, which is located 110 km from the main mining centre.

The development of the Istochnoe deposit was started in 2014 at Khiagda mine (Republic of Buryatia).

The Gornoe Mining Company has completed exploration, engineering and hydrogeological studies and continued pilot mining project development for Berezovoe deposit located in Trans-Baikal district.

In 2014, the concept for Argunskoye and Zherlovoye deposits development was completed and it will be the basis for the new mine No. 6 construction at Priargunsky Mining-Chemical Production Association.

The intensity of other uranium deposit development in Elkon and Trans-Baikal uranium ore districts has decreased because of unfavourable market conditions.

Uranium resources

Identified resources (reasonably assured and inferred resources)

In 2013-2014, a comprehensive exploration and technical-economic evaluation of uranium resources was undertaken.

As of 1 January 2014, total recoverable uranium resources in Russia attributable to category RAR and Inferred resources amounted to 695 200 tU. It is an increase of 6 000 tU or approximately 1% compared to 1 January 2013. The increase was mainly achieved by additional exploration and resources estimation for uranium sandstone deposits in the Khiagda uranium district.

Recoverable reasonably assured resources increased almost by 5% and amounted to 273 800 tU, 83% of which are recoverable at a cost less than USD 130/kgU and only 10% are recoverable at a cost less than USD 80/kgU. 64% of RAR resources may be mined by conventional underground mining method. All resources attributable to the category less than USD 80/kgU are planned to be mined by in situ leach method.

Inferred uranium resources amounted to 421 400 tU, of which only about 5% are recoverable at a cost of less than USD 80/kgU. Over 63% of inferred uranium resources are expected to be mined by conventional underground mining method.

Undiscovered conventional resources (prognosticated and speculative resources)

As of 1 January 2014, Russian prognosticated uranium resources amounted to 126 300 tU, and speculative resources to 538 000 tU. In the Russian classification system, “prognosticated” corresponds to P_1, and “speculative” to P_2 and P_3 categories.

The majority of prognosticated resources are located in the Trans-Baikal region (Streltsovsk and East Trans-Baikal uranium ore districts), in the Republic of Buryatia (Vitim district), in the Republic of Sakha-Yakutia (Elkon district) and the Republic of Kalmykia.

Uranium production

Historical review

The first Russian uranium mine was the Lermontov Complex, presently referred to as the Lermontov State Enterprise "Almaz". Almaz is located 1.5 km from the town of Lermontov in the Stavropol region of Russia. The Beshtau and Byk vein-type deposits were mined, and both are currently depleted. Their original resources totalled only 5 300 tU (at an average grade of 0.1% U) and were extracted by two underground mines starting in 1950. Mine 1 (Beshtau) was closed in 1975 and mine 2 (Byk) in 1990. The ore was processed at the local processing plant using sulphuric acid leaching. From 1965 to 1989, small amounts were also produced via stope (block) and heap leaching methods. From the 1980s until 1991, uranium ore transported from Ukraine and Kazakhstan was also processed at Almaz. Production from local deposits totalled 5 685 tU, with 3 930 tU extracted by underground mining and 1 755 tU by a combination of the different leaching technologies.

Between 1968 and 1980, 440 tU were produced by open-pit mining from the small Sanarskoye deposit in the Trans-Ural district by the Malyshevsk Mine, which was the operator of this project.

The joint Stock Company "Priargunsky Mining-Chemical Production Association" (Priargunsky) has been the largest uranium production centre in Russia over the past several decades. The Priargunsky production centre is located in the Chita region, 10-20 km from the town of Krasnokamensk (population of about 60 000). The production is based on 19 volcanic deposits of the Streltsovsk uranium district, which has an overall average grade of about 0.16% U. Mining has been conducted since 1968 by two open pits (both now depleted) and five underground mines. Underground mines 1, 2 and Glubokiy have been active for more than 40 years and mine 8 started operating in 2012. Milling and processing have been carried out since 1974 at the local hydrometallurgical plant using sulphuric acid leaching with subsequent recovery by ion-exchange extraction. Since the 1990s, low-grade ore has been processed by heap and small amounts by stope/block leaching method.

To date, about 144 000 tU has been produced at the Priargunsky mining complex, making it the largest uranium production centre in the world. Cumulative production through 2014 at the Russian uranium mines totalled 159 000 tU through the end of 2014.

Status of production capabilities

Uranium production in Russia is carried out by three mining centres owned by the Atomredmetzoloto Uranium Holding. In 2014, uranium production in Russia amounted to 2 991 tU, of which 1 970 tU were produced using conventional underground mining method and 1 021 tU produced using in situ leach method. From the 1 970 tU initially mined by underground method, 1 687 tU was produced at the hydro-metallurgic plant by conventional ore reprocessing, and 283 tU was processed by heap leaching with subsequent solutions treatment.

The Priargunsky Mining-Chemical Production Association (PMCPA) remains the key uranium mining centre in Russia. Its resource base is represented by the volcanic-type uranium deposits of the Streltsovsk uranium ore district with current in situ resources tonnage at about 107 000 tU as of 1 January 2015.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Priargunsky Mining Combine (Priargunsky)	Dalur	Khiagda	Elkon Mining and Metallurgical Complex (Elkon)	Gornoe Uranium Mining Company (Gornoe)
Production centre classification	Existing	Existing	Existing	Prospective	Prospective
Date of first production	1968	2004	2010	2025-2030	N/A
Source of ore:					
Deposit name(s)	Antei, Streltsovskoe and others	Dalmatovskoe Khokhlovskoe and others	Khiagda, Vershinnoe and others	Yuzhnoe, Severnoe	Gornoe, Berezovoe
Deposit type(s)	Volcanic	Sandstone basal channel	Sandstone basal channel	Metasomatic	Vein
Recoverable resources (tU)	95 700	7 400	29 900	303 600	3 200
Grade (% U)	0.16	0.04	0.05	0.15	0.20
Mining operation:					
Type (OP/UG/ISL)	UG, HL	ISL	ISL	UG	UG, HL, IPL
Size (tonnes ore/day)	6 700	N/A	N/A	5 500	1 900
Average mining recovery (%)	95	75	75	85	70
Processing plant:					
Acid/alkaline	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	IX
Size (tonnes ore/day)	4 700	No data	No data	No data	No data
Average process recovery (%)	95	98	98	95	95
Nominal production capacity (tU/year)	3 000	700	1 000	5 000	300
Plans for expansion	Yes	Yes	Yes	N/A	N/A
Other remarks					

The Priargunsky mining centre is implementing a set of activities focused on optimisation and technical modernisation of the operating mines, and on completing construction of mine No. 8, which has a planned capacity of 370 tons of ore per year. In 2014, the Priargunsky mining centre prepared a new concept for Argunskoe and Zherlovoye deposits development, which will be used in the future as a basis for a new mine No. 6 feasibility study. The Priargunsky mining centre also conducts exploration at flanks and deep horizons of existing deposits located in Streltsovsky ore field and regional prospecting for new deposits in the South Priargun province.

Dalur Mine in Kurgan Region has been mining the Dalmatovskoye and Khokhlovskoe deposits using sulphuric acid in situ leaching method. The known recoverable resources of these two deposits were estimated at around 9 000 tU as of 1 January 2015. In 2014, Dalur produced 578 tU. The development expansion at the Ust-Uksyansky section of Dalmatovo deposit was completed in 2014. In addition, in 2013-2014 exploration was carried out and pilot plant capacity was expanded at Khokhlovskoe deposit.

Khiagda mine has been developing the deposits of Khiagda ore field by in situ leach method with total recoverable resources exceeding 39 000 tU. In 2014, uranium production was 443 tU, which is 3 tons above 2013 results. During 2013-2014, the mine continued main facilities construction and started new Istochnoe deposit development.

The exploration activities were continued in order to supply long-term production plans with a reliable resource base. In 2013, the roadmap for a group of Khiagda uranium deposits was approved, which ensures the production capacity of 1 000 tU/y in a mid-term perspective.

Employment in the uranium industry

In 2014, the Russian uranium industry employed 8 790 persons, of whom 7 929 are Priargunsky employees, 448 are employed at Dalur and 413 are employed at Khiagda. Of the Priargunsky employees, 5 265 were directly involved in uranium production and processing, while the remainder worked in auxiliary and service companies (coal open-pit mining, power plant, logistic company, etc.).

Future production centres

In 2013-2014, the Uranium holding Atomredmetzoloto and its daughter companies continued exploration, design studies and research work to prepare deposits in the Trans-Baikal region and Sothern Yakutia for development.

Gornoe Mining Company (Trans-Baikal region) upon geologic exploration, engineering and hydrogeological research completion, has continued pilot mining project design for Berezovoe deposit.

The development intensity at the other uranium deposits in Elkon and Trans-Baikal districts was suspended because of unfavourable market conditions.

Secondary supply

Fabrication and/or use of mixed oxide fuel

The fuel supply for large-scale nuclear power from a long-term perspective requires consideration of fast breeder reactors. The activities for physical start-up of Beloyarsk NPP BN-800 reactor were begun in 2014 for this task implementation. It is designed to use hybrid core containing fuel assemblies with both uranium and mixed oxide (MOX) fuel. The full transfer of the reactor installation core to MOX fuel will be accomplished, presumably by 2019.

Reprocessed uranium

Russia has all competences for using the reprocessed uranium (RepU) in the thermal reactors fuel cycles. The reprocessed uranium is used as a secondary source to fabricate nuclear fuel for Russian nuclear power plants. Russia also provides services for foreign customers to produce nuclear fuel from RepU.

Uranium requirements

As of 1 January 2015, 10 nuclear power plants in Russia operated 33 units with a total installed capacity of 25.2 GWe. They generated 17% of the electricity produced in the country. In the European part of Russia, the share of nuclear power electricity reached 40%.

In 2014, Russian nuclear power plants generated 180.5 billion kW hrs of electricity. The current annual consumption of Russian NPPs in the uranium equivalent is about 4 000 tU.

Uranium fuel requirements are being supplied by uranium produced in the Russia and Kazakhstan, uranium stockpiles and secondary sources.

Uranium exploration and development expenditures and drilling effort – domestic

(RUB millions)

	2012	2013	2014	2015 (expected)
Industry exploration expenditures	840	403	266	109
Government exploration expenditures	910	1 004	982	720
Industry development expenditures	390	123	98	136
Government development expenditures	0	0	0	0
Total expenditures	2 140	1 530	1 346	965
Industry exploration drilling (m)	56 750	76 100	67 200	19 000
Industry exploration holes drilled	225	366	253	190
Government exploration drilling (m)	64 000	82 600	75 300	55 000
Government exploration holes drilled	380	340	300	230
Industry development drilling (m)	N/A	N/A	N/A	N/A
Industry development holes drilled	N/A	N/A	N/A	N/A
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	120 750	158 700	142 500	74 000
Subtotal exploration holes	605	706	553	420
Subtotal development drilling (m)	N/A	N/A	N/A	N/A
Subtotal development holes	N/A	N/A	N/A	N/A
Total drilling (m)	120 750	158 700	142 500	74 000
Total number of holes drilled	605	706	553	420

Uranium exploration and development expenditures (non-domestic)

(USD millions)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	8.8	11.7	3.0	17.1
Government exploration expenditures				
Industry* development expenditures	21.3	6.5	1.9	0.6
Government development expenditures				
Total expenditures	**30.1**	**18.2**	**4.9**	**17.7**

* State Corporation Rosatom.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	176 400	176 400	85-90
In situ leaching acid	0	27 300	27 300	27 300	75
Co-product and by-product	0	0	0	45 400	65
Unspecified	0	0	24 700	24 700	75
Total	**0**	**27 300**	**228 400**	**273 800**	**80**

Overall recovery factor was 80%.

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	164 100	164 100	85
In situ leaching acid	0	27 300	27 300	27 300	75
In-place leaching*	0	0	500	500	70
Heap leaching from UG**	0	0	11 800	11 800	70
Unspecified	0	0	24 700	70 100	75
Total	**0**	**27 300**	**228 400**	**273 800**	**80**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	27 300	27 300	27 300
Granite-related	0	0	1 600	1 600
Intrusive	0	0	0	45 400
Volcanic-related	0	0	86 600	86 600
Metasomatite	0	0	104 100	104 100
Phosphate	0	0	8 800	8 800
Total	**0**	**27 300**	**228 400**	**273 800**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	0	233 700	283 600	85-90
Open-pit mining (OP)	0	0	200	200	70
In situ leaching acid	0	20 400	20 400	24 500	75
Co-product and by-product	0	0	0	34 700	65
Unspecified	0	0	25 100	78 400	75
Total	**0**	**20 400**	**279 400**	**421 400**	**80**

Overall recovery factor was 80%.

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	0	227 600	274 800	85
In situ leaching acid	0	20 400	20 400	24 500	75
In-place leaching*	0	0	2 100	4 600	70
Heap leaching** from UG	0	0	4 000	4 200	70
Heap leaching** from OP	0	0	200	200	70
Unspecified	0	0	25 100	113 100	75
Total	**0**	**20 400**	**279 400**	**421 400**	**80**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	20 400	20 400	67 600
Granite-related	0	0	2 700	5 700
Intrusive	0	0	0	34 700
Volcanic-related	0	0	31 400	51 500
Metasomatite	0	0	222 100	256 400
Phosphate	0	0	2 800	5 500
Total	**0**	**20 400**	**279 400**	**421 400**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	126 300	126 300

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	N/A	538 000

Historical uranium production by production method

(tonnes U concentrate)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining	38 655	0	0	0	38 655	0
Underground mining	104 091	2 001	2 133	1 970	110 195	1 914
In situ leaching	7 110	861	1 002	1 021	9 994	1 099
Total	149 856	2 862	3 135	2 991	158 844	3 013

Historical uranium production by processing method

(tonnes U concentrate)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	139 722	1 763	1 937	1 687	145 109	1 566
In-place leaching*	241	0	0	0	241	0
Heap leaching**	2 783	238	196	283	3 500	348
In situ leaching	7 110	861	1 002	1 021	9 994	1 099
Total	**149 856**	**2 862**	**3 135**	**2 991**	**158 844**	**3 013**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end 2014	2015 (expected)
Sandstone	7 110	861	1 002	1 021	9 994	1 099
Volcanic and caldera-related	142 746	2 001	2 133	1 970	148 850	1 914
Total	**149 856**	**2 862**	**3 135**	**2 991**	**158 844**	**3 013**

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
2 991	100	0	0	0	0	0	0	2 991	100

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 099	1 099	3 013	3 013	1 720	1 720	3 060	3 060

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
1 970	1 970	5 430	5 430	1 980	1 980	5 280	9 610	1 680	1 680	N/A	N/A

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	172.2	180.5

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	9 526	10 164	8 790	7 125
Employment directly related to uranium production	5 810	7 180	6 126	5 495

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
25 200	25 200	Low	High	Low	High	Low	High	Low	High	Low	High
		27 200	27 200	31 600	31 600	32 500	35 000	32 500	41 400	32 000	42 700

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
4 400	4 400	Low	High	Low	High	Low	High	Low	High	Low	High
		4 700	4 700	5 500	5 500	5 700	6 100	5 700	7 200	5 600	7 400

Slovak Republic

Uranium exploration and mine development

Historical review

Beginning in 1947, uranium exploration (surface radiometric prospecting) was performed in different areas of the Slovak Republic (part of the former Czechoslovakia). Surface and airborne radiometric techniques, along with prospecting, borehole logging, geoelectric and geomagnetic prospecting and hydrogeochemistry were used to determine six regions of uranium mineralisation. Based on the results of this early work, it was concluded that the Slovak Republic had only small uranium resources of economic interest. Between 1985 and 1990, state exploration activities in the eastern part of the Slovak Ore Mountains led to the estimation of resources of economic interest at the Košice deposit. Uranium mining was terminated in 1989-1990 as an attenuation programme for exploration, and mining was instituted between 1990 and 2003, bringing state-funded exploration activities to an end. No uranium exploration occurred between 1990 and 2005.

Recent and ongoing uranium exploration and mine development activities

Until 1 January 2015, three exploration licences for uranium were applicable in the Slovak Republic. Exploration companies involved include: Ludovika Energy Ltd (related to European Uranium Resources), performing exploration in two areas; and Beckov Minerals Ltd (related to Ultra Uranium, Canada), performing exploration in one area in western Slovak Republic.

Ludovika Energy Ltd (a subsidiary of European Uranium Resources) continued exploration in two prospecting areas in eastern areas of the Slovak Republic. The most prospective exploration licence covers uranium mineralisation in Kuriskova, near Košice. On 30 January 2012, European Uranium Resources announced the results of a preliminary feasibility study prepared by Tetra Tech, Inc. of Golden, Colorado. Highlights of the PFS include an initial rate of return of 30.8%, a 1.9-year payback a net present value of USD 277 million at an 8% discount rate (pre-tax, base case assuming prices of USD 68/lb U_3O_8 and USD 15/lb Mo). Indicated resources total 28.5 million pounds of U_3O_8 (10 960 tU) and inferred resources amount to 12.7 million pounds of U_3O_8 (4 885 tU), using a cut-off of 0.05% U. Life of mine operating costs are USD 22.98/lb U_3O_8 (USD 59.75/kgU), assuming a net molybdenum credit of about USD 1.27 per pound of U_3O_8 (USD 3.30/kgU). The project can be developed as an underground mine and a processing facility that would utilise conventional alkaline (non-acid) processing.

In April 2014, European Uranium Resources Ltd entered into an agreement for the sale of its Kuriskova and Novoveská Huta uranium projects to Forte Energy NL. In October 2014, European Uranium Resources Ltd announced that it had executed a definitive agreement that allows Forte Energy NL to earn a 50% interest in the company's uranium projects. The interest will be held through ownership of 50% of the company's currently wholly owned Slovak subsidiaries, Ludovika Energy and Ludovika Mining, which hold the mineral licences comprising the Kuriskova and Novoveská Huta uranium projects.

In November 2014, European Uranium Resources Ltd reported that the management committee of the joint venture between Forte Energy NL and European Uranium Resources Ltd met in the Slovak Republic to discuss and agree upon upcoming plans for the Kuriskova project to be funded solely by Forte (www.euresources.com).

Crown Energy Ltd (a subsidiary of GB Energy) drilled five exploration holes (totalling 204 m) in 2011. During 2012, GB Energy completed exploration programmes over the Kluknava and Vitaz-II exploration areas. In June 2012, following an extensive review of archival material, Crown Energy Ltd uncovered data from a 1960s drilling programme in the vicinity of the Kluknava and Vitaz-II licence areas. Given the potential for data that was generated from this activity to provide new information, GB Energy deferred new exploration works until the data could be fully analysed. Detailed study and results of interpretation of the 1960s programme were expected to be published in 2014 (www.gbenergy.com.au). No new information on prospection activities appeared and exploration licences expired in 2014.

Activities and exploration results of Beckov Minerals Ltd in exploration area Horka nad Vahom - Kalnica were not published.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

In 2012, a pre-feasibility study was finalised and a new reserves calculation report for Košice I (Kuriskova area) was approved by the Commission for Reserves Classification (Ministry of Environment of the Slovak Republic). This revised total increased Košice I resources by over 9 000 tU from the total reported in 2011. At present, total indicated and inferred uranium resources in the two registered uranium deposits represent a total of 19 318 tU.

Deposit	Organisation	Ore resources (t)	U resources (tU)
Košice I	Ludovika Energy Ltd	5 427 000	15 830
Novoveská Huta	Ludovika Energy Ltd	3 876 000	3 488

Undiscovered conventional resources (prognosticated and speculative resources)

Prognosticated resources are estimated to occur in areas surrounding identified deposits and a new estimate of prognosticated resources for the Košice deposit has been developed.

Deposit	Estimated grade (%)	Ore resources (t)	U resources (tU)
Košice I	0.2% U	1 845 432	3 691
Novoveská Huta	0.06% U	12 040 000	7 224

Uranium production

Historical review

During the first period of uranium exploration (1954-1957), a small amount (1.4 tU) was mined in the Novoveská Huta – Hnilcik region. From 1961 to 1990, a total of 210 tU was mined, mainly from Novoveská Huta as a by-product of copper mining, but also from the Muran, Kravany, Svabovce and Vikartovce deposits.

Environmental activities and socio-cultural issues

Environmental activities cover monitoring activities in the historical mining area of the Novoveská Huta deposit. Monitoring includes chemical analyses of mine water outflow as well as geochemical and geological engineering evaluations of the condition of tailings and waste rock piles.

Partial monitoring of such factors is part of a national environmental monitoring network that is focused on natural or anthropogenic geological hazards (as indicated by the acronym ČMS GF). Selected mining sites are monitored, including the above-mentioned area.

Waste rock management must be performed according to Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC. In the Slovak Republic, related legislation is NR SR (National Council of the Slovak Republic) Act No. 514/2008 Col. on the management of waste from extractive industries and the Decree of the MŽP SR (Ministry of the Environment of the Slovak Republic) No. 255/2010 Col., which executes the act on the management of waste from extractive industries.

Several studies and environmental evaluations of radioactive materials and the impacts of mining in this locality were conducted in the past:

- Bezák, J. and A. Donát (1996), "Mine Waste Piles and Settling Pits – Evaluation of Natural Radioactivity of Selected Deposit Sites" (*Haldy a odkaliská – zhodnotenie prirodzenej rádioaktivity vybraných ložísk nerastných surovín*). Ministry of the Environment of the Slovak Republic, Uranpres JSC.
- Daniel, J., E. Mašlár and I. Mašlárová (2001), "Effectiveness of Remediation of Uranium Activities on Slovakian Territory" (*Účinnosť revitalizácie po uránovej činnosti na území Slovenska*), Ministry of the Environment of the Slovak Republic, Uranpres JSC.
- Daniel, J., et al. (2005), "Evaluation on Geological Works for U Ores in Selected Regions of the Western Carpathians in the Territory of Slovakia" (*Zhodnotenie geologických prác na U rudy vo vybraných oblastiach Západných Karpát na území Slovenska*), Final Report, Ministry of the Environment of the Slovak Republic, Uranpres JSC.
- Letkovičová, M. and Božíková, K. 2008: *Dlhodobá demograficko - epidemiologická štúdia obyvateľstva Spišskej Novej Vsi, Environment, a.s., Centrum bioštatistiky a environmentalistiky, Nitra* (Long-term demographic-epidemiologic population study; in Slovak language only).
- Thorne M. C., et al. (2000), "Remediation of Uranium Liabilities in Slovakia", Final Report, AEA Technology, UK.

Uranium requirements*

The Slovak Republic has two nuclear power plants (Bohunice and Mochovce) with a total of four pressurised water reactors, of the VVER-440 type. Two reactors are in operation at each site and all four reactors operate continually at increased power (107% of the nominal power). As of 31 December 2014, the total installed capacity amounted to 1 814 MWe net.

An additional two reactors are currently under construction at the Mochovce site (units 3 and 4). Based on actual schedules, completion of the two new reactors in Mochovce NPP could be delayed, meaning that unit 3 (80% complete) could be connected to the grid in the third quarter of 2016, and the similar capacity unit 4 in 2017 (presently 60% ready).

Design and development works for the use of nuclear fuel with higher enrichment on units 3 and 4 Bohunice NPP and units 1 and 2 Mochovce NPP were successfully completed, and during the year 2014 fresh nuclear fuel with average enrichment of 4.87% of ^{235}U was loaded into all four reactors.

*Supply and procurement strategy**

In June 2014, Slovenské Elektrárne signed a contract with the Russian company TVEL to supply fresh nuclear fuel for units 3 and 4 of the Bohunice NPP and units 1 and 2 of the Mochovce NPP. The contract covers the period from 2016 to 2021 and includes the fuel fabrication for all four units and the supply of nuclear material for Bohunice unit 4 and Mochovce unit 2. Simultaneously, Slovenské Elektrárne signed a contract with the French company Areva to supply enriched uranium product for the fabrication of the nuclear fuel for Bohunice unit 3 and Mochovce unit 1, covered by the above-mentioned contract with TVEL.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Energy Policy of the Slovak Republic (Resolution of the Government of the Slovak Republic No. 29/2006)

One of the priorities set to facilitate meeting objectives of the energy policy is to utilise domestic primary energy sources for electricity and heat production in an economically effective basis.

Energy Security Strategy of the Slovak Republic (Resolution of the Government of the Slovak Republic No. 732/2008)

The objective of the energy security strategy is to achieve a competitive, secure, reliable and efficient supply of all forms of energy at reasonable costs that protect the consumer and the environment and promote sustainable development, security of supply and technical safety.

The high share of nuclear energy in the energy mix of the Slovak Republic relies on dependable sources of sufficient numbers of fuel elements, which are only at this time offered in Europe by Russia and France. It is considered that in the future, these fuel element producers could require from customers a counter-value in the form of uranium as a certain form of payment.

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* Data provided by Slovenské Elektrárne, a.s; ENEL Group.

Legislative and economic support for the efficient and rational use of domestic uranium resources is needed to considerably reduce the dependency on imported energy sources, whose market prices have risen sharply in past years. Increased uranium prices and higher nuclear fuel costs can privilege those states which will be able to supply their own uranium and require its further processing to produce nuclear fuel.

If the anticipated situation occurs, it will be necessary to create the appropriate legislative conditions for the extraction of uranium by amending the relevant laws and strategic documents, including the Raw Materials Policy, since domestic deposits of uranium ore are located near Košice and Spisska Nova Ves – Novoveská Huta. The possibility of extracting uranium in the Slovak Republic is also to be assessed from the perspective of maximum environmental protection. Mining projects must be harmonised with the development of documentation by concerned municipalities and regional governments in conformity with the applicable legislation.

In order to meet the Energy Security Strategy targets, it is necessary to assess the feasibility of uranium extraction in the Slovak Republic. It is important to rationally and effectively support the use of domestic energy sources with the aim of decreasing dependency on imports.

European Uranium signs a Memorandum of Understanding with the Slovak Ministry of Economy

In December 2012, European Uranium Resources Ltd (EUU) reported that it had signed a Memorandum of Understanding with the Ministry of Economy of the Slovak Republic. The memorandum defines the parameters by which EUU and the ministry will co-operate in advancing the Košice uranium deposit – on which EUU holds the exploration licence – through ongoing feasibility and environmental studies. A PFS completed by Tetra Tech, Inc. indicates that the Košice uranium deposit can be developed as an underground mine using the best technologies available with minimal environmental impact and that it could be one of the lowest-cost uranium producers in the world.

Uranium stocks[†]

The Slovak Republic does not maintain an inventory of natural or reprocessed uranium.

Slovenské Elektrárne has a small stock of enriched uranium in the form of complete fuel assemblies. The number provided in the table "Total uranium stocks", mentioned small amount of fuel assemblies and fuel for first core loading of Mochovce unit 3. Part of this fuel for first core loading is stored at the fuel manufacturing plant and approximately one-half was delivered to the Mochovce NPP in 2014.

[†] Data provided by Slovenské Elektrárne, a.s; ENEL Group.

Uranium exploration and development expenditures and drilling effort – domestic

(EUR million)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	2.0	1.5	0.3	N/A
Government exploration expenditures	0	0	0	0
Industry* development expenditures	0	N/A	N/A	N/A
Government development expenditures	0	0	0	0
Total expenditures	**2.0**	**1.5**	**0.3**	**N/A**
Industry* exploration drilling (m)	1 106	N/A	N/A	N/A
Industry* exploration holes drilled	3	N/A	N/A	N/A
Government exploration drilling (m)	0	0	0	0
Government exploration holes drilled	0	0	0	0
Government exploration trenches (m)	0	0	0	0
Government exploration trenches (number)	0	0	0	0
Industry* development drilling (m)	0	N/A	N/A	N/A
Industry* development holes drilled	0	N/A	N/A	N/A
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	1 106	N/A	N/A	N/A
Subtotal exploration holes drilled	3	N/A	N/A	N/A
Subtotal development drilling (m)	0	N/A	N/A	N/A
Subtotal development holes drilled	0	N/A	N/A	N/A
Total drilling (m)	**1 106**	**N/A**	**N/A**	N/A
Total number of holes drilled	**25**	**18**	**N/A**	**N/A**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Volcanic-related		10 950**	10 950**	10 950**
Total		**10 950**	**10 950**	**10 950**

* In situ resources.

** Indicated resources (pre-feasibility study).

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)		10 950**	10 950**	10 950**	92***
Total		**10 950**	**10 950**	**10 950**	

* In situ resources.

** Indicated resources (pre-feasibility study).

*** Processing recovery.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from UG		10 950**	10 950**	10 950**	92***
Total		**10 950**	**10 950**	**10 950**	

* In situ resources.

** Indicated resources (pre-feasibility study).

*** Processing recovery.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Volcanic-related		4 881**	8 369**	8 369**
Total		**4 881**	**8 369**	**8 369**

* In situ resources.

** Inferred resources (pre-feasibility study).

Inferred conventional resources by production method

(tonnes U*)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)		4 881**	8 369**	8 369**	90-92**
Total		**4 881**	**8 369**	**8 369**	

* In situ resources.

** Inferred resources (pre-feasibility study).

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG		4 881**	8 369**	8 369**	90-92**
Total		**4 881**	**8 369**	**8 369**	

* In situ resources.

** Inferred resources (pre-feasibility study).

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
	3 691	10 915

Note: Category shift concerning new reserves calculation and estimated ore quality.

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Volcanic-related	211	0	0	0	211	0
Total	**211**	**0**	**0**	**0**	**211**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	50**	0	0	0	50	0
Underground mining*	161**	0	0	0	161	0
Total	**211**	**0**	**0**	**0**	**211**	**0**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

** Estimate.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	211	0	0	0	211	0
Total	**211**	**0**	**0**	**0**	**211**	**0**

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	14.7	14.5

Note: Data provided by Slovenské Elektrárne, a.s. (ENEL Group).

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
1 814	1 814	1 814	1 814	2 729	2 815	2 815	2 918	2 815	2 918	2 815	2 918

Note: Data provided by Slovenské Elektrárne, a.s. (ENEL Group).

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
354	362	365	365	483	483	490	533	491	534	490	533

Note: Data provided by Slovenské Elektrárne, a.s. (ENEL Group).

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	N/A*	N/A	0	N/A
Producer	0	0	0	0	0
Utility	0	227.63*	0	0	0
Total	**0**	**N/A**	**N/A**	**0**	**N/A**

Note: Data provided by Slovenské Elektrárne, a.s. (ENEL Group).

* In form of complete fuel assemblies.

For conversion of enriched uranium product to natural U-equivalent conventional tails assay of 0.25% was used.

Slovenia

Uranium exploration and mine development

Historical review

Exploration of the Žirovski Vrh area began in 1961. In 1968, the P-10 tunnel was developed to access the orebody. Mining began at Žirovski Vrh in 1982 and uranium concentrate production (as yellow cake) began in 1985.

Recent and ongoing uranium exploration and mine development activities

Expenditures for exploration ended in 1990. There are no recent or ongoing uranium exploration activities in Slovenia.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

A resource assessment of the Žirovski deposit was carried out in 1994. RAR are estimated to amount to 2 200 tU in ore with an average grade of 0.14% U in the <USD 80/kgU category. Inferred resources total 5 000 tU in the <USD 80/kgU category and 10 000 tU in the <USD 130/kgU category at an average grade of 0.13% U. This deposit occurs in the grey sandstone of the Permian Groeden formation, where the orebodies occur as linear arrays of elongated lenses within folded sandstone.

Undiscovered conventional resources (prognosticated and speculative resources)

Undiscovered resource estimates remain the same as reported earlier.

Uranium production

Historical review

The Žirovski Vrh uranium mine, located 20 km south-west of Škofja Loka, was the only uranium producer in Slovenia. Ore production began in 1982 and the associated ore processing plant (annual production capability of 102 tU) began operations in 1984, initially treating stockpiled ore. The ore (which occurs in numerous small bodies in the mineralised coarse-grained sandstone) was mined selectively using a conventional underground room and pillar, cut-and-fill operation with a haulage tunnel and ventilation shaft. In 1990, operations were terminated. Cumulative production from the Žirovski Vrh mine-mill complex totalled 382 tU (620 000 tonnes ore at an average grade of 0.072% U).

Status of production capability

In 1992, a decision for final closure and subsequent decommissioning of the Žirovski Vrh mine and mill was made and there has been no production at the facility since. All production was reserved for the former Yugoslavia. In 1994, the plan for decommissioning of the facility was adopted by the Slovenian government.

Environmental activities and socio-cultural issues

The government-owned Žirovski Vrh Mine Company manages all activities connected with the rehabilitation of the former uranium production site, consisting of underground mining facilities, surface milling facilities, the waste rock pile and tailings disposal site. It obtains all remediation permits required, performs the remediation works and monitors the environmental impact of the site during the remediation phase. After finishing the remediation works, the remaining disposal sites and the mine water effluents are put under long-term environmental surveillance that is carried out by the national organisation for radioactive waste management – the Agency for Radioactive Waste Management (ARAO). The mine effluents are monitored for uranium, radium and other chemical contaminants, the disposal sites are monitored for radon exhalation and uranium and radium in water effluents.

The annual effective dose contribution from all mine objects has significantly decreased as a result of remediation activities. Since 2011 its value dropped below 0.1 mSv/a, compared to about 0.4 mSv/a during operation. Background annual effective levels are 5 mSv/a in the area surrounding the mine.

Associated with the uranium production site are a hydrometallurgical tailings disposal site and the waste rock disposal site. Environmental remediation of the disposal site for hydrometallurgical tailings is in its final stage, the critical factor being the stability of the site. All remediation works are finished on the site of the mine waste pile, and in 2015 the long-term environmental surveillance of the site started.

Monitoring

The mine's air and water effluents have been monitored on a regular base since the start of the ore production in 1982. The programme, modified when production stopped in 1990, is ongoing. Emissions to surface waters and air are monitored, and doses to the critical group of inhabitants have been calculated since 1980. Treatment of the mine's effluents is not planned considering the low concentrations of radioactive contaminants.

Tailings impoundment

There is one 4.5 ha specially designed long-term site for hydrometallurgical tailings, called Boršt. It is situated on the slope of a hill between 530 and 570 m above sea level. At this disposal site, 610 000 tons of hydrometallurgical waste, 111 000 tons of mine waste and 9 450 tons of material, collected during decontamination of the mill tailings in the Boršt site vicinity, have been disposed, with a total activity of 48.8 TBq. The tailings have been stored in dry condition as a result of the filtration of the leached liquor. The surface is covered with a two-meter thick, engineered multi-layer soil cover with a clay base to prevent leaching of contaminants, and is covered with grass. Although the remediation of the site was completed in 2010, it will probably require additional remediation measures considering activation of the landslide beneath the disposal site. At the time of reporting, the remediation measures have not been completed yet. Additional works for stabilising the slope have to be performed to meet the conditions for site closure and to start the long-term environmental surveillance.

Waste rock management

All waste piles were relocated to the central mine waste pile Jazbec. All other sites have been decontaminated to a green field condition. The 5 ha Jazbec facility contains 1 910 425 tonnes of mine waste, neutralised hydrometallurgical tailing and contaminated material from decommissioning of mining and milling facilities, with a total activity of 21.7 TBq. It is covered with an engineered multilayer, two-meter-thick soil cover, and planted with grass. A concrete drainage tunnel was constructed at the bottom of the waste rock pile to drain seepage and groundwater into a local stream. Environmental remediation works at the Jazbec disposal site have been completed and the administrative procedure for the site closure finished in 2015. The responsibility for long-term surveillance and maintenance of the site was transferred to the national organisation for radioactive waste management (ARAO) in 2015.

Uranium requirements

The sole nuclear power plant in Slovenia is based at Krško. It started commercial operation in January 1983 and was modernised in 2000 with replacement steam generators that increased net capacity to 676 MWe. Net capacity was increased in 2006 to 696 MWe with low-pressure turbine replacement and again in 2009 to 698 MWe after modernisation of the turbine control system. The power plant is 50% owned by Slovenia and Croatia.

There has been no significant change in the Slovenian nuclear energy programme in the last two years (2013-2014). One nuclear power plant (Nuklearna Elektrarna Krško) is in operation. Uranium requirements for Nuklearna Elektrarna Krško are relatively stable. The current fuel cycles are 18 months in duration and planned to continue at this cycle basis. In 2012, the Slovenian Nuclear Safety Administration approved the ageing management programme; a prerequisite for the operation of the Nuklearna Elektrarna Krško beyond 2030 up until the year 2043.

Supply and procurement strategy

The total uranium requirement of Nuklearna Elektrarna Krško per operating cycle remains as reported in 2013. There are no operating or strategic uranium reserves in Slovenia and supply is imported based on requirement contracts.

A new long-term supply contract was concluded in 2013. The current procurement strategy utilises enriched UF_6 supplied to the fuel manufacturer from the uranium supplier when it is required for fuel assembly construction. No physical deliveries of U_3O_8 or UF_6 are made to the Nuklearna Elektrarna Krško site. The manufactured fuel assemblies arrive just before they are used for power production. There are no plans in the foreseeable future to build a uranium stockpile by Nuklearna Elektrarna Krško. The strategy for commercial spent nuclear fuel management currently does not include the use of reprocessed uranium and Nuklearna Elektrarna Krško is not licenced for MOX use.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Slovenia is not a uranium-producing country; uranium stocks are imported for the commercial operation of the nuclear power plant (Nuklearna Elektrarna Krško) as final products (manufactured nuclear fuel assemblies).

Uranium stocks

There is no uranium stock policy in Slovenia. Nuklearna Elektrarna Krško has no uranium stocks or intention to create a uranium stock policy. All required uranium stocks are purchased on a "just-in-time" basis.

Uranium prices

This information is considered confidential.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	2 200	2 200	2 200
Total	**0**	**2 200**	**2 200**	**2 200**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining	0	2 200	2 200	2 200
Total	**0**	**2 200**	**2 200**	**2 200**

* In situ resources.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	5 000	10 000	10 000
Total	**0**	**5 000**	**10 000**	**10 000**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining	0	5 000	10 000	10 000
Total	**0**	**5 000**	**10 000**	**10 000**

* In situ resources.

Prognosticated resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	1 060	1 060

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Underground mining[1]	382	0	0	0	382	0
Total	**382**	**0**	**0**	**0**	**382**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	5.036	6.061

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
681	692	688	698	688	698	688	698	688	698	688	698

Note: Low and high values were taken as dependable power and maximum designed net power, respectively.

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
149	149	119	179	119	179	119	179	119	179	119	179

Note: The Krško nuclear power plant operates 18-month cycles with a fresh fuel load of 224 tonnes of natural uranium equivalent. Some years no uranium supply is required (e.g. 2014, 2017 and 2020). The values in the table are the average yearly values (i.e. 224 tU x 12/18 = 149 tU). Low and high variability is ±20% from the expected value; this is calculated from maximum change that could occur from a change in fuel assembly design or variation in cycle length (i.e. 12-24 months). The variability shown in some previous reports (2005, 2007, 2009 and 2011) was lower than shown in the 2015 table, as it was based on observed 18-month cycle-to-cycle differences and may not be a fair representation in such a long timescale prediction. Since 2013, the larger variability has been reported.

South Africa

Uranium exploration and mine development

Historical review

South Africa has been an important player in the international market since it first started producing uranium in 1952. It has been steadily and consistently producing uranium since then, albeit at a lower level in recent years. Eight of the thirteen deposit types defined in the Red Book are found in South Africa, namely paleo-quartz-pebble conglomerate, sandstone, lignite-coal, intrusive, surficial, granite-related and phosphate deposits. The major part of the resource base is hosted by the quartz-pebble conglomerates and derived tailings, with significant amounts of resources in the sandstone and coal-hosted deposits. The other deposit types make a relatively small contribution to the national uranium resource inventory. Virtually all of South Africa's historical uranium production was derived from quartz-pebble conglomerate deposits with a small proportion being from the Palabora copper-bearing carbonatite. All current production is sourced from the quartz-pebble conglomerate deposits.

The majority of past production was as a by-product of gold or, to a minor extent, copper. Only two primary uranium producers have existed in South Africa. The first was the Beisa mine in the Free State in the early 1980s and the latter was the Dominion Reefs Uranium Mine near Klerksdorp which operated in the early 2000s.

There are six distinct uranium provinces in South Africa. The oldest are the Palaeozoic-aged Mozaan basin in the north-east and the slightly younger Witwatersrand Basin in central South Africa. The Precambrian-aged Palabora and Pilanesberg carbonatite complexes lie in the north, with the Precambrian to Cambrian granite complexes in the north-west. The sandstone deposits of the Karoo in the south central parts, as well as the coal-hosted deposits of the Springbok Flats are of Permo-Triassic age. The youngest are the Tertiary to recent surficial deposits in the Northwest Cape and the phosphorite deposits off the south-west coast.

The surge in uranium prices between 2005 and 2007 stimulated significant corporate interest in South Africa. Much of the ground over the Witwatersrand Basin was held by existing mining companies and extensive re-evaluations of uranium resource holdings were undertaken. Of great interest was the resources held in the vast tailings dams created by over 100 years of gold mining. Gold Fields, Rand Uranium, Harmony and AngloGold Ashanti launched detailed feasibility studies into the resources contained in tailings.

Available ground with known uranium occurrences such as in the Karoo Basin and Springbok Flats was snatched up by companies such as UraMin and Holgoun Energy. UraMin was subsequently taken over by Areva, an acquisition that included the Trekkopjie deposit in Namibia and the Ryst Kuil Channel in the Karoo Basin. Smaller companies obtained prospecting licences over smaller known deposits in the Karoo Basin, as well as deposits in the granitic and surficial terrains in the north-west of the country.

Recent and ongoing uranium exploration and mine development activities

Peninsula Energy operates in South Africa through its subsidiary called Tasman RSA Holdings (Pty) Ltd, and has a total of 41 prospecting rights covering 7 774 km^2 in the Karoo Uranium Province (located in the south-western part of South Africa) which has been subdivided into the Eastern and Western sectors. A significant portion of the delineated resource is within the Eastern Sector. Peninsula Energy has identified new areas of uranium mineralisation in the stacked sandstone units which host extended uranium mineralisation beyond the historic drill limits, thereby increasing the resource potential. In December 2012, Peninsula Energy acquired all of Areva's properties located in the Karoo Uranium Province, including the Ryst Kuil deposit. The current and ongoing work by Peninsula Energy is focused on developing sufficient resources to support the development of open-pit and underground mining operations that will supply a viable central processing facility near the town of Beaufort West. Since the commencement of exploration in 2006, Tasman has completed approximately 31 000 m of reverse circulation and diamond drilling, and geophysically logged an additional 15 000 m of open historic holes. In February 2013, Tasman commenced drilling along the Ryst Kuil channel in the Eastern Sector of its Karoo Projects which has returned encouraging initial results. To date, a total of 67 reverse circulation holes have been completed at the De Pannen project area, with a total of 2 745 m; which has resulted in upgrading of a portion of inferred, in situ resources to indicated resource category. There has been no physical exploration activity (i.e. drilling) in 2014. The only recent field work has been location and radiometric probing of historic holes (drilled by Union Carbide Exploration Corporation) in the Ryst Kuil area but there is still insufficient information for declaration of resources according to modern reporting requirements. Tasman is continuing with a downhole gamma logging programme at Ryst Kuil to validate the historical results. In total, about 336 holes in the Ryst Kuil trend totalling 30 386 m has been probed by the end of 2013.

In 2013, Peninsula released the results of the initial scoping study which were positive, enabling the commencement of the pre-feasibility study in the second half of 2013 which included extensive metallurgical test works. Subsequent to the finalisation of the metallurgical test work, a rerun was conducted of an alkaline versus acid leach processes to determine the optimal treatment solution and way forward through pre-feasibility and bankable feasibility studies. This review was completed in June 2014, and the results indicated that better recovery efficiencies were consistently achieved using acid leaching across all sampled areas. The initial result showed the average recovery efficiency for acid leach of 90.8% compared to 83.1% for alkaline leach. From an operating cost perspective, the result of the review also indicated that ongoing operating costs per ton of uranium produced would be materially lower using acid leach processing route as compared to alkaline leach processing route. In June 2014, the company submitted mining rights applications over all their prospecting areas in the Karoo region. The application process is expected to take up to two years and hence the planned commencement of mine development has been delayed from 2016 to 2018.

HolGoun Uranium and Power Limited completed a pre-feasibility study of its project in the Springbok Flats Basin and began a bankable feasibility study in 2012. Uranium is hosted by coal in the Springbok Flats. HolGoun's bankable feasibility study comprised resource and reserve estimations, bulk sampling and pilot plant test work, geotechnical and groundwater study, mine and underground infrastructure design, overall environmental issues, financial and economic evaluations and a mining rights application. The initial development of this project envisaged an annual production capacity of about 700 tU_3O_8 (595 tU) at a feed grade of 0.96 kg/t of ore during the first seven years of production. Thereafter, the annual production was planned to be about 500 tU_3O_8 (425 tU) at a feed grade of 0.63 kg/t of ore. However, no results have been made available by HolGoun regarding the bankable feasibility study progress.

The Council for Geoscience (a governmental organisation) has drilled five boreholes in the Springbok Flats Basin as part of the project that is investigating the relationship between uranium (distribution, concentration, style and origin) and the coal-hosting sedimentary rocks of the Springbok Flats Basin. The preliminary results show uranium is concentrated in vitrinite-rich, bituminous coal in the upper parts of the coal zones. Very small amounts of uranium occur within the mudstone which lies conformably above the coal zones.

AngloGold Ashanti's operations in South Africa are all located in the Witwatersrand Basin, in two mining districts: the Vaal River and West Wits areas. The Vaal River Operations consists of the Kopanang and Moab Khotsong underground mines, located about 180 km south-west of Johannesburg near the town of Orkney. The Great Noligwa mine has been incorporated with the Moab Khotsong mine. The West Wits operations consist of the Mponeng and Tautona underground mines (i.e. Savuka is included in the Tautona mine), located about 70 km south-west of Johannesburg near the town of Carletonville. The surface operations include the Vaal River surface, Mine Waste Solutions (MWS), and the West Wits surface operations. The MWS, even though it forms part of AngloGold's surface operations, operates independently and is located approximately 8 km from the town of Klerksdorp near Stilfontein and within 20 km of the Vaal River Surface operations. The MWS feed sources (i.e. tailings storage facilities) are scattered over an area that stretches approximately 13.5 km north-south and 14 km east-west. All these gold operations have substantial uranium resources, but the production of uranium is only carried out at the South Uranium Plant (feed sources being the ore from Kopanang, Great Noligwa and Moab Khotsong underground mines) and at the MWS Uranium plant (feed sources being the tailings storage facilities).

AngloGold Ashanti's brownfield exploration continued with a total of ten surface holes being drilled in 2013, comprising four at Mponeng's Western Utra-Deep Levels, three at Moab Khotsong, two at project Zaaiplaats (which is part of Moab Khotsong), and the completion of one shallower surface hole to the south-west of Kopanang. There were eight underground drilling machines, and one surface drilling machine, in operation in 2014.

Gold One International Ltd acquired the Rand Uranium properties, as well as the Ezulwini mine in 2012. One of the key objectives associated with these acquisitions was to re-establish the Cooke underground and Randfontein surface operations as gold mines and subsequently to develop uranium co-product potential. The Cooke underground operations comprise Cooke 1, 2, 3 and Ezulwini which are serviced by a developed network of mining and civil infrastructure with adequate electricity and water supplies. Ezulwini was integrated into the Cooke underground complex as Cooke 4. The primary mining horizons in the Cooke operations include the Middle Elsburg reef which is a gold- and uranium-bearing reef which has been less extensively mined compared to the primarily gold-bearing reef known as the Upper Elsburg. Ongoing exploration and resource development work has highlighted numerous potential resource extensions. A feasibility study was completed in 2012 on a high uranium yielding area at Cooke 3, which consists of both unmined ground and a number of higher-grade pillars. The area is associated with existing underground development. The feasibility study considered uranium extraction through the Cooke 4 uranium plant (Ezulwini). The Randfontein surface operations host gold and uranium surface resources which present attractive opportunities for future extraction. These tailings include the Cooke tailings dam, the Millsite complex, Lindum, Dump 20 slime and the Old 4 dam.

Sibanye Gold Ltd acquired Cooke assets and Randfontein operations from Gold One Ltd, and also the Witwatersrand Consolidated Gold Resources Limited (Wits Gold) assets, in 2014. These acquisitions by Sibanye Gold will allow the company to leverage regional and operational synergies in the Witwatersrand Basin. Sibanye now owns and operates four underground and surface gold operations – the Cooke operations located about 30 km south-west of Johannesburg in the West Wits; Driefontein operations located about 70-80 km west of Johannesburg; and Kloof operations located about 60-70 km west of Johannesburg, as well as the Beatrix Operation located about 240 km south-west of Johannesburg, near the town of Welkom, in the southern Free State. Sibanye has a number of other projects including the West Rand Tailings Retreatment Project (WRTRP) on the Far West Rand and the Burnstone project on the South Rand of Gauteng province, as well as the Beisa North, Beisa South, Bloemhoek, De Bron-Merriespruit, Hakkies and Robijn projects in the Free State. Uranium production is currently being done at Cooke 4 (Ezulwini) Uranium plant with feed sources being ore from the Cooke operations.

A detailed feasibility study of the WRTRP was completed by mid-2015. A pre-feasibility study concluded in 2013 confirmed the economic viability of the WRTRP which involves the construction of a large-scale central processing plant for the extraction of gold and uranium from the retreatment of historic and current tailings. A definitive feasibility study is due for completion by mid-2015. The definitive feasibility study will focus on leveraging existing surface infrastructure as well as the available uranium treatment capacity at the Ezulwini gold and uranium processing plant to sustain surface gold and uranium production prior to the development of the central processing plant. Extraction of uranium from the tailings storage facilities, i.e. WRTRP, can be up to 135 tonnes of uranium per annum once the WRTRP project is up and running.

A pre-feasibility study of the Beatrix West Section (Beisa project) was completed in December 2014. Various regulatory approvals and permits are required before the Beatrix West Section can be advanced, with these processes having been expected to begin in 2015. Ongoing optimisation and review of the pre-feasibility study will continue in parallel with the permitting process.

Harmony Gold Ltd developed two uranium projects to feasibility stage in 2012: Harmony Uranium TPM (Tshepong, Phakisa and Masimong); and the Free State Tailings Uranium Project. The initial plans were that the TPM Project will be extracting uranium from the Tshepong, Phakisa and Masimong underground mines while the Free State Tailings Uranium Project will be extracting uranium from the old tailings storage facilities owned by Harmony. The feasibility study of the TPM Uranium Project was supported by a demonstration plant campaign and associated metallurgical test work. However, these projects have been deferred because of financial constraints.

Namakwa Uranium, which is owned 74% by Aardvark Uranium Ltd and 26% by Gilstra Exploration, has continued exploration in the Henkries Project, in which the area has been subdivided into Henkries Central, Henkries North and Henkries South. Most of the delineated resources, mainly in Henkries Central, occur within 20 m from the surface. Given the shallow and soft nature of the deposit, as well as good infrastructure serving the project area, the project is regarded as potentially viable for future uranium extraction. Xtract Resources conducted a due diligence with view to acquire the Henkries Project in the Namaqualand, Northern Cape Province in 2014. However, Xtract has decided not to go ahead with the acquisition of the Namakwa Uranium deposit as it has found that the project does not meet its investment criteria.

Uranium resources

All the resources reported are estimates obtained from exploration and mining companies' annual reports, as well as information obtained from AngloGold Ashanti, Peninsula Energy, Sibanye Gold, Harmony Gold, HolGoun and Namakwa Uranium.

Identified conventional resources (reasonably assured and inferred resources)

The Witwatersrand Basin contains about 75% of total identified uranium resources in South Africa, in both the underground, hosted by quartz-pebble conglomerates and their resulting tailings storage facilities. Approximately 47% of the total national identified resources are in the Witwatersrand underground operations, 28% in their associated tailings facilities, 20% in the Springbok Flats Basin and about 5% in the sandstone-hosted deposits of the Karoo Basin. The uranium pay limit in the most parts of the Witwatersrand Basin is calculated on a by-product basis, according to which the uranium is not classified as resources unless it occurs in an area of gold mineralisation that satisfy the estimated gold cut-off grades. In addition, uranium in these projects only attracts costs of transporting ore from the underground or tailings operations to the processing plants, and the treatment of uranium while gold carries all other costs.

The reasonably assured conventional resources at a cost category of USD 80/kgU have increased by 16% compared to the same category of resources reported in the 2014 edition of the Red Book while there is an increase of about 6% at a cost category of USD 130/kgU, and a decrease of 13% at a cost category of USD 260/kgU. The inferred conventional resources at a cost category of USD 80/kgU have decreased by 35% compared to the same category reported in the 2014 edition of the Red Book, while there is a decrease of 62% for USD 130/kgU category compared to the figure reported in 2014, as well as a decrease of 36% for the cost category of USD 260/kgU. All these comparisons are based on in situ uranium resources. The reasons for these changes include additional information obtained from extensive drilling programmes (which resulted in revised geological modelling and hence estimates), combined with additional information derived during mining, hence a portion of inferred resources has been moved into the reasonably assured conventional resources. In addition, the revised estimates have moved a portion of inferred resources of the Witwatersrand Basin below the depth of 2 500 m and below the revised current gold cut-off grades, in some projects (i.e. Middle Elsburg reef), into prognosticated conventional resources (which was approximately 72 600 tU as reported in the 2014 edition of the Red Book).

Undiscovered conventional resources (prognosticated and speculative resources)

The estimation of undiscovered conventional resources is currently ongoing, but the initial figures have been included in this edition of the Red Book. The Karoo Uranium Province is estimated to contain between 90 000 to about 150 000 tonnes of uranium. This exploration target is based on the total cumulative prospective – sandstone strike length of about 200 km. The rationale was that the Ryst Kuil channel is distributed over a cumulative strike length of about 23 km, and known to contain about 17 335 tonnes of uranium which represents about 754 tonnes of uranium per kilometre. Therefore, the total cumulative prospective strike length of the undrilled sections of the channel multiplied by the demonstrated tonnage/km defines the exploration target in the Karoo Uranium Province. The Witwatersrand Basin has a total of about 470 tailing storage facilities, of which most of these were not included in the reasonably assured and inferred conventional resources.

Unconventional resources and other materials

As reported in the 2011 edition of the Red Book, a field of manganiferous phosphate nodules was identified off the west and south-west coast of South Africa on the continental shelf. The nodules contain low grades of uranium and are currently considered uneconomic with respect to both phosphate and uranium extraction. However, renewed interest in phosphate-hosted uranium deposits may engender future investigation. The unconventional resources were estimated at 180 000 tU.

Uranium production

Historical review

South Africa has been a consistent producer of uranium since 1952, but its international importance has declined in recent years. In the late 1970s and early 1980s, it was ranked the second or third largest producer in the world, but in recent years output has declined significantly and by 2010 South Africa ranked 12th in global uranium production. Peak production was achieved at over 6 000 tU/yr in the early 1980s when it accounted for 14% of total world output.

In 2013, the uranium production was 531 tU, which is about a 14% increase compared to production in 2012. Furthermore, in 2014, the uranium production increased by 7% compared to the 2013 total, amounting to 566 tU. The increase in the 2013 national total production was caused by the increase in production at the AngloGold Ashanti's Vaal River Operations (despite the industry-wide strike actions and safety related stoppages), while the further increase in production in 2014 was attributed by the start of production at Cooke 4 uranium plant (Ezulwini).

It was expected that in 2015, uranium production would increase to about 800 tU as the MWS and Cooke 4 plants ramped up productions.

Status of production facilities, production capability, recent and ongoing activities and other issues

AngloGold Ashanti acquired the MWS tailings retreatment operation in the Vaal River region in July 2012. MWS comprises tailings storage facilities that originated from the processing of ore from the Buffelsfontein, Hartebeestfontein and the Stilfontein gold mines. The current uranium production from South Africa is sourced from the AngloGold's Vaal River and surface operations, as well as Sibanye Gold's Cooke operations. The Vaal River Operations are comprised of Kopanang and Moab Khotsong underground mines. Moab Khotsong and Great Noligwa mines were integrated into one mine in order to reduce high shaft costs as the Great Noligwa mine is ageing and were designed in an era when cost pressures were significantly lower and grades were markedly better. The Great Noligwa ore body will now be accessed through Moab Khotsong, which will enhance efficiency. The primary reefs mined by these operations are the Vaal reef and the secondary Crystalkop reef. The reef is milled at the Noligwa gold plant and treated in the South Uranium Plant for uranium oxide extraction by the reverse leach process. Ammonium diuranate (ADU or "yellow cake"), the final product of the South Uranium Plant, is transported to Nufcor (located near Johannesburg) where the material is calcined and packed for shipment to conversion facilities. Mining at Moab Khotsong is based on scattered mining method together with an integrated backfill support system that incorporates bracket pillars. At Kopanang, a sequential grid mining layout is used from which scattered mining takes place. The South Uranium Plant throughput capacity is 263 000 tonnes for a 30-day month, with an approximate uranium production capacity of 52 tU per month.

The AngloGold's surface operations include MWS, which operates independently and processes slurry material reclaimed hydraulically from the various tailings storage facilities. The tailings are reclaimed using a number of hydraulic (high-pressure water) monitoring guns to deliver water at pressure. The tailings material is reclaimed by blasting the tailings storage facility face with the high-pressure water resulting in the slurry gravitating towards pumping stations. These monitoring guns can be monitored to selectively reclaim required areas from the tailing storage facilities. The reclamation strategy is aimed at mining the higher-grade first. The pump stations are located at the lowest point of the dams to ensure that the slurry from the dams will gravitate towards the pump stations from where the slurry will be pumped to the processing plants. The MWS uranium plant was commissioned during the fourth quarter of 2014. MWS uranium plant extracts uranium from the MWS flotation plant's concentrate product and has a throughput capacity of 100 800 tonnes for a 30-day month with an approximate uranium production capacity of 25 tU per month. The process involved employs a conventional sulphuric acid leach, counter current thickener decantation, counter current ion-exchange, solvent extraction and ammonium di-urinate precipitation. The replacement of the uranium solvent extraction section within the South Uranium Plant, to ensure sustainable operations over the life of the operation, was completed in 2013.

Uranium production from Sibanye owned Cooke operations begun in May 2014, which resulted in an inventory of about 69 tU at the end of 2014, even though no uranium was sold during the year. Uranium production costs at Cooke operations averaged approximately USD 62/KgU. The Cooke shafts are mining multiple reefs with Cooke 1 and 3 utilising a combination of trackless and conventional mining. Conventional narrow reef stoping is the principal mining method employed, while trackless bord and pillar mining with 6 m bords is applied in the wider reef areas. The mining methods for Cooke 4 shaft is drift and fill with ade-stress cut conventional underground breast mining as well as board and pillar mining. Uranium processing is done at Cooke 4 (Ezulwini) Uranium plant. During mining, the gold ores from the Upper Elsburg reef and the gold/uranium ores from the Middle Elsburg reef are kept separate. The gold ores (from Upper Elsburg reef) are sent straight to the gold plant, while the gold/uranium ores (from the Middle Elsburg reef) are sent to the uranium plant first. Uranium production from Cooke operations is forecast at approximately 96 tonnes of uranium per annum by the end of 2015, and 106 tonnes of uranium by 2017.

Cooke 4 mine (Ezulwini) experienced dire financial circumstances in 2014, and there was a real possibility of placing the mine under care and maintenance, or closing it. However, a number of cost cutting measures have been taken at the end of 2014 in order to return the shaft to sustainable profits. These cost cutting measures included reduction of 392 employees from Cooke 4 mine (from a total of 2 403 employees). This reduction included 38 employees from the Cooke 4 plant (from a total of 238 employees).

The earthquake in 2014 (which was about 5.3 on the Richter scale) affected the operations in the Witwatersrand Basin including those at Vaal River and Cooke operations. Production was halted in the Vaal River underground operations for up to ten days to allow for the aftershocks to subside and to undertake repairs before production resumed.

Shiva Uranium is currently operating at the Dominion Reefs deposit, on three underground shafts; the Dominion 1 (D1), Dominion 2 (D2) and the Rietkuil declines. In February 2011, Shiva produced 1.6 tU_3O_8 (1.4 tU). However, uranium production stopped as a result of other developments, with plans for significant production in the future. Currently, only gold is produced at the Dominion Reefs mine.

The Harmony Uranium Tshepong, Phakisa and Masimong (TPM) Project was established to evaluate the potential for economic recovery of uranium from ore mined at Tshepong, Phakisa and Masimong mines in the Free State province. The project was expected to produce about 340 tU/yr at peak production of 280 000 tonnes of underground ore per month over a 20-year life. An engineering study was completed in 2012, resulting in a reduced capital cost for the project and mitigating potential gold loss in the uranium extraction process. The TPM and the Free State Tailings Uranium projects, with regards to uranium production, have now been deferred as a result of financial constraints.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5	Centre #6
Name of production centre	South Uranium Plant (AngloGold Ashanti)	Mine Waste Solutions (AngloGold Ashanti)	Cooke 4, previously known as Ezulwini (Sibanye)	Dominion Reefs Uranium Mine (Shiva Uranium)	Beaufort West (Peninsula Energy)	Springbok Flats Basin (HolGoun)
Production centre classification	Existing	Existing	Existing	Existing	Planned	Planned
Start-up date	1979	2013	2009	2007	2018	2020
Source of ore:						
Deposit name(s)	Wits Basin (Kopanang, Great Noligwa and Moab Khotsong underground mines)	Tailings in the Vaal River region (Wits Basin)	Wits Basin (Cooke 1, 2, 3, 4)	Dominion Reefs	Karoo Uranium Province (Ryst Kuil and others)	Springbok Flats Basin (Settlers area)
Deposit type(s)	Quartz-pebble conglomerate	Tailings	Quartz-pebble conglomerate	Quartz-pebble conglomerate	Sandstone	Coal
Recoverable resources (tU)	37 970	60 532	51 556	72 613	6 821	47 800
Grade (% U)	0.052	0.008	0.011	0.111	0.126	0.096
Mining operation:						
Type (OP/UG/ISL)	UG	Tailings reprocessing	UG	UG	OP + UG	UG
Size (tonnes ore/day)	8 767	65 000	3 330	N/A	N/A	N/A
Average mining recovery (%)	60-80	90-100	N/A	N/A	N/A	N/A
Processing plant:						
Acid/alkaline	Acid	Acid	Acid	Acid	N/A	Acid
Type (IX/SX/AL)	CCD/CCIX/SX	CCD/CCIX/SX	IX/SX	IX/SX	N/A	SX
Size (tonnes ore/day)	8 767 tpd	3 360 tpd	3 330 tpd	N/A	N/A	N/A
Average process recovery (%)	75	65	N/A	N/A	N/A	68
Nominal production capacity (tU/year)	470	291	500	N/A	1 036	600
Plans for expansion	No	No	No	No	No	No
Other remarks		Recommissioning 2014	(1)	(2)	N/A	

1. Uranium processing at the MWS was recommissioned in the fourth quarter of 2014.
2. The uranium plant was reopened in the beginning of 2011, but the uranium processing was stopped several months later.

CCD = counter current decantation; CCIX = continuous counter current ion exchange.

Ownership structure of the uranium industry

AngloGold Ashanti's primary stock exchange listing is on the Johannesburg Stock Exchange (JSE) Limited. It is also listed on the exchanges in New York, London, Australia and Ghana, as well as on Euronext Paris and Euronext Brussels. In South Africa, AngloGold Ashanti operates six wholly owned underground mines which are located in two geographical regions in the Witwatersrand Basin. The most important are Vaal River Operations gold mines which produce uranium as a by-product. AngloGold Ashanti Ltd acquired the MWS tailings retreatment operation in the Vaal River region in July 2012 for about USD 335 million.

Sibanye Gold Limited separated from Gold Fields Limited in February 2013. Sibanye has its ordinary shares listed on the main board of the JSE in terms of its stock exchange licence and its American Depository Receipts (ADRs) on the New York Stock Exchange (NYSE). In 2014, Sibanye assumed control of the Cooke underground and surface operations, including the Randfontein operations, from Gold One International Limited (Gold One) and also concluded the acquisition of Witwatersrand Consolidated Gold Resources Limited (Wits Gold), a JSE and Toronto Stock Exchange (TSX) listed gold and uranium exploration company with significant gold resources in South Africa.

Harmony Gold's primary listing is on the JSE Limited (share code: HAR) in South Africa. Harmony's ordinary shares are also listed on stock exchanges in London (HRM), Paris (HG) and Berlin (HAM1), and are quoted in the form of American depositary receipts on the New York and Nasdaq exchanges (HMY), and as international depositary receipts on the Brussels exchange (HMY).

Peninsula Energy Ltd is a public company listed on the Australian Securities Exchange and incorporated in Western Australia. Tasman Pacific Minerals Limited is wholly owned by Peninsula Energy, which owns prospecting rights in the Karoo Uranium Province. Peninsula Energy acquired all of Areva's assets in the Karoo Uranium Province in December 2012, including the Ryst Kuil Project.

Employment in the uranium industry

AngloGold Ashanti employed 175 workers in 2013 and 168 workers in 2014 that were directly involved in the uranium production at the South and MWS uranium plants. At Cooke 4 a total of 238 employees were employed in 2014. The total employment, directly related to uranium production at South Uranium Plant, MWS Uranium plant and Cooke 4 Uranium plant for 2014, was 406. That total was expected to increase to 472 workers in 2015.

The total employment related to existing centres in South Africa was 1 742 for 2013, and 4 141 in 2014.

Future production centres

Future production centres include the Dominion Reef mine, Sibanye's West Rand Tailings Retreatment Project, and Beaufort West (Karoo Basin).

Environmental activities and socio-cultural issues

Exploration and mining companies are committed to the responsible use and management of the natural resources under their prospecting and mining rights. Site visits and inspections are conducted regularly to verify that the commitments detailed in their environment management programmes are being adhered to. Exploration and drilling include a responsibility to rehabilitate each site once drilling has been completed. In terms of applications for mining rights, and a part of the Social and Labour Plan, the companies are required to inform the interested and affected parties in the proposed mining area of its intended activities.

Tasman Ltd (Peninsula Energy) held an Environmental Management Plan initiation meeting in May 2014 as part of the mining rights application processes around the Beaufort West. Public participation meetings commenced during June 2014 with interested and affected parties and continued to the third quarter of 2014.

There were three significant environmental incidents at MWS in 2013. The tailings pipeline running from MWS to the tailings storage facility failed following the illegal removal of the pipeline's flanges, leading to a spillage. Operations were temporarily suspended and containment walls built to contain the spill and minimise the environmental impact. Following a series of remediation efforts, water quality in the Koekemoer Spruit, near MWS, had largely returned to pre-spillage conditions in the weeks following the incident. Interim process water containment infrastructure, which was a priority, was completed in 2013. Work is to begin on the construction of more permanent return water facilities. The Department of Water Affairs and the National Nuclear Regulator have reviewed operations at MWS and approved proposed action plans and progress made.

The potential for inter-mine flooding at both the Vaal River and West Wits operations remains a risk and major focus area, compounded by the failure of neighbouring mines to contribute to pumping costs. At year-end, AngloGold Ashanti was pumping water from underground operations that it does not own and that have ceased working, to prevent flooding of its current mine workings. The region's strategic environmental focus area remain integrated water management, closure planning, waste management, knowledge management, legal compliance and the dust mitigation programme for tailings storage facilities. AngloGold Ashanti now use excess water from the underground at its Vaal River Operations for hydraulic tailings reclamation at MWS.

The Broad-Based Socio-Economic Empowerment Charter for the South African Mining and Minerals Industry (The Mining Charter) which gives effect to the Mineral and Petroleum Resources Development (Act No. 28 of 2002), is aimed at transforming the mining industry to redress historical imbalances by substantially and meaningfully expanding opportunities for historically disadvantaged South Africans (HDSA). The charter has given mining companies provision to offset the value of the level of beneficiation achieved against a portion of its HDSA ownership requirements of up to 11% as compared to the current required level of 26% (to be achieved by the end of 2014). Furthermore, mining companies are required to procure a minimum of 40% of their capital goods, 70% of services and 50% consumables from Black Economic Empowerment entities.

The Mining Charter reached the end of the second five-year commitment period at the end of 2014. The Department of Mineral Resources released the initial findings of the Broad-Based Socio-Economic Empowerment Charter for the South African Mining and Minerals Industry at the beginning of April 2015 (the targets of the 2014 Mining Charter) that 90% of the mining companies in South Africa have achieved the 26% of the HDSA ownership target (interpretations was on an employment-weighted basis), with an average of 32.5% HDSA ownership. However, only 20% of the companies (weighted for the number of people employed) that had concluded empowerment transactions fulfilled the full requirements of meaningful economic participations as inscribed in the charter.

AngloGold Ashanti has designed a framework, following extensive stakeholder engagement, to integrate community development into core business activities, while providing support for national development policies and objectives, particularly those addressing youth unemployment. AngloGold Ashanti's contribution to education in both local and labour-sending communities is a priority. The Vaal Reefs Technical High School's science laboratories were officially opened in 2013. In addition, the Merafong Agricultural Project, which employs 20 people, is funded by AngloGold Ashanti. Other social responsibilities included economic initiatives in the labour-sending areas such as the remote villages of the Eastern Cape Province.

The labour relations challenges and unprotected strikes that affected South African mining industry in 2011 and 2012, continued into 2013 and 2014. Engagement with labour was dominated by biennial wage negotiations in the Witwatersrand operations, which were impacted by the emergence of Association of Mineworkers and Construction Union (AMCU), with majority of its members coming from the National Union of Mineworkers (NUM). However, wage agreement was reached in mid-2013 by the AngloGold Ashanti's Vaal River Operations following a three-day strike. The second year of a two-year wage agreement began in June 2014 including providing the employees with financial guidance and advice. Following these wage negotiations and several employee satisfaction surveys, several key requirements were highlighted including improved employee communication and improved management trainings.

Regulatory regime

The Department of Mineral Resources, the Department of Water Affairs, the Department of Environmental Affairs and the Department of Energy, including the National Nuclear Regulator, perform regulatory functions relating to exploration and mining of uranium in South Africa.

According to the Mineral Resources and Development Act No. 28 of 2002, an applicant of prospecting or mining right must make the prescribed financial provision for the rehabilitation or management of negative environmental impacts before the approval of such rights. If the holder of the prospecting or mining right fails to rehabilitate or is unable to undertake such rehabilitation then part or all of the financial provision will be used for rehabilitation. The holder of a prospecting or mining right must annually assess their environmental liabilities and accordingly increase their financial provision to the satisfaction of the Minister of Mineral Resources. If the minister is not satisfied with the assessment and the financial provision, then the minister may appoint an independent assessor to conduct the assessment and determine the financial provision. The requirement to maintain and retain the financial provision remains in force until a closure certificate has been issued after the closure of mining or prospecting operation. The minister may still retain a portion of the financial provision as may be required to rehabilitate the closed mining or prospecting operation in respect of latent or residual environmental impacts. No closure certificate will be issued until the rehabilitation has been done and the chief inspector, as well as all the governmental regulatory departments related to uranium exploration and mining, have confirmed that the provisions pertaining to health, safety, environment and management of potential pollution to water have been addressed.

Uranium requirements

Koeberg is South Africa's only nuclear power plant. It has two light-water thermal reactors; Koeberg I commissioned in 1984 and Koeberg II in 1985, with a combined installed capacity of 1 840 MW. Together, they require about 294 tU/yr.

The government has drawn up the Integrated Resource Plan 2010, which includes increasing the nuclear capacity from 1.8 GWe (which is about 5% of the current total energy in South Africa) to 9.6 GWe by 2030, which will represent about 23% of the total country's energy. The first new nuclear plant is expected to come online in 2023. To spearhead this programme, a National Nuclear Energy Executive Coordination Committee was established towards the end of 2011 as an authority for nuclear energy expansion programme. The committee incorporates the Nuclear Energy Corporation of South Africa (NECSA), South African electricity public utility (Eskom), the National

Nuclear Regulator and governmental departments including the Department of Energy and the Department of Public Enterprises. An IAEA Integrated Nuclear Infrastructure Review was done in 2013. Furthermore, inter-governmental agreements have been signed with several vendor nations including China, France, Russia, Korea and the United States. The bidding process was expected to begin in 2015, and selection of a strategic partner expected by mid-2016.

The proposed sites for the nuclear reactors are said to be in the Eastern Cape, Western Cape, Northern Cape and Kwa Zulu Natal provinces. Eskom conducted an environmental investigation, including seismic hazards assessments of the proposed sites for nuclear power plants, including the Thyspunt (Eastern Cape Province) and the Duyneyfontein (Western Cape Province). The environmental investigation and assessments for the Thyspunt site has been completed.

The planned nuclear reactors and the existing Koeberg plant will require a total of about 1 536 tU/yr by 2030.

Supply and procurement strategy

With the commitment of government to build nuclear power plants to compliment the Koeberg plant, the government considers that preparatory work for beneficiation of uranium is important. According to the Beneficiation Strategy document published in 2011, interventions for the successful implementation of nuclear power generation include: quantification of uranium reserves; determining the economic feasibility of re-establishing uranium enrichment; developing a plan for comprehensive waste treatment and mine rehabilitation; and finalisation of the uranium policy with all the relevant stakeholders. Ten commodities, including uranium, were selected for promotion and enhance local beneficiation in South Africa. More information is found at www.info.gov.za.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The National Nuclear Regulator Act No. 47 of 1999, the Nuclear Energy Act No. 46 of 1999, National Radioactive Waste Disposal Institute Act No. 53 of 2008, and the Mineral and Petroleum Resources Development Act No. 28 of 2002 are the basis of national policies relating to prospecting for and mining of uranium in South Africa, as well as the export of uranium and disposal of spent nuclear fuel. More information on these policies can be found on the following links:

- www.gov.za/documents/national-nuclear-regulator-act;
- www.gov.za/documents/nuclear-energy-act;
- www.energy.gov.za/files/policies/act_nuclear_53_2008_NatRadioActWaste.pdf;
- www.gov.za/documents/mineral-and-petroleum-resources-development-act.

The Department of Mineral Resources has embarked on a process of reviewing the mining legislative framework, in which the Cabinet has approved the proposals on the amendment of the Mineral and Petroleum Resources Development Bill and gazetted it for further comments. The focus of the amendments is to remove ambiguities in the act that previously created room for multiple interpretations, to ensure the act remains current and relevant and to align the provisions of the act with relevant legislation in other parts of the government, among others. The amendments of the act will also integrate the mining licensing approach in government, together with the Department of Water Affairs as well as the Department of Environmental Affairs as compared to the current fragmented approach to licensing requirements for mining. The enactment of the amended the Mineral and Petroleum Resources Development Act No. 28 of 2002 has been delayed, and it has been returned to the parliament for review.

More information on the amendments to the Mineral and Petroleum Resources Development Act No. 28 of 2002 can be found at www.gov.za/documents/mineral-and-petroleum-resources-development-act.

Uranium stocks

The information and figures on uranium stocks are classified as confidential, and hence could not be accessed from Eskom.

Uranium prices

No uranium prices were available.

Uranium exploration and development expenditures and drilling effort – domestic

(ZAR [South African rand])

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	188 183 202	11 550 286	10 775 196	50 000 000
Government exploration expenditures	0	2 000 000	0	0
Industry* development expenditures	87 895 589**	7 205 000	6 886 000	10 000 000
Government development expenditures	0	0	0	0
Total expenditures	**276 078 791****	**18 755 286**	**17 661 196**	**60 000 000**
Industry* exploration drilling (m)	32 000	2 472	0	68 000
Industry* exploration holes drilled	414	67	0	1 050
Industry exploration trenches (m)	0	0	0	0
Industry trenches (number)	0	0	0	0
Government exploration drilling (m)	0	1 970	0	0
Government exploration holes drilled	0	5	0	0
Government exploration trenches (m)	0	0	0	0
Government trenches (number)	0	0	0	0
Industry* development drilling (m)	52 354	88 348	63 308	90 500
Industry* development holes drilled	638	699	454	710
Government development drilling (m)	0	0	0	0
Government development holes drilled	0	0	0	0
Subtotal exploration drilling (m)	32 000	4 442	0	68 000
Subtotal exploration holes drilled	414	72	0	1 050
Subtotal development drilling (m)	52 354	88 348	63 308	90 500
Subtotal development holes drilled	638	699	454	710
Total drilling (m)	**84 354**	**92 790**	**63 308**	**158 500**
Total number of holes drilled	**1 052**	**771**	**454**	**1 760**

* Non-government.

** Includes expenditures for both uranium and gold in the Witwatersrand Basin.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	7 261	8 526
Paleo-quartz-pebble conglomerate*	0	167 874	230 321	249 892
Surficial	0	0	0	1 146
Total	**0**	**167 874**	**237 582**	**259 564**

* Paleo-quartz-pebble conglomerate resources include tailings resources as well.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)*	0	0	7 261	9 672	80
Co-product and by-product	0	167 874	230 321	249 892	70
Total	**0**	**167 874**	**237 582**	**259 564**	**70**

* The resources for sandstone-hosted deposits in the Karoo Basin are included in the open-pit method; however, in reality the potential production will be conducted by both open-pit and underground mining, the ratio of resources to each method is unknown at present.

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG*	0	167 874	230 321	249 892	70
Conventional from OP	0	0	7 261	9 672	80
Total	**0**	**167 874**	**237 582**	**259 564**	**70**

* Conventional from UG also includes tailings resources from the Witwatersrand Basin.

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	10 467	13 491
Paleo-quartz-pebble conglomerate*	0	61 656	74 361	104 861
Surficial	0	0	0	589
Lignite and Coal	0	0	0	70 775
Total	**0**	**61 656**	**84 828**	**189 716**

* Includes tailings resources in the Witwatersrand Basin.

Inferred conventional resources by production method

(tonnes U)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Underground mining (UG)*	0	0	0	70 775	68
Open-pit mining (OP)**	0	0	10 467	14 080	80
Co-product and by-product	0	61 656	74 361	104 861	75
Total	**0**	**61 656**	**84 828**	**189 716**	**73**

* Underground mining resources only include resources from the Springbok Flats Basin. The resources from underground operations in the Witwatersrand Basin are included in the "co-product and by-product" category.

** Resources in the Karoo Basin are included in the open-pit mining method, even though both open-pit and underground mining method are expected to be used. The recovery factor used for the open-pit method (80%) is speculative only.

Inferred conventional resources by processing method

(tonnes U)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**	**Recovery factor (%)**
Conventional from UG	0	61 656	74 361	175 636	72
Conventional from OP	0	0	10 467	14 080	80
Total	**0**	**61 656**	**84 828**	**189 716**	**73**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	74 000	159 000

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
243 000	411 000	280 000

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	**Total through end of 2011**	**2012**	**2013**	**2014**	**Total through end of 2014**	**2015 (expected)**
Paleo-quartz-pebble conglomerate	157 946	467	531	566	159 510	800
Total	**157 946**	**467**	**531**	**566**	**159 510**	**800**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Co-product/by-product	157 946	467	531	566	159 510	800
Total	**157 946**	**467**	**531**	**566**	**159 510**	**800**

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	157 946	467	531	566	159 510	800
Total	**157 946**	**467**	**531**	**566**	**159 510**	**800**

Ownership of uranium production in 2014

Domestic				**Foreign**				**Totals**	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
0	0	566	100	0	0	0	0	566	N/A

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	237	1 742	4 141	3 815
Employment directly related to uranium production	182	175	406	472

Short-term production capability

(tonnes U/year)

2013				**2015**				**2020**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	531	0	0	0	800		0	0	950	1 300

2025				**2030**				**2035**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	1 160	3 000	0	0	1 180	2 800	0	0	1 090	2 500

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	13.6	14.8

Installed nuclear generating capacity to 2035

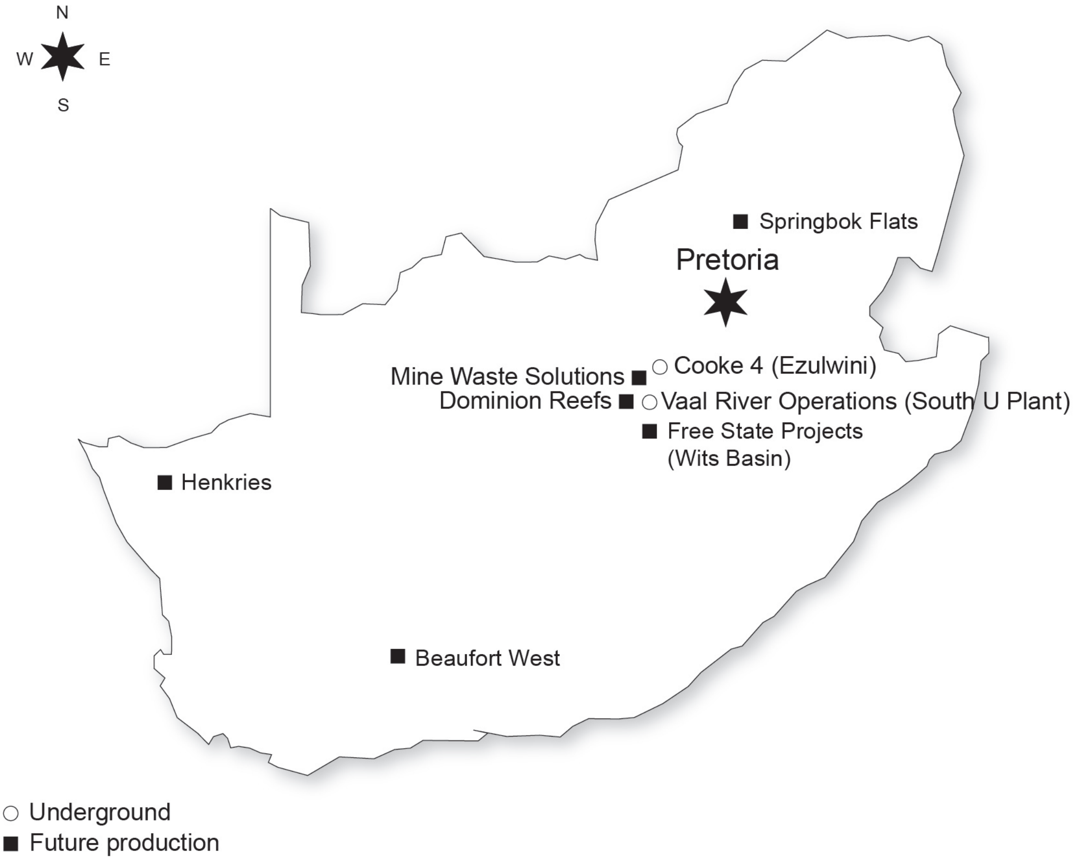
(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
1 840	1 840	1 840	1 840	1 840	1 840	1 840	1 840	1 840	7 200	1 840	9 600	1 840	9 600

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
294	294	294	294	294	294	294	294	294	1 152	294	1 536	294	1 536



Spain

Uranium exploration and mine development

Historical review

Uranium exploration started in 1951 and was carried out by the Junta de Energía Nuclear (JEN). Initial targets were the Hercynian granites of western Spain. In 1957 and 1958, the first occurrences in Precambrian-Cambrian schists were discovered, including the Fe deposit, located in the province of Salamanca. In 1965, exploration of sedimentary rocks began and the Mazarete deposit in Guadalajara province was discovered. In 1972, the Empresa Nacional del Uranio, S.A. (ENUSA) (today ENUSA Industrias Avanzadas, S.A.), a state-owned company, was established to take charge of all the nuclear fuel cycle front-end activities. Its shareholders are the Sociedad Estatal de Participaciones Industriales (SEPI) holding 60% of the capital, and the Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT, previously JEN), holding the remaining 40%. Exploration activities by the ENUSA ended in 1992. Joint venture exploration between ENUSA and other companies continued until the end of 1994. During this period, most of the Spanish territory was surveyed using a variety of methods, adapted to different stages of exploration, and ample airborne and ground radiometric coverage of the most interesting areas was achieved.

Recent and ongoing uranium exploration and mine development activities

Berkeley Resources has been granted one mining licence in the province of Salamanca covering 2 720 Ha and a total of 25 investigation licences spanning the provinces of Salamanca Cáceres and Badajoz covering a total of 105 762 Ha. This company has been actively exploring for uranium for several years, with a focus on a number of historically known uranium projects located within their tenements.

Berkeley's "Salamanca" Project comprised the Retortillo and Alameda deposits (in the Salamanca province) and also the Gambuta one (in the Cáceres province), which has been increased with the announcement by Berkeley of a new discovery of the Zona 7 deposit, which, according to that company, may add 30 Mlb of U_3O_8 to the previously identified resources (58 Mlb of U_3O_8).

As Zona 7 is located within 10 km of the proposed centralised processing plant at Retortillo, as previously said, it may be integrated with planned development of Retortillo and Alameda, and potentially increase the level of production and/or mine life of the Salamanca Project.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The identified resources reported a total of 88.2 Mlb of U_3O_8 (33 923 tU), which includes 4.4 Mlb at the measured category, 29.1 Mlb as Indicated, and 54.8 Mlb as inferred.

All reported resources are mineable by conventional open pit.

Uranium production

Historical review

Production started in 1959 at the Andújar plant, Jaén province, and continued until 1981. The Don Benito plant, Badajoz province remained in operation from 1983 to 1990. Production at the Fe mine (Salamanca province) started in 1975 with heap leaching (Elefante plant). A new dynamic leaching plant (Quercus) started in 1993 and was shut down in December 2000. The licence for a definitive shutdown of the production, submitted to regulatory authorities in December 2002, was approved in July 2003.

Status of production capability

Mining activities were terminated in December 2000 with the closure of Saelices el Chico uranium mines and production of uranium concentrates ended in November 2002 when the associated Quercus processing plant was shut down. A decommissioning plan was presented to regulatory authorities in 2005. However, due firstly to the need to decommission the former Elefante processing plant and the restoration of mines at the same site before decommissioning Quercus and secondly, a 2009 agreement between ENUSA and Berkeley to complete a feasibility study on the state reserves in the Salamanca province, the decommissioning plan was put on standby. Nevertheless, by September 2015, a new plan for decommissioning was presented to regulatory authorities.

Ownership structure of the uranium industry

Quercus, the only production facility in Spain, still pending decommissioning, belongs to the company ENUSA Industrias Avanzadas, S.A.

Employment in the uranium industry

Employment at the Fe mine totalled 23 at the end of 2014. All of these workers are dedicated to the mining restoration, surveillance and decommissioning programmes.

Berkeley totalises a range of 30-50 employees, depending on the activity carried out at each time. Berkeley's activity is focused on the project development of the Salamanca Project.

Future production centres

Berkeley Minera España has announced its intention to bring four potential open-pit uranium mines into production: Retortillo-Santidad, Alameda, Zona 7 and Gambuta (the former three in the Salamanca region and the latter in the Cáceres region). Berkeley applied to the competent authority (autonomous regional government) for an exploitation permit for the Retortillo-Santidad mining project in October 2011 and the mining licence was granted in April 2014, once the Environmental Licence was in place and the Nuclear Safety Council informed favourably. Likewise, according to the nuclear regulation, Berkeley requested the site authorisation for the radioactive facility to the Ministry of Industry, Energy and Tourism (MINETUR), in March 2012, which was granted by September 2015, after favourable report of the CSN, allowing Berkeley to request a construction authorisation. The project, according to Berkeley and including only Retortillo and Alameda deposits, should have an average production of 2.7 Mlbs U_3O_8/yr (1 030 tU/yr) during an 11-year period of operation, with steady state production of 3.3 Mlbs U_3O_8/yr (1 260 tU/yr).

Secondary sources of uranium

Spain reports mixed oxide fuel and re-enriched tails production and use as zero.

Environmental activities and socio-cultural issues

The present condition of former uranium production facilities in Spain are as follows:

- Fábrica de Uranio de Andújar (Jaén province): Mill and tailings piles have been closed and remediated, with an ongoing ten-year surveillance and control programme (groundwater quality, erosion control, infiltration and radon control). This programme has been extended.
- Mine and plant "LOBO-G" (Badajoz province): The open-pit and mill tailings dump have been closed and remediated, with a surveillance and control programme (groundwater quality, erosion control, infiltration and radon control) in place until 2004. A long-term stewardship and monitoring programme was begun after the declaration of closure.
- Old mines (Andalucía and Extremadura regions): Underground and open-pit mines were restored, with work completed in 2000.
- Two old mines in Salamanca (Valdemascaño and Casillas de Flores) were restored in 2007, following which a surveillance programme was initiated, ending in 2011. Results were evaluated by regulatory authorities and it was determined that an extension of the surveillance period until 2016 was required.
- Elefante plant (Salamanca province): The decommissioning plan, including industrial facilities and heap leaching piles, was approved by regulatory authorities in January 2001. The plant was dismantled and ore stockpiles were levelled and covered in 2004. A monitoring and control programme has been in place since 2005.
- In 2004, the mining restoration plan of the open-pit exploitation in Saelices el Chico (Salamanca province) was approved by regulatory authorities. Implementation of this plan was finished in 2008 and the proposed surveillance and control programme was sent to regulatory authorities for approval. A monitoring and control programme has been in place since this year.
- Quercus plant (Salamanca province): Mining activities ended in December 2000 and uranium processing in November 2002. A decommissioning plan was submitted to regulatory authorities in 2005. However, because of the need for the decommissioning of the former Elefante processing plant and for the restoration of some of the mines at the same site before turning to the decommissioning of Quercus – owing to the 2009 agreement between ENUSA and Berkeley – this decommissioning plan was put on standby. By September 2015, a new plan for decommissioning was due to be presented to the regulatory authorities. During this time, a surveillance and maintenance programme has been in place for the plant and associated facilities.

Uranium mining regulatory regime

In Spain, the mining regime is regulated by the Mines Act (Act 22/1973), modified by Act 54/1980 and by Royal Decree 2857/1978. The investigation and use of radioactive ores is governed by this act in those areas that are not specifically considered in the Nuclear Energy Act (Act 25/1964), Chapter IV of which deals with the prospecting, investigation and use of radioactive ores, as well as the commercialisation of such ores and their concentrates.

According to Article 2 of the Mines Act, all natural deposits and other geological resources in Spain are assets belonging to the public domain, investigation and use of which may be undertaken directly by the state or assigned in accordance with the rules. Pursuant to Article 1 of Act 54/1980, which amends the Mines Act, radioactive ores are part of Section D, i.e. resources of national energy interest.

Pursuant to Article 19 of the Nuclear Energy Act, the prospecting, investigation and use of radioactive ores and the obtaining of concentrates are declared to be free throughout the entire national territory, except in those areas set aside by the state. Individuals or companies who wish to prospect for radioactive ores are required to request an investigation permit from the state and subsequently, if the existence of one or more resources open to rational exploitation is revealed, to request an exploitation licence. This licence confers the right to exploit the resources and is granted for a 30-year period, extendable by similar periods to a maximum of 90 years. The permits and licences are granted by the autonomous communities, in keeping with the transfer to them of state competences in mining and energy issues, except when the mining activity in question affects several autonomous communities or state reserves in which case the competent authority is the MINETUR, by virtue of the Mines Act.

The Nuclear Safety Council (CSN) is the organisation responsible for nuclear safety and radiological protection. In accordance with Article 2 of the act creating the CSN (Act 15/1980), one of the main competences of the council is to issue reports to the MINETUR on nuclear safety and radiological protection, prior to the resolutions adopted by the latter regarding the granting of authorisations for the operation, restoration or closure of uranium mines and production facilities. These reports are mandatory in all cases and binding when negative in their findings or denying authorisation, or as regards the conditions established when they are positive.

Regarding restoration plans and financial guarantees for the mining activities, according to the Royal Decree 975/2009 of 12 June on the management of waste resulting from extractive industries and the protection and restoration of the environment affected by mining activities, a restoration plan must be submitted for approval to the mining authority (the autonomous regional government or MINETUR, in the case of those mining activities affecting several autonomous communities or state reserves), the approval of which will be given together with the granting of the exploitation licence. The mining authority will neither grant the licence nor approve the plan unless environmental restoration of the site is guaranteed. To that end, two financial guaranties have to be set up by the company before starting any mining activity, one for the rehabilitation of the environment affected by the exploitation of the ores and the second one for the management of the generated waste, both to comply with the objectives and conditions established in the authorised restoration plan even in the case that the company does not exist at the time of the restoration.

Regarding decommissioning of the associated milling facilities, those are considered, by the Regulation on Nuclear and Radioactive Installations (RINR, approved by Royal Decree 1836/1999 and modified several times afterwards) as radioactive facilities of the nuclear fuel cycle and are subject to previous construction and exploitation licences. An exploitation licence requires the applicant to submit decommissioning and closure forecasts, including, among other things, the final management of the radioactive wastes as well as the economic and financial calculations to guarantee closure of the site. The last amendment of the RINR, by Royal Decree 102/2014, requires the constitution of a financial guarantee before granting this licence.

Uranium requirements

As of 1 May 2015, the net capacity of the seven Spanish nuclear reactors under commercial operation (Almaraz units 1 and 2, Ascó units 1 and 2, Cofrentes, Vandellós 2 and Trillo nuclear power plants) was about 7.1 GWe. No new reactors are expected to be built in the near future. Through 2010 and 2011, the Spanish government approved ten-year licence renewal for Ascó units 1 and 2, Almaraz units 1 and 2, Vandellós unit 2 and the lone Cofrentes unit. In 2014, the Trillo NPP received its renewal for operation until 2024. Accordingly, uranium requirements for the Spanish nuclear fleet in the coming years will foreseeably range from 1 150 to 1 250 tU/yr.

Supply and procurement strategy

All uranium procurement activities are carried out by ENUSA Industrias Avanzadas S.A. on behalf of the Spanish utilities that own the seven nuclear reactors under commercial operation in Spain.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Spain's uranium import policy provides for diversification of supply. The Spanish legislation leaves uranium exploration and production open to national and foreign companies.

Uranium stocks

Present Spanish regulation provides that a strategic uranium inventory contained in enriched uranium should be held jointly by the utilities that own NPPs. The current stock contains the equivalent of at least 608 tU (721 tU_3O_8). Additional inventories could be maintained depending on uranium market conditions.

Uranium exploration and development expenditures and drilling effort – domestic

(USD)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	12 105 683	13 000 000	5 400 000	7 000 000
Total expenditures	**12 105 683**	**13 000 000**	**5 400 000**	**7 000 000**
Industry* exploration drilling (m)	12 857	13 033	8 539	13 000
Industry* exploration holes drilled	214	174	133	180
Subtotal exploration drilling (m)	12 857	13 033	8 539	13 000
Subtotal exploration holes drilled	214	174	133	180
Total drilling (m)	**12 857**	**13 033**	**8 539**	**13 000**
Total number of holes drilled	**214**	**174**	**133**	**180**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related/metasediments-hosted	0	0	0	12 900
Total	**0**	**0**	**0**	**12 900**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	0	12 900	85
Total	**0**	**0**	**0**	**12 900**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP	0	0	0	12 900	75
Total	**0**	**0**	**0**	**12 900**	

Inferred resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related/metasediments-hosted	0	0	0	21 000
Total	**0**	**0**	**0**	**21 000**

Inferred resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)	0	0	0	21 000	85
Total	**0**	**0**	**0**	**21 000**	

Inferred resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP	0	0	0	21 000	75
Total	**0**	**0**	**0**	**21 000**	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Granite-related	5 028	0	0	0	5 028	0
Total	**5 028**	**0**	**0**	**0**	**5 028**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	5 028	0	0	0	5 028	0
Total	**5 028**	**0**	**0**	**0**	**5 028**	**0**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	4 961	0	0	0	4 961	0
Other methods*	67	0	0	0	67	0
Total	**5 028**	**0**	**0**	**0**	**5 028**	**0**

* Includes mine water treatment and environmental restoration.

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres	23	23	23	23
Employment directly related to uranium production	0	0	0	0

Net nuclear electricity generation

	2013	2014
Nuclear electricity generated (TWh net)	54.3	54.8

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
7 069	7 069	7 069	7 069	7 069	7 069	N/A	N/A	N/A	N/A	N/A	N/A

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
1 185	1 124	1 200	1 400	1 150	1 250	1 150	1 250	N/A	N/A	N/A	N/A

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	0	0	0	0	0
Producer	0	0	0	0	0
Utility	N/A	608	0	N/A	N/A
Total	**N/A**	**608**	**0**	**N/A**	**N/A**

Sweden*

Uranium exploration and mine development

Historical review

Uranium exploration in Sweden was first carried out between 1950 and 1985, initially through AB Atomenergi and from 1967 by the Geological Survey of Sweden and associated companies. At the end of 1985, exploration activities were stopped as a result of the availability of uranium at low prices on the world market. This early work did, however, result in the delineation of four main uranium provinces in Sweden.

The first is in the Upper Cambrian and Lower Ordovician sediments in southern Sweden and along the border of the Caledonian mountain range in central Sweden. The uranium occurrences are stratiform, in black (alum) shales. Billingen (Vastergotland), where the Ranstad deposits are located, covers an area of more than 500 km^2.

The second uranium province Arjeplog-Arvidsjaur-Sorsele, is immediately south of the Arctic Circle. It comprises one deposit (Pleutajokk) and a group of more than 20 occurrences. The individual occurrences are discordant, of a vein or impregnation-type, associated with sodium-metasomatism.

A third province is located north of Ostersund in central Sweden. Several discordant mineralised zones have been discovered in, or adjacent to, a window of Precambrian basement within the metamorphic Caledonides. A fourth province is located near Asele in northern Sweden.

Since 2007, a number of exploration companies have been active in Sweden, in many cases focusing work on areas where discoveries were made during the initial phase of exploration. Two Canadian companies, Mawson Resources and Continental Precious Minerals have been most active and between the two companies 12 800 tU (33 280 Mlbs U_3O_8 in situ) have been reported from nine historical occurrences using Geological Survey of Sweden data with some recently twinned drill holes. The Duobblon project is the largest with an inferred resource of 3 370 tU grading 0.024% U. In addition to these small epigenetic vein, fracture and intrusive-related uranium deposits some companies are reassessing the massive low-grade potential of the black shales of central Sweden.

Recent and ongoing uranium exploration and mine development activities

Most activity during 2013 and 2014 has been related to the potential of the alum (black) shale where uranium can be recovered as a by-product along with other co-products such as molybdenum, vanadium, nickel, zinc and petroleum products. Exploration expenses figures for the course of these two years are however not available.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2015, Sweden's total identified conventional resources had not changed since the last estimates reported in the 2014 Red Book edition.

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* Report prepared by the NEA/IAEA, based on previous Red Books and company reports.

Undiscovered conventional resources (prognosticated and speculative resources)

Neither prognosticated nor speculative resources are reported in Sweden.

Unconventional resources and other materials

In past editions of the Red Book, the potential for very large, low-grade resources of uranium in the alum shale was noted (300 000 tU mineable in the Billingen area of southern Sweden alone) and limited production was undertaken in the 1960s. By the late 1980s however, the cost of production was considered too high for economic production with uranium prices of the time and these deposits were no longer reported in the Red Book.

With renewed interest in uranium owing to strengthening prices since 2003, exploration of the alum shale in central Sweden was resumed with alternative production methods under consideration to reduce production costs. Continental Precious Minerals has 72 mineral exploration licences throughout Sweden but the company has been focusing on its Viken licence in central Sweden, a black shale deposit with elevated concentrations of uranium, nickel, molybdenum and vanadium. Continental is investigating mining by a relatively shallow open pit with bio-heap leaching as a process technology. An updated preliminary economic assessment was completed in 2014, which incorporated 152 diamond drill holes (26 293 m) on the Viken and surrounding licences. This project has district scale potential from exploration, with capacity to expand mineable portion of the resources on the Viken and nearby licences. The potentially mineable portion of resource for the Viken Deposit was estimated at 1 163 million lbs U_3O_8 with 0.017% U_3O_8 (447 308 tU) according to the updated preliminary economic assessment made in 2014. Continental announced in September 2015 that the applications made to the Inspectorate of Mines in Sweden to renew several of its Viken project licences, have been approved.

In late 2009, Australian Securities Exchange-listed Aura Energy applied for significant landholdings to investigate the alum shale. The company initially reported a JORC compliant in situ inferred resource at its Häggån Project of 111 933 tU at 0.013% U. This was subsequently upgraded to 307 692 tU. Further increases can be expected, since the existing resource estimate is based on 15% of the Häggån Project area. A scoping study was completed which examined a range of heap leach options including bio-heap leaching, with positive results reported. Aura and Areva entered into a binding co-operation agreement in February 2013 however, after completing due diligence on the project, Areva announced in July 2013 that it would not proceed with a proposed partnership to develop the Häggån uranium and polymetallic project. In December 2013, Aura considered that given the current market conditions, to reassess the 2012 Häggån Scoping Study, on smaller scales more likely to attract funding. The company considered three smaller size options: 3.5 Mtpa, 5.0 Mtpa and 7.5 Mtpa, which could be used to provide a development alternative with a substantially lower front-end capital cost requirement. Aura concludes that the remodelling "has demonstrated robust project financials at all scales of operation".

In December 2011, Tournigan Energy acquired all of Mawson Resource's "non-core" uranium interests in Sweden and Finland and subsequently changed its name to European Uranium Resources Ltd. Areva, a major shareholder in Mawson, participated in an exclusive private placement with the new company. Mawson's main focus is their Rompas gold-uranium project in Finland and European Uranium's main focus is their Kuriskova uranium deposit in the Slovak Republic. The deal has resulted in Mawson shareholders owning approximately 20.5% of the restructured Tournigan (European Uranium).

Mawson Resources completed work on the Tåsjö Project in 2006 and 2007, investigating uranium contained in mineralised phosphatic shale with rare earth elements in northern Sweden. The area was discovered in 1957 by the Swedish Atomic

Energy Company and subsequently explored in the early 1970s by the Geological Survey of Sweden and the Stora Kopparberg and Boliden companies. The size of the exploration target outlined by the Swedish Atomic Energy Company in the 1960s was confirmed by Mawson at about 42 300 tU at 0.042% U, although the tonnages and grades are considered conceptual at this time.

Clearly there are significant unconventional uranium resources that potentially could be available to the market in future years if costs of production of the bio-heap leaching technology under evaluation justify economic production. The deposits also contain high values of V, Mo, Ni and Zn.

Uranium production

Historical review

In the 1960s, a total of 200 tU were produced from the alum shale deposit in Ranstad that represents all of Sweden's historical production. This mine is now being restored to protect the environment.

Status of production capability

There is currently no uranium production in Sweden.

Future production centres

Aura's Häggån Project consists of 110 km^2 in the Storsjön District in Sweden. Uranium occurs along with molybdenum, nickel, vanadium and zinc in black shales which form a 20 to 250 m thick near continuous sheet throughout the area drilled by Aura during 2008-2011 programmes. A Scoping Study was completed in February 2012 by independent consultants RMDSTEM Limited using initial pit shells containing >741 Mt ore with much of the prospective area remaining in the tenements untested by drilling. The two stages of bio-heap leaching test work show up to 85% uranium extraction, as well as 58% nickel and 18% molybdenum. An annual production rate of 3 000 tU has being considered. However, in December 2013, Aura Energy Ltd announced that given the current market conditions, the results of remodelling the 2012 scoping study for smaller size options, are more likely to attract funding than a project with a high initial capital cost.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Sweden does not currently use mixed oxide fuel or reprocessed uranium.

Environmental activities and socio-cultural issues

The Ranstad mine was rehabilitated in the 1990s at a total cost of SEK 150 million (about USD 20 million). An environmental monitoring programme is now being carried out. Local resistance has blocked efforts to renew uranium exploration in the area.

Uranium requirements

The ten currently operational reactors provided about 41% of the electricity generated in 2014 and require about 1 500 to 1 900 tU annually.

Following the Fukushima Daiichi accident, the government ordered a comprehensive review of the current reactor fleet ahead of the EU stress tests. The national review and the EU stress tests identified a number of measures to strengthen safety, in particular relating to responses to severe accidents. All modernisation and safety upgrades identified for all nuclear plants were completed by 2015.

Nationally owned Vattenfall, the largest Nordic utility, filed an application in 2012 to build up to two reactors to replace its older units, noting that an investment decision would not be made for a number of years. In response to the application, the Swedish Radiation Safety Authority indicated that the application process may take up to 15 years in total. In 2013, Vattenfall announced a plan to invest USD 2.4 billion between 2013 and 2017 to further modernise and upgrade its five most recently built units (Ringhals 3, 4 and Forsmark 1-3) in order to continue operations for up to 60 years.

The results of the election in September 2014 brought to an end the possibility of constructing replacement reactors at existing sites, when a new coalition government set up an energy commission to drive the country towards total reliance on renewable energy sources. It indicated that current nuclear generating capacity should be replaced by renewable energy sources or made redundant by reduced demand through energy conservation.

Also, in response to the proposed 17% increase in taxes from 2015, the operators of the NPPs indicated that older plants may have to be shut down earlier than expected because the increased taxes, along with demanding and costly post-Fukushima safety upgrades, reduces profitability. In November 2014, Vattenfall announced that it had been instructed to stop analysing the case for the construction of replacement reactors.

Supply and procurement strategy

The utilities are free to negotiate their own purchases.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Two separate permits under the Minerals Act and the Environmental Code are required to mine uranium deposits in Sweden. In addition, the Nuclear Activities Act contains provisions regulating the right to acquire, possess or deal in any other way with nuclear materials or minerals containing such materials.

Permit applications under the Environmental Code are considered by the government, and permits may only be granted if approval has been recommended by the local authority in whose areas the deposit occurs.

Uranium stocks

The Swedish parliament decided in 1998 to replace the previous obligation that utilities had to keep a stockpile of enriched uranium corresponding to the production of 35 TWh with a reporting mechanism. Sweden reports no information on uranium stocks.

Uranium prices

As Sweden is now part of the deregulated Nordic electricity market, costs of nuclear fuel are no longer reported.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related			4 248	4 248
Volcanic-related			551	551
Metasomatite			1 696	1 696
Total			**6 495**	**6 495**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 870	4 870	75
Total			**4 870**	**4 870**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 870	4 870	75
Total			**4 870**	**4 870**	

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Granite-related			603	603
Volcanic-related			4 849	4 849
Metasomatite			852	852
Total			**6 303**	**6 303**

* In situ resources.

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 725	4 725	75
Total			**4 725**	**4 725**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unspecified			4 725	4 725	75
Total			**4 725**	**4 725**	

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Black shale	200	0	0	0	200	0
Total	**200**	**0**	**0**	**0**	**200**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining[1]	200	0	0	0	200	0
Total	**200**	**0**	**0**	**0**	**200**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	200	0	0	0	200	0
Total	**200**	**0**	**0**	**0**	**200**	**0**

Net nuclear electricity generation*

	2013	2014
Nuclear electricity generated (TWh net)	63.6	62.2

* NEA (2015), *Nuclear Energy Data*, OECD, Paris.

Installed nuclear generating capacity to 2035*

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
9 500	9 500	Low	High	Low	High	Low	High	Low	High	Low	High
		9 500**	N/A	N/A	10 000	N/A	N/A	N/A	7 800	N/A	N/A

* NEA (2015), *Nuclear Energy Data*, OECD, Paris.

** NEA/IAEA estimate.

Annual reactor-related uranium requirements to 2035 (excluding MOX)*

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
1 414	1 433	Low	High	Low	High	Low	High	Low	High	Low	High
		1 000	1 880	1 000	1 880	1 000	1 500	800	1 500	800	1 500

* NEA (2015), *Nuclear Energy Data*, OECD, Paris.

Tanzania[*]

Uranium exploration and mine development

Historical review

Uranium was first discovered in Chiwiligo pegmatite in the Uluguru Mountains in 1953. The first general evaluation of uranium potential of Tanzania was a country-wide airborne geophysical survey for the government between 1976 and 1979. Results revealed a large number of radiometric anomalies in a variety of geological settings.

A uranium exploration programme was subsequently carried out by Uranerzbergbau GmbH between 1978 and 1983, but was stopped because of declining uranium prices. Targets of this survey were anomalies in the Karoo, in younger surficial sediments, in phosphatic sediments of Pleistocene age and carbonatite of the Gallapo. Numerous occurrences of surface uranium mineralisation have been identified and there is potential for several uranium deposit types in the country.

A large part of the southern Tanzanian geology is comprised of Karoo rocks, terrigenous sediments of a few thousand metres of thickness that accumulated in basins during the Late Paleozoic-Early Mesozoic. The basal series is comprised of glacial deposits, which in turn are overlain by fluvial-deltaic coal-bearing sediments succeeded by arkoses and continental red beds. Transitional carbonaceous shales with coals gradually develop into thick lacustrine series which are topped by Late Permian bone-bearing beds. The Triassic is characterised by a very thick fluvio-deltaic succession of siliciclastics resting with regional unconformity on the Permian. This Early Triassic sequence exhibits well-developed repetitive depositional cycles. Heightened uranium values are observed in the Triassic arenaceous series with diagenetic alteration and subsequent cementation.

Interest in uranium exploration was rekindled after the rise of uranium prices in 2007 and the URT government issues over 70 licences. Present exploration is focused on identification of sandstone-type uranium deposits in the Karoo Basin in southern part and surficial-type deposits in the central part of the country.

The uranium JORC and NI-43/101 compliant resources (measured, indicated and inferred) reported by various companies are given in the following table below.

Recent and ongoing uranium exploration and mine development activities

Mantra Resources completed an environmental and social impact assessment in 2011 and submitted the reports to the Tanzanian National Environmental Management Council in support of an application for a mining licence. Mantra Resources was acquired in 2011 by the Russian Atomredmetzoloto. An updated resource of the Nyota deposit estimate in September 2011 boosted total in situ resources by over 40% to 119.4 Mlbs U_3O_8 (45 924 tU) and formed the basis of a feasibility study. Uranium One Inc. was appointed as the project operator.

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[*] NEA/IAEA estimate based on company reports and other publicly available data.

In 2012, Mantra Resources continued regional exploration drilling at the Mkuju River regional area and near Nyota, which focused on new mineralised zones and resources estimation.

Uranium resources of Tanzania (UDEPO, 2013*)

Deposit name	Resources (tU)	Grade (%U)	Estimated in	Type	Sub-type	Operator
Likuyu North	2 346	0.020	2011	Sandstone	Tabular	Uranex NL
Manyoni district-Zone A	1 771	0.0127	2008	Surficial	Lacustrine-playa	Uranex NL
Manyoni district-Zone C 1	6 122	0.0125	2011	Surficial	Lacustrine-playa	Uranex NL
Manyoni district-Zone C West	347	0.0119	2011	Surficial	Lacustrine-playa	Uranex NL
Manyoni district-Zone E	2 079	0.0110	2011	Surficial	Lacustrine-playa	Uranex NL
Manyoni district-Zone F	462	0.0119	2011	Surficial	Lacustrine-playa	Uranex NL
Manyoni district-Zone G	655	0.0127	2011	Surficial	Lacustrine-playa	Uranex NL
Mtonya	775	0.022	2013	Sandstone	Tabular	Uranium Resources Inc.
Nyota	58 505	0.026	2013	Sandstone	Tabular	Mantra/Uranium One

Note: The biggest deposit so far is the Nyota deposit, part of the Mantra/Uranium One Mkuju River Project.

* World Distribution of Uranium Deposits (UDEPO) – https://infcis.iaea.org/UDEPO/About.cshtml.

Drilling activities and historical data analysis resulted in a 28% total resources increase in June 2013 to 152.1 Mlbs U_3O_8 (58 505 tU), including 124.6 Mlbs U_3O_8 (47 927 tU) measured and indicated at an average grade of 303 ppm U_3O_8 (0.0257% U) at a 100 ppm U_3O_8 (0.0085% U) cut-off grade. Recent activity at the Mkuju River project focused on feasibility study optimisation and update, licensing and permitting. In June 2012, the UNESCO World Heritage Committee approved an application by the Tanzanian government for a minor adjustment to the boundary of the Selous World Heritage Game Reserve removing the Mkuju River project and an adjacent buffer zone from the Selous World Heritage Game Reserve site. The Mkuju River uranium mine project obtained an environmental impact assessment certificate in October 2012 from the Tanzanian government and in April 2013, a mining licence was granted to Mantra.

In 2013, Mantra Resources main exploration activities were focused on Nyota deposit resources verification through a grade control programme implementation and ISL on-site push-pull testing to identify principal mineralisation amenability for ISL mining. Initial ISL testing has yielded encouraging results. The ISL project is currently at the R&D stage, and the next steps have been identified and planned. In 2015, Mantra Resources obtained official approval and started a more advanced hydrogeology and two spot ISL test works. It will continue to explore and investigate the ISL potential via a responsible, stage-gated approach.

Drilling to date by Uranex at Likuyu North has identified a mineralised zone extended to 2.6 km of the 5 km zone defined by the surface radiometric anomaly. In April 2012, a maiden resource was estimated at 6.1 Mlb U_3O_8 (2 346 tU) with an average grade of 237 ppm U_3O_8 (0.02% U) reported at a 100 ppm U_3O_8 (0.0085% U) cut-off grade. Efforts have been undertaken to define economic uranium mineralisation within the project area that is not associated with surface radiometric anomalism and three zones were targeted for drilling at Likuyu North during the 2012 drilling programme.

In 2010, Uranex reported inferred resources of 12 000 tU in a shallow deposit at Manyoni which is adjacent to the Bahi deposit. The region incorporates an extensive closed draining system developed over weathered uranium rich granites. This drainage captures dissolved uranium leached from underlying rocks and transports it to suitable precipitation trap sites (playa lakes). The shallow-natured deposits found to date in the Bahi playa lake system in Central Tanzania have some characteristics comparable to the Yilgarn calcrete uranium province in Western Australia. The Manyoni Project encompasses up to five playa lakes in the Manyoni District.

Uranium Resources Plc. completed 159 diamond drill holes (39 000 m) and announced the maiden resource of 3.6 Mt ore containing 2 Mlb U_3O_8 (769 tU) with grading of 255 ppm U_3O_8 (0.00216% U) at the Mtonya Project. The resource is potentially amenable to in situ leach recovery. The uranium mineralisation is known to occur to depths of 350 m in continuous 30 to 50 metre-wide roll fronts. In total, three tiers of redox fronts up to 200 m thick were identified. Mtonya is currently on care and maintenance. However, in 2014, the company continued to evaluate its exploration and development strategy, including corporate transactions, in order to advance and realise Mtonya's value.

Uranex and Uranium Resources Plc. have reported no significant uranium related exploration activities since 2013.

In 2010, a memorandum of understanding signed between Japan Oil, Gas and Metal National Corporation and the Geological Survey of Tanzania (GST) has resulted in the two institutions joining efforts to explore and assess mineral resources in the country.

In 2013, Australian-based East African Resources Ltd (EAR) obtained prospecting licences for the Madaba property, where work carried out from 1979-1982 by Uranerzbergbau GmbH identified six anomalous uranium zones. The site is also located within the Selous World Heritage Game Reserve. EAR has commissioned an environmental impact assessment as requested by the Ministry of Natural Resources and Tourism in support of an application for site access.

Identified conventional resources (reasonably assured and inferred resources)

There are no significant changes in Tanzanian uranium resources since the previous report. Total identified in situ uranium resources from four areas in Tanzania amount to 72 738 tU. Over 80% of the total relates to the Nyota sandstone deposit at Mkuju River. It contains 47 927 tU of measured and indicated resources and 10 578 tU of inferred resources all in the <USD 80/kgU cost category (<USD 31/lb U_3O_8). The Manyoni playa lake calcrete deposits make up 11 146 tU of identified resources of which 9 477 tU is inferred. The remaining resource includes two sandstone-type deposits: the Likuju North with 2 346 tU and the Mtonya deposit which comprises 775 tU and is potentially in situ recovery (ISL) amenable.

Undiscovered conventional resources (prognosticated and speculative resources)

Undiscovered resources are not reported, however there is potential for sandstone-type uranium deposits in Karoo sediments in several areas.

Uranium production

There has been no uranium produced in Tanzania.

Future production centres

The Mkuju River feasibility study was completed in November 2013. Front-end engineering and design (FEED) and Pre-FEED initiatives continued until June 2014. Current activities at the project are focused on licensing and permitting matters, ongoing value engineering opportunities to optimise the capital and operating costs and an ISL pilot test programme (which was initiated in Q2 2015). ISL could prove to be an alternative extraction method for the Mkuju River project and similar ore bodies in the region.

In October 2012, the Tanzanian Ministry of the Environment issued an environmental impact assessment certificate to Mantra in respect of the Mkuju River Project, and in April 2013, the Tanzanian government issued a special mining licence to Mantra for the project. In September 2014, Uranium One submitted an updated works programme aligned to the current anticipated timeline for the development of the project to the Ministry of Energy and Minerals, and the approval of the revised works programme was received in February 2015.

Negotiations with the Tanzanian government on the terms of a mine development agreement (MDA) which includes fiscal stabilisation for the project were successfully concluded in August 2015 and Mantra Resources is awaiting confirmation from the Ministry of Energy and Minerals of the date for signing of the MDA.

According to the current definitive feasibility study the resources will be mined in multiple pits feeding a single mill with conventional acid leach and resin-in-pulp recovery. ISL mining using acid may be employed, particularly for about 15% of resources outside designed pits and below the water table. One-third of the total resource is below the water table, so the ISL potential could be greater. A preliminary feasibility study on heap leaching of lower-grade ore demonstrated that it was not feasible to use this method in full scale because of the high volume of earthworks, lower recovery and high related capital and operating expenditures.

In 2013-2015, Mantra Resources continued project technical optimisation focused on its economy improvement and costs reduction.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1
Name of production centre	Mkuju River
Production centre classification	Planned
Date of first production (year)	N/A
Source of ore:	
Deposit name(s)	Nyota
Deposit type(s)	Sandstone
Recoverable resources (tU)	31 700
Grade (% U)	0.0425
Mining operation:	
Type (OP/UG/ISL)	OP
Size (tonnes ore/day)	18 000
Average mining recovery (%)	90
Processing plant:	
Acid/alkaline	Acid
Type (IX/SX)	Resin-in-pulp
Size (tonnes ore/day) For ISL (mega or kilolitre/day or litre/hour, specify)	18 000
Average process recovery (%)	85
Nominal production capacity (tU/year)	3 000
Plans for expansion (yes/no)	no
Other remarks	The techno-economic optimisation is underway.

Environmental activities and socio-cultural issues

The Tanzanian government has worked to allay public concerns over the prospect of uranium mining. The environmental, health, economic and social impacts are to be carefully considered and the government indicated that it is aware of the high safety standards required for uranium mining in order to protect people and the environment.

Elephant poachers have taken advantage of the road constructed for access to Mkuju River uranium project, located in the area excised from the Selous Game Reserve. In May 2014, the operator entered into a memorandum of understanding with the Ministry of Natural Resources and Tourism to conduct combined anti-poaching initiatives. The UNESCO World Heritage Committee is monitoring the situation since all of its demands must be met in order to fulfil the Mkuju River project requirements.

National policies relating to uranium

In 2010, the Tanzanian government substantially amended the Mining Act of 1998. The revised act increased royalty payments for mineral extraction on the gross value of minerals produced (from 3% to 5% for uranium) and mandated the government the ability to acquire shareholdings in future mining projects through a development agreement negotiated between the government and the mineral rights holder. The Parliamentary Committee for Energy and Minerals in Tanzania has directed that no mining of uranium can take place until a policy and legislation on extraction are in place.

The IAEA conducted a Uranium Production Site Appraisal Team review in 2013, providing recommendations to the country, a newcomer to uranium mining, in the application of international good practices and preparations for planned uranium mining activities. The scope of the appraisal process included exploration, resource assessment, planning, environmental and social impact assessment, mining, processing, waste management, site management, remediation and final closure.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		38 342	39 111	39 111
Surficial			1 335	1 335
Carbonate				
Total		**38 342**	**40 446**	**40 446**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)		38 342	40 446	40 446	80
Total		**38 342**	**40 446**	**40 446**	80

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP		38 342	40 446	40 446	80
Total		**38 342**	**40 446**	**40 446**	80

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone		8 462	10 162	10 162
Surficial			7 581	7 581
Total		**8 462**	**17 743**	**17 743**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)		8 462	17 123	17 123	80
In situ leaching acid			620	620	80
Total		**8 462**	**17 743**	**17 743**	80

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP		8 462	17 123	17 123	80
In situ leaching acid			620	620	80
Total		**8 462**	**17 743**	**17 743**	80

Short-term production capability

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	0

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	2 000	0	2 000	0	N/A	0	3 000

Thailand

Uranium exploration and mine development

Historical review

Uranium exploration was carried out in the early 1970s by the Royal Thai Department of Mineral Resources (DMR). Uranium occurrences were found in various geological environments including sandstone and granite host rocks. Sandstone-type mineralisation occurs in the Phu Wiang district of the Khon Kaen province, north-eastern Thailand. This area had been independently investigated by the DMR. The area was investigated in co-operation with foreign organisations. The granite-hosted uranium occurrences associated with fluorite were discovered in the Doi Tao district, Chiang Mai province and the Muang district of Tak province, northern Thailand. These occurrences have received the most attention.

The most important uranium exploration activity carried out in Thailand is the nationwide airborne geophysical survey completed between 1985 and 1987. The survey was conducted by Kenting Earth Sciences International Limited of Canada, as contractor to DMR.

Recent and ongoing uranium exploration and mine development activities

There is no known recent or ongoing uranium exploration or mine development activities in any part of Thailand.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

There has been no production history of conventional resources, so there is no identified conventional resource.

Undiscovered conventional resources (prognosticated and speculative resources)

There are no known undiscovered conventional resources.

Unconventional resources and other materials

There has been active study in uranium extraction from Thailand's seawater since the end of 2011. To date, no U_3O_8 has been separated and purified yet. The objective of the study is to study and improve the extraction technique, rather than the actual amount and rate of recovery of the uranium.

Uranium production

Historical review

There has been no historical uranium production in Thailand.

Status of production facilities, production capability, recent and ongoing activities and other issues

There is no past or current production facility in Thailand.

Ownership structure of the uranium industry

N/A.

Employment in the uranium industry

None.

Future production centres

In the future, if uranium extraction from seawater becomes economically competitive, the Electricity Generating Authority of Thailand (EGAT) may consider investment in a production centre. But, as of the present time, there is no foreseeable plan.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

There is no production or use of mixed oxide fuels in Thailand.

Production and/or use of re-enriched tails

There is no production or use of re-enriched fuels in Thailand.

Production and/or use of reprocessed uranium

There is no production or use of reprocessed uranium in Thailand.

Regulatory regime

There is no regulatory regime for uranium mining in Thailand because there is no uranium industry here. But currently, the Office of Atoms for Peace (OAP) is the regulator on the use of atomic energy in Thailand. So, if there is a uranium mining industry in Thailand in the future, OAP will most likely be the main agency responsible for regulation.

Uranium requirements

According to Thailand's Power Development Plan 2015 (PDP 2015), which covers the years 2015-2036, the first two nuclear power plants will be connected to the grid in 2035 and 2036. However, the government has not made any formal decision to begin construction yet. The uranium requirement is based on the assumption that the first plant will start operation in 2035 and the second plant in 2036. Each unit will produce about 1 000 MWe.

Supply and procurement strategy

All fuel assemblies for future nuclear power plants will be purchased from overseas. There is no current plan on future procurement strategy. There is no plan in the foreseeable future to set up a fuel production plant in Thailand.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

There is no current government policy on uranium. However, there are laws and regulations on the use of atomic energy and radioactive materials. Uranium import and export is included in these laws. The laws are the Atomic Energy for Peace Act B.E. 2504 (1961) and the Ministerial Act on Licensing and Management Procedures for Special Nuclear Materials B.E. 2550 (2007).

Uranium stocks

There is no uranium stock for use in nuclear power reactors in Thailand.

Uranium prices

There is no known uranium transaction in Thailand, so there is no public data on uranium price in Thailand.

Installed nuclear generating capacity to 2035

(MWe net)

2011	2012	2013		2015		2020		2025		2030		2035	
0	0	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	0	0	0	0	0	0	0	0	0	1 000

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2011	2012	2013		2015		2020		2025		2030		2035	
0	0	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	0	0	0	0	0	0	0	0	0	160

Note: No first core load for the new plant is included in the uranium requirements data. The uranium requirement figures provided do not include plans to build an inventory of uranium.

Turkey

Uranium exploration and mine development

Historical background

General Directorate of Mineral Research and Exploration

Uranium exploration in Turkey began in 1956-1957 and was directed towards the discovery of vein-type deposits in crystalline terrain, such as acidic igneous and metamorphic rocks. As a result of these activities, some pitchblende mineralisation was found but these occurrences were not accepted as economic deposits. Since 1960, studies have been conducted in sedimentary rocks which surround the crystalline rock and some small orebodies containing autunite and torbernite mineralisation have been found in different parts of the country. In the mid-1970s, the first hidden uranium deposit with black ore, below the water table, was found in the Koprubaşı area of Manisa. As a result of these exploration activities, a total of 9 129 tonnes U_3O_8 (7 740 tU) in situ resources were identified in the Manisa-Köprübaşı (2 852 tonnes U_3O_8; 2 419 tU), Uşak-Eşme (490 tonnes U_3O_8; 415 tU), Aydın-Koçarlı (208 tonnes U_3O_8; 176 tU), Aydın-Söke (1 729 tonnes U_3O_8; 1 466 tU) and Yozgat-Sorgun (3 850 tonnes U_3O_8; 3 265 tU) regions.

Eti Mine Works General Management (Eti Maden)

State-owned organisation Eti Maden is responsible for a total of six uranium mine sites with uranium resources. Geological exploration has been performed by the General Directorate of Mineral Research and Exploration (MTA) at these sites in the past. Between 1960-1980, uranium exploration was performed by aerial prospecting, general and detailed prospecting on-site, geologic mapping studies and drilling activities. These uranium sites were transferred to Eti Maden as possible mines which can be operated by the state under law number 2840 on the "Operation of Boron Salts, Trona and Asphaltite Mines and Nuclear Energy Raw Materials" (10 June 1983).

Recent and ongoing uranium exploration and mine development activities

General Directorate of Mineral Research and Exploration

In 2012, granite, acidic igneous and sedimentary rocks around Manisa, Denizli and Aydın (an area of approximately 5 000 km^2) were explored for radioactive raw materials. Exploration for radioactive raw materials was also performed in sites licensed by MTA inside Manisa, Uşak and Nevşehir.

In 2013, granite, acidic igneous and sedimentary rocks around Aydın and Denizli (an area of approximately 5 000 km^2) was explored for radioactive raw materials. Exploration for radioactive raw materials was also performed in sites licensed by MTA inside Manisa, Uşak and Nevşehir.

In 2014, exploration for radioactive raw materials was conducted in sites licensed by MTA inside Manisa, Uşak and Nevşehir.

In 2015, exploration for radioactive raw materials was planned to be conducted in sites licensed by MTA inside Manisa and Nevşehir.

Private sector exploration

Adur, a wholly owned subsidiary of Anatolia Energy, a Turkish uranium exploration company with current and active drill programmes at the Temrezli and Sefaatli uranium sites, has carried out exploration and resource evaluation drilling with a total of 206 drill holes completed for a total drill advance of over 26 000 m since 2011 in both Sefaatli and Temrezli projects. Over 16 000 m of drilling was in Temrezli region. Until now, 112 holes have been completed in Temrezli project. The drilling in Temrezli, mostly twinning the earlier MTA drill holes but also in-fill and step-out holes, confirmed work conducted in the 1980s and extended the uranium mineralisation to the north-east over a strike length of more than 3 000 m.

All drill holes were geologically and geophysically logged, the latter using the company's matrix system from Mount Sopris with a probe-type 2PGA-1000 to record gamma ray intensity in counts per second (cps), electrical self-potential and single-point electrical resistance.

In 2011, CSA Global Pty Ltd prepared a JORC compliant mineral resource estimate for the Temrezli deposit of 13.282 Mlb U_3O_8 (6 025 tU) (measured, indicated and inferred) in situ uranium at an average grade of 1 157 ppm (0.117% U_3O_8).

Preliminary metallurgical bottle-roll leach test work confirmed MTA's earlier work and 93% and 90% uranium recovery was obtained by using an acid or alkali leach method, respectively.

Several hydrological test wells were conducted at Temrezli since 2012 in order to assess the regional groundwater conditions and to conduct hydraulic testing of the mineralised horizons at a scale typically seen at in situ recovery (ISR) operations. Test work was performed by HydroSolutions, a US-based hydrogeologist with considerable experience in ground water conditions relating to uranium ISR operations throughout western United States. The test confirmed the aquifer has sufficient flow rate for ISR mining.

Regional exploration identified new areas of mineralisation, at West Sorgun and Akoluk. The rotary and diamond drill programme tested a number of regional sites that are considered prospective for Eocene-aged sediment-hosted uranium mineralisation, similar to what is seen at the Temrezli uranium deposit.

A limited drilling programme in the Sefaatli area confirmed sporadic uranium mineralisation first discovered by the MTA in the 1980s. This is the region's second most significant occurrence of uranium mineralisation with equivalent uranium values up to 1 310 ppm eU_3O_8 for mineralised lenses 1.4 m thick and at depths between 20 and 43 m. These results combined with a high water table and a sandstone-rich stratigraphy, suggest that the mineralisation style appears similar to that observed at Temrezli and thus may be amenable to ISL mining.

Since early stage studies indicate that the Temrezli uranium deposit will be amenable to ISL mining, a preliminary economic assessment (PEA) contract was awarded to US-based WWC Engineering of Sheridan, Wyoming. The PEA is completed and followed by a preliminary feasibility study which was awarded to Tetra Tech, US origin company; the preliminary feasibility study was completed and issued in early 2015 and indicated that the project is economically feasible to proceed, with a total expected recovery of 9.7 Mlbs U_3O_8 over 12 years, with operating costs of less than USD 17 per lb U_3O_8 (USD 44.2/kgU). Adur initiated the environmental impact assessment process by preparing and submitting a project description to the Ministry of Environment and Urban Planning in 2015. Adur will also initiate the permitting process with Turkish Atomic

Energy Commission regarding licensing Temrezli site as a nuclear facility, since ISR operations are considered as nuclear facilities. In 2015, the permits and licences would be obtained prior to initiating the construction planned for early 2016.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Identified conventional uranium resources in Turkey determined from exploration activities performed by MTA in the past, with the addition of JORC compliant resources identified through recent work by Adur exploration are described in more detail:

- Manisa-Köprübaşı: 2 419 tU in ten orebodies and at grades of 0.04-0.05% U_3O_8 (0.034-0.042% U) in fluvial Neogene sediments;
- Uşak-Eşme: 415 tU at 0.05% U3O8 (0.042% U) in Neogene lacustrine sediments;
- Aydın-Koçarlı: 176 tU at 0.05% U3O8 (0.042% U) in Neogene sediments;
- Aydın-Söke: 1 466 tU at 0.08% U3O8 (0.068% U) in gneiss fracture zones;
- Yozgat-Sorgun: 4 633 tU at 0.117% U_3O_8 in Eocene deltaic lagoon sediments.

Temrezli (Yozgat/Sorgun) uranium deposit is one of Turkey's largest and highest grade uranium deposits, with a JORC compliant Mineral Resource estimate of 13 282 Mlb of contained uranium at an average grade of 1 157 ppm (0.117%) U_3O_8 at an average depth of 120 m. The mineral resource estimate is as follows in detail:

Class	Tonnes	Grade (ppm U_3O_8)	Contained metal (pounds U_3O_8)	Contained metal (tonnes U_3O_8)
Measured*	2 008 000	1 378	6 100 000	2 767
Indicated*	2 178 000	1 080	5 185 000	2 352
Inferred*	1 020 000	888	1 997 000	906
Total resource*	5 206 000	1 157	13 282 000	6 025

* Numbers rounded for reporting purposes.

Undiscovered conventional resources (prognosticated and speculative resources)

- Temrezli Project: The ongoing exploration and development drillings is to be continued and is expected to increase the resource by a potential of 1-3 Mlb U_3O_8.
- Sefaatli Prospect: Exploration and development drillings was being conducted in 2015 and is expected to increase the known uranium resource values by approximately 5-6 Mlb U_3O_8. The recent drill results include 1.10 m mineralisation at a grade of 2 150 ppm eU_3O_8 from 39 m.

Unconventional resources and other materials

None reported, but grassroots exploration is in place.

Uranium production

Historical review

Research on laboratory-scale production of uranium yellow cake and the production of nuclear fuel was performed in the past (7th National Development Plan of the Republic of Turkey between 1996 and 2000).

Status of production facilities, production capability, recent and ongoing activities and other issues

None reported.

Environmental activities and socio-cultural issues

An environmental impact assessment is not required by the Ministry of Environment and Urbanisation for uranium exploration. However, an environmental impact assessment is required with an application for a licence to operate a uranium mine. Licensing for exploration and mine development activities in wildlife protection and development sites require the submission of an environmental impact assessment report.

Regulatory regime

The Turkish Atomic Energy Authority (TAEK), as the regulatory body of Turkey, undertakes all the regulatory activities concerning nuclear and radiation safety together with the co-ordination and support of research and development activities in nuclear field.

TAEK was established by the Act of Turkish Atomic Energy Authority which was issued in the Official Gazette number 17753 on 13 July 1982, as a government body reporting to the Prime Minister. TAEK had been affiliated with the Ministry of Energy and Natural Resources since 2002.

TAEK is responsible for defining safety measures for all nuclear activities and for drawing up regulations concerning radiation protection and the licensing and safety of nuclear installations.

In Turkey, nuclear installations are licensed by TAEK regarding nuclear safety, security and radiation protection issues. The licensing procedure for nuclear fuel cycle facilities is laid out in the Decree on Licensing of Nuclear Installations. According to this decree nuclear fuel cycle facilities are:

- mining, milling and refining facilities;
- conversion facilities;
- enrichment facilities;
- nuclear fuel element fabrication facilities;
- reprocessing facilities for used fuel elements;
- radioactive waste management facilities for processing the radioactive wastes (including final storage).

The licensing procedure for nuclear fuel cycle facilities is initiated by an application from the owner to be recognised as such. The licensing process comprises three main stages in succession: site licence, construction licence and operating licence. There are several permits functioning as hold points during the licensing process, such as a limited work permit, start test operating, pre-operational test permit, full capacity work permit, permission to restart operations and permission to modify the installation. For each authorisation, documents required for review and assessment of TAEK are defined in the decree. The authorisation process for the decommissioning stage is not defined in the decree however; authorisation for decommissioning will be defined in a draft law and other relevant legislation.

The Law on Mining (number 3213) of 4 June 1985 includes articles for environmental remediation during and after mining activities. Mining organisations must submit a financial bond for environmental remediation prior to the issuance of a mining licence.

After mining activities have been completed and the site has been environmentally remediated, the submitted financial bond is returned to the mining organisation. In case the financial bond is not sufficient to implement environmental remediation activities, additional costs are requested from the operator according to law number 6183.

Uranium requirements

There are no nuclear power plants in operation, under construction or decommissioned in Turkey. However, Turkey has been considering building a nuclear power plant since the 1970s. Rising energy demand, import dependence and industrial activity are the driving forces behind Turkey's move towards developing a civil nuclear power generation programme. Turkey's recent efforts in this area can be characterised as a first-of-a-kind approach in the nuclear sector and has been referred to as an intergovernmental agreement (IGA) model, with long-term contracts in the frame of power purchase agreements (PPA). In this approach, a project company undertakes to design, build, operate and maintain a power plant, whereas the Turkish government is responsible for providing the site, various financial and non-financial guarantees, construction support and licensing. The project company is also responsible for managing wastes and decommissioning the facility.

An IGA, signed with Russia for the construction of four VVER-1200 units at the Mediterranean Akkuyu site, entered into force on 21 July 2010. The Russian side established a project company in Turkey and it started site surveys and environmental impact assessment studies. The Russian side will have the majority share of the power plant and own the plant during its entire operational lifetime. Turkey also signed an IGA with Japan on 3 May 2013 to build four ATMEA1 units at the Black Sea Sinop site. This agreement has been ratified by the Turkish parliament on 1 April 2015 together with the respective annexes.

Supply and procurement strategy

In order to promote private sector investments for the construction and operation of nuclear power plants, the Law on the Construction and Operation of Nuclear Power Plants and Energy Sale, numbered 5710 and dated 9 November 2007 ("Nuclear Law") was enacted in Turkey. Article 3 of the Nuclear Law states that the procedures and principles regarding fuel supply shall be prepared by the Ministry of Energy and Natural Resources and set up in a regulation which shall come into force with the approval of the Council of Ministers.

Provisions related to fuel supply for the Akkuyu NPP have been included under the IGA signed with Russia for the construction of the four VVER-1200 units. Under Article 12 of this agreement it is stated that nuclear fuel shall be sourced from suppliers on the basis of long-term agreements between the project company established by the Russian side in Turkey and the suppliers.

Provisions related to fuel supply for the Sinop NPP will be established upon the completion of the feasibility study.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

The law on the "Operation of Boron Salts, Trona and Asphaltite Mines and Nuclear Energy Raw Materials" numbered 2840 and dated 10 June 1983 states that the exploration and operation of such mines are carried out by the state.

Mining Law numbered 3213 (dated 4 June 1985) classifies uranium reserves under the 6th group of mines together with all other radioactive minerals and supersedes law number 2840. Article 49 of law number 3213 states that provisions under law number 2840 are preserved, although private companies are now allowed to explore for and operate thorium and uranium mines. Article 50 states that exploration and operation of thorium and uranium mines are subject to this law and the minerals extracted can only be sold to entities determined by the Council of Ministers.

The law on the "Amendment of mining law and other laws" numbered 6592 and dated 18 February 2015 has reclassified the uranium reserves under the 4th group of minerals together with all radioactive minerals. With this amendment the radioactive minerals are placed in the same group with complex minerals.

Uranium stocks

Uranium stocks in Turkey consist of natural uranium used by the Çekmece Nuclear Research and Training Center affiliated to Turkish Atomic Energy Authority for research purposes.

Uranium exploration and development expenditures and drilling effort – domestic

(TRY [Turkish lira] – excluding VAT)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	3 255 000	500 000	5 452 657	1 500 000
Government exploration expenditures	1 366 696	3 350 000	2 595 000	2 970 000
Industry* development expenditures	530 000	2 000 000	2 336 851	15 000 000
Government development expenditures			0	0
Total expenditures	**5 151 696**	**5 850 000**	**10 384 508**	**19 470 000**
Industry* exploration drilling (m)	3 098	1 087	6 466	3 000
Industry* exploration holes drilled	27	12	61	30
Industry* exploration trenches (m)			0	0
Industry* exploration trenches (number)			0	0
Government exploration drilling (m)	6 172	11 250	1961	8 000
Government exploration holes drilled	30	50	91	50
Government exploration trenches (m)			0	0
Government exploration trenches (number)			0	0
Industry* development drilling (m)	504	3 985	2 877	4 500
Industry* development holes drilled	4	38	23	30
Government development drilling (m)			0	0
Government development holes drilled			0	0
Subtotal exploration drilling (m)	9 270	12 337	21 427	11 000
Subtotal exploration holes drilled	57	62	152	80
Subtotal development drilling (m)	504	3 985	2 877	4 500
Subtotal development holes drilled	4	38	23	30
Total drilling (m)	**9 774**	**16 322**	**24 304**	**15 500**
Total number of holes drilled	**61**	**100**	**175**	**110**

* Non-government.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Sandstone		6 947	6 947	6 947
Metamorphite		1 466	1 466	1 466
Total		**8 413**	**8 413**	**8 413**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Open-pit mining (OP)		4 476	4 476	4 476
Unspecified		3 937	3 937	3 937
Total		**8 413**	**8 413**	**8 413**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U*)

Processing method	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Heap leaching** from OP		4 476	4 476	4 476
Unspecified		3 937	3 937	3 937
Total		**8 413**	**8 413**	**8 413**

* In situ resources.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Sandstone		696	696	696
Total		**696**	**696**	**696**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified		696	696	696
Total		**696**	**696**	**696**

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified		696	696	696
Total		**696**	**696**	**696**

* In situ resources.

Installed nuclear generating capacity to 2035

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	N/A	N/A	N/A	5 840	N/A	9 280	N/A	9 280

Annual reactor-related uranium requirements to 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
		0	0	0	0	N/A	175	N/A	175	N/A	175

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Enrichment tails	LWR reprocessed uranium stocks	Total
Government	1.97				
Total	**1.97**				

Ukraine

Uranium exploration and mine development

Historical review

Prospecting for uranium in Ukraine began in 1944 with the analysis of geological exploration data and mining activity results in the Northern Krivoy Rog ore basin. The Pervomayskoye and Zheltorechenskoye uranium deposits were discovered in the 1950s. These deposits were mined out in 1967 and 1989, respectively.

During the same period of time, the first sandstone-type deposits were discovered.

In the mid-1960s, the main geological exploration was concentrated in the Kirovograd ore area for the discovery of metasomatite-type uranium deposits. Deposits such as Michurinskiy, Vatutinskiy, Severinskiy, Central and Novokonstantinovskiy were discovered in this area.

Metasomatite-type deposits make up the main part of uranium resources of Ukraine. The average ore grade in these deposits is 0.1-0.2% U.

The second uranium resources source is sandstone-type deposits, with an average ore grade between 0.02 and 0.06% U. They are suitable for mining by ISL.

Ongoing uranium exploration and mine development activities

During 2013, 2014 and 2015, SE Kirovgeology carried out uranium exploration activities as follows:

- geological prospecting for sandstone-type uranium deposits on the Troytskaya (45 km^2) and Vladimirskaya (26 km^2) areas;
- geological prospecting for vein-type uranium deposits in the Rozanovskaya (45 km^2) area with mapping at a scale of 1:25 000;
- geological prognostic mapping at a scale of 1:25 000 in southern part of the Kirovogradskiy uranium ore fault;
- geological prospecting for uranium deposits in the Pokrovskiy (14 km^2) area at a scale of 1:10 000;
- prognostic calculation of the uranium and thorium resources of the Dibrovskoye rare earth element occurrence, which is found in the Pryazov block of the Ukrainian Shield;
- geological prospecting for uranium deposits in the northern-east flank of Novokonstantinovskoye deposits, (46 km^2) area at 1:10 000 scale;
- evaluation of the northern-east flank of the Vatutinskiy deposit for uranium bearing;
- drawing up of the map of Ukrainian Shield for uranium, thorium deposits and occurrences at 1:500 000;
- evaluation of potential thorium resources in the Ukrainian Shield rocks.

Ukraine thorium deposit types and speculative resources

(tonnes Th)

Deposit type	Resources tTh (in situ)
Carbonatite	
Placer	
Granite-related	53 940
Alkaline rocks	37 037
Metasomatite	150 439
Metamorphite	10 253
Other	
Total	**251 663**

The Ukrainian state and private companies do not carry out any exploration for uranium in other countries. Foreign or private companies do not carry out any uranium exploration activities in Ukraine.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

As of 1 January 2015, identified uranium resources (reasonably assured and inferred resources) recoverable at costs <USD 260/kgU were 220 754 tU. Uranium resources recoverable at costs <USD 80/kgU were 58 957 tU. Mining and processing losses are taken into account in these figures.

The main uranium resources of economic interest are found in two types of deposits:

- Metasomatite-type, mono-metallic deposits located within the Kirovograd block of the Ukrainian Shield. The uranium ore grade is 0.1-0.2% U. All deposits are amenable to underground mining.
- Sandstone-type deposits located within the Dnieper-Bug metallogenic area (17.3 thousand km^2). The uranium ore grade is 0.01-0.06% U. In addition to uranium, in these ores, molybdenum, selenium and rare earth elements of the lanthanide group occur. These deposits are amenable to mining by ISL.

Undiscovered resources (prognosticated and speculative resources)

After review, undiscovered resources were recalculated and amount to 277 500 tU, including:

- Prognosticated resources amount to 22 500 tU and are found at the flanks of identified deposits.
- Speculative resources amount to 255 000 tU. The calculation is based on the data from the Uranium prognostic map (scale of 1:500 000), which was drawn up by SE Kirovgeology. Speculative resources are subdivided according to geological types as follows:
  - 133 500 tU metasomatite-type;

- 20 000 tU in sandstone deposits in the Ukrainian Shield;
- 16 500 tU in sandstone (in bitumen) on the slopes of the Ukrainian Shield;
- 40 000 tU in "unconformity-related" type deposits;
- 30 000 tU in granite-related type deposits;
- 15 000 tU in "intrusive" potassium metasomatite deposits.

Uranium production

Historical review

The mining of uranium ore began in 1946 at the deposits of Pervomayskoye and Zheltorechenskoye, using conventional underground methods.

In 1949, the first production began in Ukraine at a uranium process plant, Pridneprovskiy Chemical Plant (PCP), in the town of Dneprodzerzhinsk.

In 1951, the government founded the Vostochnyi Mining-process Combinat (VostGOK) in Zheltiye Vody in the Dnepropetrovsk region, for the mining and processing of ore from Pervomayskoye and Zheltorechenskoye deposits. The Pervomayskoye deposit was mined out in 1967 and the Zheltorechenskoye deposit was mined out in 1989.

In 1959, the second uranium process plant was built in Zheltiye Vody.

Today, VostGok operates uranium production facilities in the Central Ukrainian ore province. The company is mining the Michurinskiy (3 km south of Kirovograd), Central (on the south-east end of Kirovograd), Vatutinskiy (near Smolino) and Novokonstantinovskiy (40 km west of Kirovograd) deposits. VostGOK plans to start mining the Severinskiy (4 km north of Kirovograd) deposit in 2020.

The Michurinskiy deposit was discovered in 1964. In 1967, construction of the Ingulskiy mine began. The average ore grade of these ore bodies is 0.1% U. Radiometric sorting of ore at the mine increases the uranium content in the ore delivered to the process plant up to 0.1-0.2% U. Two shafts, each 7 m in diameter, were sunk. The ore is hoisted along the northern shaft with two buckets with a loading capacity of 11 t. The southern shaft is used for transporting workers and provision, and for other technical aims. A ventilation shaft supplies 480 m^3 of fresh air per second to the underground mine works. Mining is conducted in blocks of 60-70 m in height at depths of 90 m, 150 m and 240 m below the surface.

The Central deposit is developed by two shafts to horizons 380 m and 1 000 m. It is connected to the Michurinskiy deposit by an underground transport tunnel 5.2 km long at the 300 m level. Ore is delivered through the tunnel to the elevating shaft of the Ingulskiy mine.

The Vatutinskiy deposit was discovered in 1965, and in 1973, construction of the Smolinskiy mine began. The industrial infrastructure of the Smolinskiy mine is situated near the town of Smolino, 80 km west of Kirovograd. Mined rock is delivered to the surface by two shafts (the "main" and "additional"). Both shafts are sunk to a depth of 460 m. The lower part of a deposit, trending to a depth 640 m, was stripped by two blind shafts ("blind-1" and "blind-2").

Stationary compressor terminals were installed on the surface of each shaft to produce compressed air used for blast drilling operations. Within each cleaned block, after the blasting, ore is moved to a loading pocket, unloaded from mine cars and transported by electric-powered trams to the main shaft, where it is crushed before being hoisted to the surface. Radiometric ore-sorting, storage, loading to railway carriages and shipping for process are carried out on the surface. Mined-out space is backfilled by hardening hydro-packing.

The Novokonstantinovskiy deposit has been developed by three shafts to horizons 480 m and 1 100 m below the surface. Mining of the Novokonstantinovskiy deposit began in 2011.

The Severinkovskiy and Podgayscevskiy deposits are developed by two shafts down to a depth of 650 m.

ISL uranium mining began in Ukraine in 1961. From 1966 to 1983, uranium in the Devladovskoye and Bratskoye deposits was extracted by using sulphuric acid ISL at depths of about 100 m. At present, both deposits are under monitoring.

Mining of the Safonovskiy and Sadoviy deposits by ISL is being planned.

Status of production facilities, production capability, recent and ongoing activities and other issues

Hydrometallurgical processing plant

The VostGOK hydrometallurgical process plant is situated in the town of Zheltiye Vody. The annual capacity of the plant is 1.5 Mt of ore. Staff is made up of 30 to 35 persons per shift. The ore is transported to the plant by specially equipped trains from two mines – Ingulskiy (100 km west) and Navokonstantinovskiy (130 km west). After crushing and radiometric sorting, the ore is leached in autoclaves using sulphuric acid at the temperature of 150 to 200°C at 20 atmospheres for 4 hours. Acid expenditure is 80 kg/t of ore. For uranium extraction, ion-exchange resin is used. After washing with a mixture of sulphuric and nitric acids, the uranium-bearing solution is subjected to further concentration and purification by solvents extraction. Ammonium gas is used for precipitation. The dewatered precipitate is subjected to calcination at 800°C until a product of dark colour is obtained.

Innovation techniques in uranium production

Metasomatite-type deposits in Ukraine have a uranium ore grade of about 0.1% U, with mineralisation (uraninite, brannerite, coffinite, nasturane) disseminated throughout the volume of ore in steeply dipping ore bodies. Since the mines are located some 100 km and 150 km from hydrometallurgical plant, transportation costs add to mining and processing costs.

Mining is carried out with the underground method. Processing of ore begins from crushing underground, followed by extraction by sulphuric acid leaching in autoclaves. Low-grade uranium ore, combined with an expensive mining and ore process technology, makes uranium production unprofitable at current market prices. In order to decrease production costs, innovative technologies are being introduced, such as underground radiometric sorting, in-place leaching and heap leaching and reprocessing of materials in dumps of operating mines.

A multistage radiometric separator, designed by VostGOK for different sized piles, allows sorting of both mined ore and material in mine dumps. After the radiometric sorting, uranium content in the ore may reach 0.03-0.3% U. The uranium content in "tailings" following this sorting is 0.006% U or less.

The rocks in the dumps have an average X-ray specific activity at the level of 1 500-1 600 Bk/kg. After the radiometric sorting, rocks going to the waste dump have X-ray levels of only 350-650 Bk/kg and thus can be used as second class construction material.

Separators may be installed both on the surface and underground. The capacity of two separators (for different machine classes) is 1 500 thousand tons of ore per year.

Three products are obtained after the radiometric separation of dump rocks:

- 30% – uranium ore grading 0.05-0.06% U;
- 55% – "tailings" with specific activity less than 740 Bk/kg for use as second class construction material;
- 15% – inert material for use as hydro-backfill of mined-out space in the mine.

After the crushing, uranium ore undergoes heap leaching (HL). Extraction of uranium during HL is about 70-75% U per year of leaching. The cost of 1 kg of U_3O_8 after HL is 62% of the cost of processing 1 kg U_3O_8 at the hydrometallurgical process plant.

Low-grade ore bodies with a uranium content of 0.04-0.06% U are mined using the in-place leaching (IPL) method. A special technology of explosion has been used for disaggregating the ore blocks. The uranium concentration in pregnant solutions changes from 1 000 mg/l at the beginning to 50 mg/l at the end of leaching the disaggregated ore blocks. The cost of IPL is 58% less than conventional technology of ore mining and processing. Three blocks have been prepared now for mining by the IPL method.

Although most metasomatite-type ore deposits are suitable for HL, finely disseminated uranium mineralisation, as in the case of highly durable abilities of low permeability, is necessary for effective HL. Therefore, the degree of crushing is the most important parameter, which determines the degree of uranium recovery and permeability. The maximum size of uranium mineral particles is usually from 1 to 5 mm. With an optimum size of ore material of 10 mm, 80-90% uranium recovery can be achieved after 2-3 months.

The heaps contain ore grades of 0.050-0.080% U, obtained as a result of the dump radiometric sorting. The volume of the heap is 40 000 tonnes of ore. At the Vatutinskiy deposits, the HL site has been built. On the site, there are four heaps with total volume 160 kt of ore. At the Michurinskiy deposits HL is still in the planning stage.

Ownership of uranium industry

All enterprises in the uranium industry (geology, mining, fuel processing) are owned by the state. The mining and processing enterprise VostGOK is part of the Department Strategic Policy of Investments and Nuclear Energy Complex in the Ministry of Energy and Coal Industry of Ukraine. SE "Kirovgeology" is responsible for the balance of uranium mineral resources of Ukraine (geological survey, evaluation and exploration of deposit) and is part of the State Service of Geology and Resources of Ukraine, the Ministry of Ecology and Natural Resources.

In April 2008, the government of Ukraine founded a new entity called "Nuclear Fuel" through the merger of existing organisations in the sphere of the directorate of the Ministry of Fuel and Energy.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Ingulskiy mine	Smolinskiy mine	Novokonstantinovskiy mine	Safonovskiy mine	Severinskiy mine
Production centre classification	Existing	Existing	Existing	Committed	Planned
Date of first production (year)	1968	1973	2011	2017	2020
Source of ore:					
Deposit name(s)	Michyrinskiy, Centralniy	Vatutinskiy	Novokonstantinovskiy	Safonovskiy	Severinskiy Podgaytsevskiy
Deposit type(s)	Metasomatic	Metasomatic	Metasomatic	Sandstone	Metasomatic
Recoverable resources (tU)	65 895	4 776	89 154	2 248	48 120
Grade (% U)	0.1	0.11	0.14	0.02	0.1
Mining operation:					
Type (OP/UG/ISL)	UG	UG	UG	ISL	UG
Size (tonnes ore/day)	2 000	2 000	6 000	N/A	4 200
Average mining recovery (%)	95	96	96	75	96
Processing plant:					
Acid/alkaline	Acid	Acid	Acid	Acid	Acid
Type (IX/SX)	IX	IX	IX	IX	IX
Size (tonnes ore/day) For ISL (mega or kilolitre/day or litre/hour)	N/A	N/A	N/A	15 000 litre/day	N/A
Average process recovery (%)	93	94	94	95	92
Nominal production capacity (tU/year)	450	500	1 500	150	1 200
Plans for expansion (yes/no)	Yes	No	No	No	No
Other remarks					
Plans for extension					

Secondary sources of uranium

- mixed oxide fuel (MOX) has never been produced in Ukraine or used in its NPPs;
- re-enrichment tails have never been produced or used in Ukraine;
- reprocessing spent nuclear fuel is not conducted in Ukraine nor has it been used.

Environmental activities and socio-cultural issues

The main environmental impact of uranium production at mines result from ore stockpiles, tailings, radiometric ore-sorting sites, waste dumps, ventilation systems infrastructure, and transport (railways, technological motor roads).

The main environmental impact from the hydrometallurgical process plant and heap leaching sites are harmful chemical and ore dust emissions, airborne transportation of aerosols and groundwater contamination from tailings impoundments. In order to minimise the environmental impacts, permanent monitoring is being conducted.

On the hydrometallurgical plant (Zheltye Vody), process water is recycled for the technological process. There are two tailings impoundments, one situated 9 km from the hydrometallurgical plant consisting of two sections (135 and 163 ha), and the second 0.5 km from the plant (55 ha). The latter has been used, and reclamation is ongoing.

There are issues connected with the decommissioning of uranium mining and uranium processing enterprises.

At the closed Prydnieprovskiy Chemical Plant, there are nine tailings impoundments (covering a total area of 268 ha containing 42 Mt of wastes) with total activity of 75 000 Ci (Curie) and some buildings and other facilities are contaminated by radioactive elements. The Cabinet of Ministers of Ukraine initiated a state programme for reclamation of the area to an environmentally safe condition with state funds since 2005 amounting to UAN 22.3 million (Ukrainian hryvnia, about USD 4.5 million).

The total cost of improving radiation protection at all enterprises of the atomic industry and all contaminated areas resulting from mining and processing of uranium is expected to amount to USD 360 million, including decontamination of polluted soils, environmental monitoring, installation of monitoring systems where necessary and improved technology for the management of water flows, radioactive rocks in dumps, polluted equipment and land areas.

Uranium requirements

Uranium production in Ukraine meets 30% of domestic nuclear energy requirements. Nuclear fuel requirements have always been provided by importing fuel from Russia (provided by TVEL). Annual fuel loadings of the 4 operating NPPs (comprised of 13 VVER-1000 units and 2 VVER 440 units) are 15 sets of fuel elements at a total cost of about USD 300 million. A target has been set that by 2020: 100% of uranium requirements for the Ukrainian nuclear fleet will be met by domestic production.

Installed nuclear generating capacity by 2035

At present, 15 reactors are operating at 4 NPPs: 6 VVER-1000 units at Zaporozhskiy, 3 VVER-1000 units at South-Ukrainian, 2 VVER-1000 and 2 VVER-400 units at Rovenskiy and 2 VVER-1000 units at Khmelnitskiy.

The national programme for nuclear energy production foresees to produce about 45% of electricity by nuclear power plants by 2030. To fulfil this requirement, annual nuclear energy production will have to increase up to 75.2 billion KWe/h. This will require life extension of operating NPPs, the construction of 12 additional units (with 10 of these having a total capacity 1 500 MWe) and during this time frame, the decommissioning of 12 NPPs which will be at the end of their operational lifetime.

Uranium policy, uranium stock and uranium price

Ukrainian government policy is increasing the production of natural uranium and improving the foreign investment climate in order to develop uranium projects in Ukraine.

Resolution N1004, the "Complex Program of creation Nuclear Fuel in Ukraine" (23 September 2009) was approved by the Cabinet of Ministers. It specifies that uranium enrichment will be conducted abroad.

On 17 April 2009, the Cabinet of Ministers of Ukraine passed Resolution N 650-p "Some Questions of Liquidation and Organisation of State Mergers in the Nuclear Industry". The resolution founded the company "Nuclear Fuel", by the merger of all state enterprises and scientific-research institutes in the field of the nuclear fuel cycle. The aim of the resolution is improving investment conditions.

The joint venture "plant for the manufacture of nuclear fuel for nuclear reactors VVER-1000 type" was established in Ukraine in October 2011. The plant is situated in Kirovograd region, close to "Vatutinskiy" uranium deposits. In the JV, 50% +1 share belongs to the state Russian company TVEL.

Technical economical assessment for construction of the plant was approved by the Cabinet of Ministers of Ukraine (statement N437 dated 27 June 2012). Total cost of construction is UAH 3.7 billion. Schedule of construction was as follows: Stage I was reached in 2015 and stage II in 2020. Planned capacity of the plant was 800 nuclear fuel sets per year. At present the activity has been postponed.

The decision to build in the zone of alienation of the Chernobyl NPP, the centralised storage of the spent fuel from domestic reactors VVER, has been made (the Law of Ukraine N4384, dated 2 September 2012). Commissioning is planned in 2016.

In September 2012, the decision to build two NPR N3 and N4 on the Khmelnitsky atomic power plant together with Russia was made (the Law of Ukraine N4384 dated 2 September 2012). Terms of commissioning the NPR N3 is set for 2018, and the NPR N4 in 2020. At present the activities have been postponed.

The government of Ukraine made the decision to build a new process plant for the Novokonstantinovskiy uranium deposit (Resolution of the Ministry of Energy and Coal Industry of Ukraine N 933-P dated 24 February 2012). Project production capacity is 1 500 000 tons of ore per year or 2 000 tons of uranium. There is no activity at the present time.

Uranium exploration and development expenditures and drilling efforts – domestic

(UAH million as of 1 January 2015)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures	0	0	0	0
Government exploration expenditures	15.1	6.9	10.3	8.1
Industry* development expenditures	0	0	0	0
Government development expenditures	5.8	3.9	5.6	6.0
Total expenditures	20.9	10.8	15.9	14.1
Industry* exploration drilling (m)	0	0	0	0
Industry* exploration holes drilled	0	0	0	0
Government exploration drilling (m)	4 683	887	856	1 000
Government exploration holes drilled	38	8	7	8
Industry* development drilling (m)	0	0	0	0
Industry* development holes drilled	0	0	0	0
Government development drilling (m)	13 063	13 061	11 197	14 250
Government development holes drilled	52	262	201	200
Subtotal exploration drilling (m)	4 683	887	856	1 000
Subtotal exploration holes drilled	34	8	7	8
Subtotal development drilling (m)	13 063	13 061	11 197	14 250
Subtotal development holes drilled	52	262	201	200
Total drilling (m)	**17 746**	**13 948**	**12 053**	**15 250**
Total number of holes drilled	**86**	**270**	**208**	**208**

* Non-government

Reasonably assured conventional resources by deposits type

(tonnes U)

Deposits type	**<USD 40/kgU**	**<USD 80/kgU**	**<USD 130/kgU**	**<USD 260/kgU**
Proterozoic unconformity	0	0	0	0
Sandstone	0	6 730	6 730	6 730
Metasomatite	0	35 295	76 132	132 690
Total	**0**	**42 025**	**82 862**	**139 420**

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining		35 295	76 132	132 690	88.4
Open-pit mining	0	0	0	0	0.0
In situ leaching acid		6 730	6 730	6 730	75.0
In situ leaching alkaline	0	0	0	0	0.0
Co-product and by-product	0	0	0	0	0.0
Unspecified	0	0	0	0	
Total		**42 025**	**82 262**	**139 420**	

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP					
Conventional from UG	0	35 295	76 132	132 690	88.4
In situ leaching acid		6 730	6 730	6 730	75.0
Total		**42 025**	**82 262**	**139 420**	

Inferred conventional resources by deposit type

(tonnes U)

Deposits type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Proterozoic unconformity					
Sandstone		897	897	897	75.0
Metasomatite		16 035	31 982	80 437	88.4
Total		**16 932**	**32 879**	**81 334**	

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining		16 035	31 982	80 437	88.7
In situ leaching acid		897	897	897	75.0
Total		**16 932**	**32 879**	**81 334**	

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP					
Conventional from UG		16 035	31 982	80 437	88.7
In situ leaching acid		897	897	897	75.0
Total		**16 932**	**32 879**	**81 334**	

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
0	8 400	22 500

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	120 000	255 000

Historical uranium production by deposits type

(tonnes U in concentrate)

Deposits type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Sandstone	3 925	0	0	0	3 925	-
Granite-related	35 000				35 000	
Metasomatite	87 987	1 012	926	954	90 879	1 000
Total	**126 912**	**1 012**	**926**	**954**	**129 804**	**1 000**

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining(1)	10 000	-	-	-	10 000	-
Underground mining(1)	103 547	1 012	926	954	104 559	1 000
In situ leaching	3 925	-	-	-	3 925	25
Co-product/by-product	10 000	-	-	-	10 000	-
Total	**126 912**	**1 012**	**926**	**954**	**129 804**	**1 000**

(1) Pre-2011 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by reprocessing method

(tonnes U in concentrate)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	126 898	991	897	935	129 786	976
In-place leaching*	4	7	5	2	18	4
Heap leaching**	10	14	24	17	55	20
Total	**126 912**	**1 012**	**926**	**954**	**129 804**	**1 000**

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

Ownership of uranium production in 2014

Domestic				Abroad				Total	
Government		Private		Government		Private			
(t U)	(%)	(t U)	(%)	(t U)	(%)	(t U)	(%)	(t U)	(%)
954	100							954	100

Uranium industry employment at existing production centres

(persons/years)

	2012	2013	2014	2015 (expected)
Total employment at existing production centres	4 350	4 480	4 500	4 500
Direct employment at uranium production	1 450	1 590	1 610	1 600

Short-term production capability at existing and committed centres by prime-cost from USD 80/kg (I) and USD 130/kg (II) up to 2035

(tonnes U/year)

2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	1 050	N/A	N/A	N/A	2 000	2 100

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	2 000	5 800	N/A	N/A	1 700	5 800	N/A	N/A	N/A	N/A

Net nuclear electricity generation

	2013	2014
Net nuclear electricity generation (TWh net)	83.2	88.6

Installed nuclear generating capacity till 2035

(GWe net)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
13.8	13.8	13.8	13.8	15.8	17.9	16.5	20.2	18.8	26.2	26.0	30.5

Annual reactor-related uranium requirements till 2035 (excluding MOX)

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
		Low	High	Low	High	Low	High	Low	High	Low	High
2 480	2 480	2 480	2 480	3 020	3 600	3 020	3 660	3 600	4 800	4 800	5 300

United Kingdom

Uranium exploration and mine development

Historical review

Some uranium mining occurred in Cornwall, as a sideline to other mineral mining, especially tin, in the late 1800s. Systematic exploration occurred in the periods 1945-1951, 1957-1960 and 1968-1982, but no significant uranium reserves were located.

Recent and ongoing uranium exploration and mine development activities

Exploration in overseas countries is carried out by private companies operating through autonomous subsidiary or affiliate organisations established in the country concerned (e.g. Rio Tinto).

There were no industry expenditures reported for domestic exploration from 1988 to the end of 2014, nor were there any government expenditures reported for exploration either domestic or abroad. Since 1983, all domestic exploration activities have been halted.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

The reasonably assured resource and inferred resources are essentially zero. There has been no geological appraisal of the UK uranium resources since 1980.

Undiscovered conventional resources (prognosticated and speculative resources)

There are small quantities of in situ undiscovered resources as well as speculative resources. Two districts are believed to contain uranium resources: the metalliferous mining region of south-west England (Cornwall and Devon) and north Scotland including Orkneys.

Unconventional resources and other materials

None to report.

Uranium production

The United Kingdom is not a uranium producer.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

None of the reactors in the United Kingdom currently use MOX fuel. In 2001, the UK government announced approval for MOX manufacture in the UK. In December 2001, British Nuclear Fuels Limited (BNFL) started the first stage of plutonium commissioning of the Sellafield MOX plant (SMP). The plant manufactured MOX fuel from plutonium oxide separated from the reprocessing of spent fuel and tails of depleted uranium oxide. Detailed programmes for SMP are considered to be commercially confidential.

On 3 August 2011, the Nuclear Decommissioning Authority (NDA) announced that the SMP was to be closed owing to a downturn in the prospects for Japanese MOX customers following the accident at the Fukushima Daiichi nuclear power plant in March 2011. On 7 June 2012, it was announced that the thermal oxide reprocessing plant would be closed in 2018 after current contracts are completed.

Production and/or use of re-enriched tails

Urenco has a long-term contractual agreement to upgrade tails material, but considers this to be commercially confidential. In November 2012, the Capenhurst site (the location of a gaseous diffusion enrichment facility that was closed in 1982), including legacy uranium enrichment tails, was transferred to Urenco, operator of the adjacent centrifuge enrichment plant. An agreement between the NDA and Urenco was signed for the processing of these NDA-owned legacy materials.

Uranium requirements

On 1 January 2015, there were 16 licensed reactors with a combined capacity of 9.2 GW operating in the United Kingdom. The UK reactor fleet is comparatively old and operators have stated that they expected up to 7.4 GW of existing nuclear capacity could close by 2019, although lifetime extension plans could extend operations of some reactors until 2023. The government has taken a series of facilitative actions to encourage nuclear new build and industry has announced ambitions for construction of up to 16 GW by 2025. New nuclear investments will be part of the total GBP 75 billion estimated for new power generation capacity needed by 2020. Three consortia are currently preparing for the construction of new nuclear power plants:

- NNB Generation Company (NNBGenco) is a joint venture led by EDF. NNBGenco has plans to build up to 6.4 GW at Hinkley Point in Somerset and Sizewell in Suffolk;
- Horizon Nuclear Power, owned by Hitachi-GE Nuclear Energy Ltd, has plans to build up to 6.6 GW at Wylfa in Anglesey and Oldbury in Gloucestershire;
- NuGen is a consortium of GDF Suez and Iberdrola. NuGen has plans to build up to 3.6 GW at Moorside near Sellafield in Cumbria.

Among the consortia, NNBGenco has made most progress having received regulatory approval (site licence, environmental permits and generic design assessment [GDA] of its EPR reactor design) in late 2012. In October 2013, the UK government announced that initial agreement had been reached on the key terms of a proposed investment contract for the Hinkley Point C nuclear power plant. The key terms include a 35-year “contract for difference” (CfD) and the “strike price” of GBP 89.50/MWh being fully indexed to the Consumer Price Index and conditional upon Sizewell C project proceeding. In October 2014, the EC decided that UK plans to support the construction and operation of the project were in line with EU state aid rules.

The GDA is one of the facilitative actions set out in the Nuclear White Paper 2008 and is undertaken by the Office for Nuclear Regulation (ONR) and the Environment Agency. GDA is a voluntary process that allows regulators to begin consideration of the generic safety, security and environmental aspects of designs for NPPs prior to applications for site-specific licence and planning consents.

For new nuclear build, Section 45 of the Energy Act 2008 requires prospective nuclear operators to submit a funded decommissioning programme (FDP) for approval by the Secretary of State for Energy and Climate Change (DECC). DECC published final FDP statutory guidance in December 2011 to assist operators to develop their programmes.

The government received an FDP submission from NNBGenco in March 2012. Discussions with NNBGenco are ongoing.

In the near to medium future, the uranium requirements in the United Kingdom will be difficult to predict owing to the proposed new build programme and the potential for commercial operators of existing power plants to obtain regulatory approval for life extensions beyond their current scheduled closure dates.

Uranium policies, uranium stocks and uranium prices

Uranium stocks

The UK uranium stockpile practices are the responsibility of the individual bodies concerned. Actual stock levels are commercially confidential.

Uranium prices

Uranium prices are commercially confidential in the United Kingdom.

United States

Uranium exploration and mine development

Historical review

From 1947 through 1970, the US government fostered a domestic private-sector uranium exploration and production industry to procure uranium for military uses and to promote research and development in peaceful atomic energy applications. By late 1957, both the number of new deposits being brought into production by private industry and production capability had increased sufficiently to meet projected requirements. Federal exploration programmes were ended at that time.

Exploration by the US uranium industry increased throughout the 1970s in response to rising prices and the projected large demand for uranium to fuel an increasing number of nuclear reactors being built or planned for civilian electric power stations. Total annual surface drilling peaked in 1978.

Exploration has primarily been for sandstone-type uranium deposits in districts such as the Grants Mineral Belt and Uravan Mineral Belt of the Colorado Plateau, the Wyoming basins and Texas Gulf Coastal Plain region.

Recent and ongoing uranium exploration and mine development activities

From 2012 to 2014, there was a 58% decrease in uranium surface drilling expenditures. In 2014, expenditures for uranium surface drilling totalled USD 28.2 million, down USD 21.7 million from expenditures in 2013 of USD 49.9 million (see table). This 44% decrease is a continuation of the downward trend in investment following the sharp decline in late 2008.

In 2014, private industry total expenditures for uranium exploration and mine development activities were USD 102.2 million, a 27% decrease from 2013 expenditures of USD 140.5 million.

In 2014, expenditures on US uranium production, including facility expenses, were USD 137.6 million, 18% less than the USD 168.2 million spent in 2013. Expenditures for land in 2014 were USD 11.6 million, a 21% decrease compared with USD 14.6 million in 2013. Land expenditures have remained generally flat since 2009.

The total expenditures for land, exploration, drilling, production and reclamation decreased by 22% from USD 308.7 million in 2013 to USD 239.7 million in 2014. Reclamation expenditures in 2014 were USD 51.74 million, a 5% decrease compared with 2013 expenditures of USD 54.4 million.

The trend of increased drilling from 2009 to 2012, reversed in 2013 and 2014. The number of holes drilled for uranium decreased by 67% from 2013 to 2014, from 5 244 holes to 1 752 holes, respectively (see table below). The total metres drilled decreased 82% from 1 171 956 m in 2013 to 395 935 m in 2014.

United States uranium expenditures, 2004-2014

(USD million)

Year	Drilling	Production	Land and other				Total expenditures
			Total land and other	Land	Exploration	Reclamation	
2004	10.6	27.8	48.4	N/A	N/A	N/A	86.9
2005	18.1	58.2	59.7	N/A	N/A	N/A	136.0
2006	40.1	65.9	155.2	41.0	23.3	50.9	221.2
2007	67.5	90.4	178.2	77.7	50.3	50.2	336.2
2008	81.9	221.2	164.4	65.2	50.2	49.1	467.6
2009	35.4	141.0	104.0	17.3	24.2	62.4	280.5
2010	44.6	133.3	99.5	20.2	34.5	44.7	277.3
2011	53.6	168.8	96.8	19.6	43.5	33.7	319.2
2012	66.6	186.9	99.4	16.8	33.3	49.3	352.9
2013	49.9	168.2	90.6	14.6	21.6	54.4	308.7
2014	8.2	137.6	74.0	11.6	10.7	51.7	239.7

Notes: Expenditures in nominal USD. Totals may not equal sum of components because of independent rounding.

Drilling: All expenditures directly associated with exploration and development drilling.

Production: All expenditures for mining, milling, processing of uranium and facility expense.

Total land and other: All expenditures for: land; geological research; geochemical and geophysical surveys; costs incurred by field personnel in the course of exploration, reclamation and restoration work; and overhead and administrative charges directly associated with supervising and supporting field activities.

N/A = Not available. W = Data withheld to avoid disclosure of individual company data.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 8.

In 2013 and 2014, the US government made no exploration expenditures for uranium domestically or abroad. Data on industry exploration expenses abroad are not available.

After increasing from 2010-2012, exploration and production expenditures decreased by 15% in 2013 and 27% in 2014. Much of these decreases were a result of a global oversupply of uranium. Additionally, the ten-year contract between Centrus Energy Corporation and Techsnabexport (TENEX) to supply commercial-origin Russian low-enriched uranium will replace some of the material previously provided by the Megatons-to-Megawatts programme, which ended in 2013. Deliveries under this contract began in 2013 and are slated to continue through 2022. The new supply of low-enriched uranium from TENEX will gradually increase until 2015, when it reaches about one-half of the annual amount supplied under the Megatons-to-Megawatts programme. The contract also includes an option to double the amount of material purchased.

Exploration and development continued to be focused primarily on sandstone-hosted uranium deposits within known US uranium provinces. The following properties are the most significant, because they are closest to production or contain a significant resource, but are not a comprehensive listing of all US uranium occurrences undergoing some form of exploration or development.

United States uranium drilling activities, 2003-2014

Year	Exploration drilling		Development drilling		Exploration and development drilling	
	Number of holes	Metres (thousand)	Number of holes	Metres (thousand)	Number of holes	Metres (thousand)
2003	N/A	N/A	N/A	N/A	W	W
2004	W	W	W	W	2 185	381
2005	W	W	W	W	3 143	508
2006	1 473	250	3 430	577	4 903	827
2007	4 351	671	4 996	898	9 347	1 569
2008	5 198	775	4 157	778	9 355	1 553
2009	1 790	320	3 889	820	5 679	1 141
2010	2 439	445	4 770	1 050	7 209	1 495
2011	5 441	1 013	5 156	915	10 597	1 928
2012	5 112	1 051	5 970	1 131	11 082	2 181
2013	1 231	280	4 013	892	5 244	1 172
2014	W	W	W	W	1 752	396

Note: Totals may not equal sum of components because of independent rounding.

N/A = Not available. W = Data withheld to avoid disclosure of individual company data.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 1.

Conventional mine development

Energy Fuels Inc. operated the Pinenut mine in Arizona. Its other conventional mines in the Colorado Plateau region are on standby. The company has stated that it plans to move its workforce to the fully permitted Canyon Mine when mining at Pinenut is completed in 2015. Both Pinenut and Canyon Mine are breccia pipe-type deposits. The following conventional mines owned by Energy Fuels are either fully, or close-to-fully, permitted and on standby status:

- Sunday Complex (Topaz, St Jude, Carnation, Sunday, and West Sunday) in Colorado with mines that are partly permitted on care and maintenance.
- Whirlwind mine in Colorado, which is fully permitted and completely rehabilitated.
- Energy Queen mine in Utah, which is almost fully permitted and partially rehabilitated.
- Henry Mountains Complex in Utah (Tony M mine), which is permitted and on care and maintenance status.
- Sheep Mountain in Wyoming, a past producer that has been idle since 1988 and for which a pre-feasibility study is complete.
- Gas Hills District in Wyoming, which is planned to be developed using multiple shallow open pits with the ore processed by heap leaching. This mine is in the early stages of permitting with a mine permit application submitted to the state of Wyoming.
- The Roca Honda mine with an updated uranium resource in 2015 and a mine permit application filed with the state of New Mexico.

Significant proposed conventional mines owned by other companies include the following:

- Slick Rock in New Mexico (Uranium Energy Corporation) completed a NI-43-101 compliant resource assessment in 2013 and pre-feasibility study in 2014.
- Rio Grande Resource's Mt. Taylor mine in New Mexico is on continued standby. An intent to file a new mill licence was filed with the US Nuclear Regulatory Commission (NRC). Environmental groups, citing over 25 years of standby status, have requested the state require the owners to close and remediate the property.
- At the Juan Tafoya and Cebolleta projects in New Mexico, Uranium Resources Inc. has updated resource estimates and a letter of intent to construct a conventional mill to process ore from these deposits has been filed with the NRC.
- Virginia Uranium Inc.'s Coles Hill deposit in Virginia is the largest undeveloped uranium deposit in the United States. Development of Coles Hill cannot proceed until a state moratorium on uranium mining is lifted.

Advanced exploration stage projects entering the pre-feasibility stage include the following:

- Oregon Energy's volcanogenic Aurora deposit in southern Oregon;
- Black Range Mineral's Hansen/Taylor Ranch Project located in the Rocky Mountains of Colorado, proposed to be mined using underground borehole mining with ablation;
- Energy Fuel's Sage Plain Project, Utah;
- Energy Fuel's Marquez/Bokum project, New Mexico;
- Uranium Energy Corporation's Anderson Project, Arizona;
- The Velvet/Wood Project, Lisbon Valley Colorado, Anfield Resources Inc.;
- Wate Breccia Pipe, (Energy Fuels Inc.), Arizona.

ISR mine development

Producers Cameco, Uranium Energy Corporation and Ur-Energy are developing satellite properties for their existing processing plants. Cameco is exploring and permitting satellite properties for their Smith Ranch and Crow Butte mines. At Smith Ranch, evaluation and permitting continue for the Gas Hills/Peach, Ruby Ranch, and Ruth and Shirley Basin projects. A plan of operations has been completed and filed with the NRC. Near the Crow Butte Mine in Nebraska, Cameco is in some stage of licensing for three satellites: the North Trend, Marsland and Three Crow expansions. Exploration and development continued on trend and in other areas of the private ranch where the Alta Mesa mine is operated by Mestena Uranium in Texas. Uranium Energy Corporation is exploring and developing several other properties in Texas as satellites to the Hobson plant, currently supplied with resins by the La Palangana mine. Potential satellite mines include the fully permitted and developing Goliad mine as well as the Burke Hollow, Channen and Salvo exploration projects. Ur-Energy is evaluating and permitting the Shirley Basin project in Wyoming to add to production from their Lost Creek mine. Energy Fuels Inc. is permitting the Hank and Jane Dough deposits as satellite well fields for the Nichols Ranch mine. Uranium One/Atomredmetzoloto is planning to develop the Ludeman project in the Great Divide Basin as a satellite property to the Willow Creek mine.

In addition to the development of satellite properties adjacent to existing processing plants, other significant developing ISR properties include:

- Dewey-Burdock, South Dakota (Powertech Resources), which is in the advanced stage of permitting;
- Lance/Ross in Wyoming (Strata Energy), which is in the advanced stage of permitting;
- Uranium Resources Inc.'s Church Rock/Mancos deposit in New Mexico with a completed feasibility study, but for which the company has deferred development because of the low price of uranium;
- Uranium Energy Corporation's Burke Hollow project in the permitting stage in Texas;
- AUC LLC's Reno Creek Project in the Powder River Basin of Wyoming.

Exploration continues for ISR mines in the Wyoming Basins, along the Texas Gulf Coast and in the Grants district of New Mexico.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Estimates of reasonably assured resources (RAR) in the United States are changed from the prior estimates that were reported as of 2012.

At the end of 2014, estimated uranium reserves were 17 425 tU at a maximum forward cost of up to USD 80 per kilogram. At up to USD 130/kgU, estimated reserves were 62 890 tU. At up to USD 260/kgU, estimated reserves were 138 204 tU. At the end of 2014, estimated uranium reserves for mines in production were 7 308 tU at a maximum forward cost of up to USD 130/kgU. Estimated reserves for properties in development drilling and under development for production were 14 617 tU at a maximum forward cost of up to USD 130/kgU.

Reserve estimates are available for 74 mines and properties for the end of 2013 and for 75 mines and properties for the end of 2014. As reported to the US Energy Information Administration (US EIA), reserves do not necessarily imply compliance with US or Canadian government definitions for purposes of investment disclosure.

Current estimates of uranium reserves cannot be compared with the much larger historical data set of uranium reserves published in the July 2010 US Department of Energy (DOE) report, *U.S. Uranium Reserves Estimates*. Those estimates were made by US EIA based on data collected by US EIA and data developed by the National Uranium Resource Evaluation (NURE) programme, operated out of Grand Junction, Colorado, by DOE and predecessor organisations. The US EIA data covered approximately 200 uranium properties, with reserve estimates collected from 1984 through 2002. The NURE data covered approximately 800 uranium properties with reserve estimates, developed from 1974 through 1983. Although the 2014 data collected on the Form EIA-851A survey, Domestic Uranium Report (Annual), cover a much smaller set of properties than the earlier US EIA and NURE data, US EIA believes that, within its scope, the EIA-851A survey data provide more reliable estimates of the uranium recoverable at the specified forward cost than estimates derived from 1974 through 2002. In particular, this is because the NURE data have not been comprehensively updated in many years and are no longer a current data source.

The United States has not historically reported inferred resources. In 2014, the United States began an evaluation of the relative importance of the inferred resource category available in published estimates of US uranium properties. Based on this limited analysis, it is estimated that minimal uranium resources for the United States would be increased by 10%, if inferred resources were tabulated in addition to RAR. In recognition of the importance of this class of resource, mechanisms for collecting inferred uranium resource data for the United States are being considered.

Undiscovered conventional resources (prognosticated and speculative resources)

Prognosticated and speculative uranium resources for the United States were last comprehensively assessed in 1980. Records of these estimates are no longer available; therefore they are no longer reported for the United States. The US Geological Survey (USGS) is now re-estimating undiscovered resources for the United States. Estimates for different regions and deposit types have been prioritised, and will be completed in an ongoing fashion. The first of the new undiscovered estimates was completed in 2015. Using a geology-based assessment methodology, the USGS estimated that a mean 85 000 tU of recoverable U_3O_8 remain as potential undiscovered resources in southern Texas. This estimate is for Tertiary sandstone-hosted uranium deposits in Texas Coastal Plain sedimentary strata.

The USGS assessment methodology uses known uranium mineral site locations and deposit resources in combination with associated geologic features to estimate numbers of undiscovered deposits and to identify regions that may host them. The method includes: i) delineation of geographic regions (tracts) that are permissive for the occurrence of deposits as guided by known deposits and a descriptive mineral deposit model, ii) probabilistic estimation of numbers of undiscovered deposits within each permissive tract, and iii) calculation of the probable amount of undiscovered uranium based on the estimated number of undiscovered deposits and grade-tonnage models of known deposits in the region using Monte Carlo simulation. This methodology produces probabilistic estimates of potential resources, but not their associated cost categories. Nor are resources reported separately in prognosticated and speculative categories. Resources within this region range between USD 100 and USD 150/kgU, spanning both the <USD 80/kgU and <USD 130/kgU cost categories. Placing these, and future undiscovered resource estimates into cost categories as well as prognosticated and speculative classes will be difficult. Calculating these resources as in situ and not recoverable will also be problematic and require significant conjecture.

Unconventional resources and other materials

Phos Energy Ltd and Cameco Corporation continue testing of the “PhosEnergy” process, which is designed to extract uranium from the processing stream at operating phosphate mines. Their demonstration plant, constructed in 2012, was transported to a phosphate fertiliser production site in Florida. Here the plant was connected to a filter grade acid stream and operated for a year until March 2015. Preliminary results demonstrated that more than 92% of uranium was recovered with no build up of sludge. Chemical and reagent consumption was within expected ranges and the phosphate stream chemistry was unaffected except for the removal of uranium. The concentrate was shipped to a processing facility in Wyoming. A pre-feasibility study has been completed for a relatively small facility (< 150 tU/yr), and returned operating costs in the lower quartile of USD 50/kgU. Moving forward, the company plans to build a commercial model based on the demonstration plant and pre-feasibility results in the United States.

Uranium production

Historical review

Following the passage of the Atomic Energy Act of 1946 (AEA), designed to meet US government uranium procurement needs, the Atomic Energy Commission (AEC) from 1947 through 1970 fostered development of a domestic uranium industry (chiefly in the western United States) through incentive programmes for exploration, development and production. To assure that the supply of uranium ore would be sufficient to meet future needs, the AEC in April 1948 announced a domestic ore procurement programme designed to stimulate prospecting and build a domestic uranium mining industry. The AEC also negotiated concentrate procurement contracts, pursuant to the Atomic Energy Act, as amended in 1954, with guaranteed prices for source materials delivered within specified times. Contracts were structured to allow milling companies that built and operated mills the opportunity to amortise plant costs during their procurement-contract period. By 1961, a total of 27 mills were being operated. Overall, 32 conventional mills and several pilot plants, concentrators, up graders, heap leach and solution-mining facilities were operated at various times. The AEC, as the sole government purchasing agent, provided the only US market for uranium. While many of the mills were closed soon after completing deliveries scheduled under AEC purchase contracts, several mills continued to produce concentrate for the commercial market after fulfilling their AEC commitments.

The Atomic Energy Act, as amended, legalised the private ownership of nuclear reactors for commercial electricity generation. By late 1957, domestic ore reserves and milling capacity were sufficient to meet government needs. In 1958, the AEC's procurement programmes were reduced in scope and, in order to foster utilisation of atomic energy for peaceful purposes, domestic producers of ore and concentrate were allowed to sell uranium to private domestic and foreign buyers. The first US commercial-market contract was finalised in 1966. The AEC announced in 1962 a "stretch out" of its procurement programme that committed the government to take only set annual quantities of uranium for 1967 through 1970. This also assisted in sustaining a viable domestic uranium industry. The US government's natural uranium procurement programme ended in 1970 and the industry became a private sector, commercial enterprise with no government purchases; however, the government continues to monitor private-industry exploration and development activities to meet federal information and data needs.

Exploration by the US uranium industry increased through the 1970s in response to rising prices and the projected large demand for uranium to fuel an increasing number of commercial nuclear power plants that were under construction or planned. US production peaked in 1980 (16 809 tU), after which the industry experienced generally declining production from 1981 to 2003. Beginning in 2004, production began increasing again in response to higher uranium prices. Production began decreasing in 2013 in response to an oversupply of uranium on the world market and consequent lower uranium prices. The oversupply was the result of reactor shutdowns in Germany and Japan following the accident at Fukushima Daiichi. Since 1991, production from ISR mining has dominated US annual production.

Status of production facilities, production capability, recent and ongoing activities and other issues

US uranium mines produced 1 761 tU in 2013, 6% more than in 2012. In 2014, US uranium mines produced 1 889 tU, 7% more than in 2013. Production in 2014 was from ten mines (underground and ISR) and the White Mesa Mill. Eight underground mines produced ore containing uranium during 2014, one more than during 2013. Uranium ore from underground mines is stockpiled and shipped to the White Mesa Mill for milling into uranium oxide (U_3O_8) concentrate (yellowcake).

Total production of US uranium concentrate (yellowcake) in 2014 was 1 881 tU, a 5% increase from 2013. In 2013, uranium concentrate production was 1 792 tU, 12% more than in 2012, from eight facilities (one mill and seven ISR plants).

At the end of 2014, one uranium mill (White Mesa in Utah) was operating with a capacity of 1 538 tonnes of ore per day. Two mills (Shootaring Canyon in Utah and Sweetwater in Wyoming) were on standby status with a combined capacity of

2 884 tonnes of ore per day. One mill (Piñon Ridge) was planned for Colorado. One heap leach plant (Sheep Mountain) is planned for Wyoming. The NRC received letters of intent for mill licence applications from Uranium Resources Inc. (Juan Tafoya mine area, New Mexico) and General Atomics (Mt. Taylor Mine area, New Mexico).

Eight ISR mines were operating in 2014 with a combined capacity of 5 116 tU per year (Crow Butte, Nebraska; Alta Mesa Project, Texas; Hobson ISR Plant/La Palangana Mine, Texas; Lost Creek Project, Nichols Ranch ISR Project, Smith Ranch-Highland Operation, Willow Creek Project and Smith Ranch satellite North Butte in Wyoming). Smith Ranch, Crow Butte, Alta Mesa and Willow Creek processed lixiviant at the mine site.

US production of uranium concentrate in the second quarter of 2015 was down 32% from the first quarter and down 28% from the second quarter of 2014. Additionally, second quarter 2015 production was the lowest quarterly US production since the fourth quarter 2005. During the second quarter 2015, US uranium was produced at six US uranium facilities, two fewer than in the first quarter 2015. Uranium was not produced at Alta Mesa Project in Texas and White Mesa Mill in Utah. Loaded resins were trucked from La Palangana to the Hobson plant in Texas, and from the North Butte and Nichols Ranch mines to the Smith Ranch plant for processing. Two ISR mines are under construction; the Goliad mine in Texas and Ross mine in Wyoming. Five other ISR and two conventional mines are in the advanced planning or permitting process in Colorado, Texas and Wyoming.

Ownership structure of the uranium industry

Eight facilities produced uranium in 2014. Ownership of these facilities included public and privately held firms with both foreign and domestic participation. Declining uranium prices have led to some consolidation and shifting in the ownership of US uranium production and processing facilities. Energy Fuels Inc. acquired the Uranerz Energy Corporation in 2015, which expanded their focus from conventional mining to include ISR amenable deposits and the operating Nichols Ranch ISR mine in Wyoming. Uranium Resources Inc. merged with Anatolia Energy Limited in 2015. Anfield Resources has acquired the Shootaring Canyon Mill from Uranium One as well as a number of conventional assets from Uranium One, Yellow Rock Resources and Alamosa Mining.

Employment in the uranium industry

Employment in the raw materials sector (exploration, mining, milling, and processing) of the US uranium industry generally declined from 1998 to 2003, and then steadily increased from 2004 to 2008. Employment levels in 2009 showed the first significant decrease over the preceding five years, but from 2009 through 2012 there were marginal gains in total employment. In 2014, total employment in the US uranium production industry was 626 person-years, a decrease of 35% from the 2013 total of 957 person-years and the lowest since 2006. Exploration employment in 2014 was 86 person-years, a 42% decrease compared with 2013. Milling and processing employment data are withheld for 2013 and 2014. Uranium mining employment in 2014 was 246 person-years, 37% less than in 2013. Reclamation employment decreased 19% from 199 person-years in 2013 to 161 person-years in 2014. Uranium production industry employment in 2014 was in nine states: Arizona, Colorado, Nebraska, New Mexico, Oregon, Texas, Utah, Washington and Wyoming.

Future production centres

There are a number of future production centres that are currently in either the permitting and licensing process or under development. Fully permitted centres are listed in the table above, and other developing centres are described in the section on conventional and ISR mine development.

Uranium production centre technical details

(as of 31 December 2014)

	Centre #1	Centre #2	Centre #3	Centre #4
Name of production centre	Crow Butte Operation	Smith Ranch/Highland (including North Butte satellite mine)	White Mesa Mill	Hobson ISR Plant/ La Palangana Mine
Production centre classification[1]	Existing	Existing	Existing	Existing
Date of first production	1991	1988	1980	1979
Source of ore:				
Deposit name(s)	Crow Butte and North Trend	Smith Ranch-Highland	Various	Palangana
Deposit type(s)	Sandstone	Sandstone	Sandstone, breccia pipe	Sandstone
Recoverable resources (tU)	W	W	W	W
Grade (% U)	W	W	W	W
Mining operation:				
Type (OP/UG/ISR)	ISR	ISR	UG	ISR
Size (tonnes ore/day)	N/A	N/A	N/A	N/A
Average mining recovery (%)	N/A	N/A	N/A	N/A
Processing plant:				
Acid/alkaline			Acid	
Type (IX/SX)	ISX	IX	SX	IX
Size (tonnes ore/day)	N/A	N/A	1 538	N/A
Average process recovery (%)	N/A	N/A	N/A	N/A
Nominal production capacity (tU/year)[1]	385	2 116	N/A	385
Plans for expansion	Unknown	Unknown	Unknown	Unknown
Other remarks[1]	Operating	Operating	Operating	Operating
State	Nebraska	Wyoming	Utah	Texas

1. US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Tables 4 and 5.

N/A = Not available. W = Data withheld to avoid disclosure of individual company data.

Uranium production centre technical details *(cont'd)*

(as of 31 December 2014)

	Centre #5	Centre #6	Centre #7	Centre #8
Name of production centre	Alta Mesa	Willow Creek Project	Lost Creek Project	Nichols Ranch ISR Project
Production centre classification[1]	Existing	Existing	Existing	Existing
Date of first production	2005	N/A	N/A	N/A
Source of ore:				
Deposit name(s)	Alta Mesa	Willow Creek	Lost Creek	Nichols Ranch and Hank
Deposit type(s)	Sandstone	Sandstone	Sandstone	Sandstone
Recoverable resources (tU)	W	N/A	N/A	N/A
Grade (% U)	W	N/A	N/A	N/A
Mining operation:				
Type (OP/UG/ISR)	ISR	ISR	ISR	ISR
Size (tonnes ore/day)	N/A	N/A	N/A	N/A
Average mining recovery (%)	N/A	N/A	N/A	N/A
Processing plant:				
Acid/alkaline				
Type (IX/SX)	IX	IX	IX	IX
Size (tonnes ore/day)	N/A	N/A	N/A	N/A
Average process recovery (%)	N/A	N/A	N/A	N/A
Nominal production capacity (tU/year)[1]	577	500	769	769
Plans for expansion	Unknown	Unknown	Unknown	Unknown
Other remarks[1]	Producing	Operating	Operating	Operating
State	Texas	Wyoming	Wyoming	Wyoming

[1] US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Tables 4 and 5.

N/A = Not available. W = Data withheld to avoid disclosure of individual company data.

Secondary sources of uranium

Production and/or use of mixed oxide fuels

Beginning in 2019, mixed oxide (MOX) fuel will be fabricated at the DOE Savannah River site in South Carolina using surplus military plutonium to fabricate fuel for commercial reactors. In February 2011, the Tennessee Valley Authority (TVA) and Areva signed a letter of intent to begin evaluating the use of MOX at TVA's Sequoyah plant in Tennessee and the Browns Ferry plant in Alabama. In order to use MOX at the TVA nuclear power plants, TVA will need to submit requests for licence amendments for the plants to the NRC. As of 31 December 2014, no such applications had been filed with the NRC. Once filed, it is likely to take the NRC one to two years to complete its review of the applications.

Production and/or use of re-enriched tails

DOE and the Bonneville Power Administration initiated a pilot project to re-enrich a portion of DOE's tails inventory. This project produced approximately 1 940 tonnes of low-enriched uranium between 2005 and 2006 for use by Energy Northwest's 1 190 MWe Columbia Generating Station between 2007 and 2015. In mid-2012, Energy Northwest and United States Enrichment Corporation, in conjunction with DOE, developed a new plan to re-enrich a portion of DOE's high-assay tails. The 2013 project produced approximately 3 738 tonnes of natural uranium, which will be used over the next ten years to fuel Energy Northwest and TVA reactors.

Production and/or use of reprocessed uranium

Reprocessed uranium use and production is zero.

In June 2008, DOE submitted a licence application to the NRC to receive authorisation to begin construction of a repository at Yucca Mountain, and in September 2008, the NRC formally docketed the application. President Obama announced in March 2009 that the proposed permanent repository at Yucca Mountain was no longer an option and that the Blue Ribbon Commission on America's Nuclear Future (BRC) would evaluate alternatives to deal with spent nuclear fuel. On 26 January 2012, the BRC issued its final report that recommended moving forward with a publicly supported siting process for a permanent repository and federally chartering an organisation to manage this process. The BRC also recommended development of an interim storage site for spent nuclear fuel until a permanent repository is available. With regard to reprocessing or recycling, the BRC noted that "… no currently available or reasonably foreseeable reactor and fuel cycle technology developments – including advances in reprocessing and recycling technologies – have the potential to fundamentally alter the waste management challenge this nation confronts over at least the next several decades, if not longer …"

Environmental activities and socio-cultural issues

Remediation activities

1. Navajo Nation sites

The US Environmental Protection Agency (EPA) is engaged in remediating uranium mining and milling impacted sites on the Navajo Nation. Between 2008 and 2012, high-priority remediation for 34 contaminated homes, 9 mine sites, and drinking water supplies for 1 825 families was completed. In addition, 240 water supplies and 520 mines were assessed. In 2015, Anadarko Petroleum and the Kerr-McGee Corporation agreed to contribute USD 5.15 billion to the clean-up of abandoned uranium sites nationwide with USD 985 million of this earmarked for remediation on the Navajo Nation. Plans for a second phase of remediation from 2014 to 2018 were completed by EPA. The main objectives are to remediate homes, to increase water infrastructure to mining areas, focus on 43 priority mines located near homes, clean up the NE Church Rock mine and Tuba City dump, treat groundwater at mill sites, conduct health studies and expand interagency outreach. Four superfund sites have been identified, and eight abandoned uranium mines are targeted by EPA for investigation, clean-up, or negotiations with responsible parties. The EPA is working with the Navajo Nation to sample water sources and inform residents about the risks of drinking water from unregulated sources. It is estimated that about 30% of residents of the Navajo Nation haul water for drinking. In 2015, the US Department of Justice announced that USD 13.2 million would be contributed to a trust fund for the evaluation of abandoned uranium mines on Navajo lands.

2. Piketown

Decommissioning and environmental remediation continues at the Gaseous Diffusion Plant in Piketown, Ohio; the plant closed in 2001. This work is funded by US government sales of uranium from excess inventories. It is estimated that this remediation project will continue until 2044 to 2052.

3. DOE lease tracts

The Atomic Energy Act authorised DOE to develop a domestic uranium supply and issue leases or permits for exploration for and mining of uranium. The DOE administers tracts of land located in the Uravan Mineral Belt in western Colorado for the exploration, mine development and operations and extraction of uranium and vanadium ores. DOE administers approximately 25 000 acres in 31 lease tracts under its uranium leasing programme (ULP). These tracts were withdrawn from the public domain in the 1940s and leased in ten-year increments. Twenty-nine of the thirty-one tracts are actively being held under lease by a number of different mining companies. In 2011, a federal court invalidated DOE's 2006 Environmental Assessment, which addressed the environmental impacts of leaseholders' activities on these tracts. Leaseholders were prohibited from performing exploration activities on these tracts – including drilling, mining or reclamation – until a full programmatic environmental impact statement (PEIS) was completed. DOE issued the final uranium leasing programme PEIS in March 2014, and in May 2014 announced its decision to continue to manage the ULP for the 31 tract for the next ten years. DOE's ULP Mitigation Plan, issued in November 2014, addresses mitigation commitments in its decision to continue to manage the ULP (i.e. how mitigation measures will be planned and implemented).

4. DOE report to Congress on defence-related uranium mines

In late 2012, the US Congress mandated that DOE prepare a report on the location and priority ranking for remediation of all mines that provided uranium for defence-related activities. The DOE, in consultation with EPA and the US Department of the Interior (DOI), completed the report in August 2014. The report addressed the following:

- the location of defence-related abandoned uranium mines on federal, state, tribal, and private lands;
- the extent of radiation hazards, other public health and safety threats, and environmental degradation caused, or that may have been caused, by the mines;
- a priority ranking to reclaim and remediate the mines;
- the potential cost and feasibility of reclamation and remediation, in accordance with applicable federal law;
- the status of any mine reclamation and remediation efforts.

The DOE determined that 4 225 mines provided uranium ore for defence-related activities. Of these mines, 26 could not be located. Approximately 69% of the mines are in Colorado and Utah, and 23% in Arizona, New Mexico and Wyoming. Nearly half of the mines are located on federal land managed by the Bureau of Land Management, an agency within DOI. About 11% of the mines are on tribal lands. The remaining mines are located on non-federal and non-Indian land or land of unknown ownership.

Mines were characterised by production size, ranging from small to very large. Cost estimates for reclamation range from USD 10 000 to USD 80 000 for small mines to USD 4.9 million to USD 14.4 million for large mines. All mines characterised as "very large" have undergone or are undergoing reclamation or remediation. Of the 4 225 mines, only 614 (15%) were confirmed as having had some form of reclamation or remediation completed.

Legislation

Federal

In 2012, over 1 million acres of federal land near the Grand Canyon in Arizona were withdrawn from mineral entry for 20 years. In October 2014, a US District Court upheld the ban on mining. This area is highly prospective for breccia pipe uranium deposits. The USGS estimates that 125 000 tU may lie within the withdrawal area. Existing claims were not affected by the ban, and mining of breccia pipes continues. Challenges by the National Mining Institute and Nuclear Energy Institute questioning whether the Secretary of DOI had the authority to withdraw the land have not been successful in court. Interdisciplinary studies of mining impacts in the region were initiated by the USGS in 2014 and are planned to continue throughout the course of the moratorium. These studies are focused on groundwater, surface water, biologic and dust impacts of mining. Active study sites include deposits that are being actively mined, those that have been reclaimed, deposits on standby status and those that remain unmined.

State

Virginia: The largest known undeveloped reserve of uranium in the United States and the seventh largest in the world is located on private land at Coles Hills in south central Virginia. In 1982, the Virginia state legislature passed a law that prohibited the issuance of any mining permits until the necessary state regulations were in place. This moratorium is still in place, and the current governor of Virginia has stated that during his term (through 2018) no effort will be made to lift the moratorium.

New Mexico: The Mt. Taylor mine is located in an area designated in 2009 as a Native American traditional cultural property by the New Mexico Cultural Properties Review Committee. In 2011, the Fifth Judicial District Court of New Mexico reversed this designation, reasoning that the area was too large to be reasonably monitored by the state to the level required by this designation. This ruling eased the way for reopening of the mine and exploration of other areas on Mt. Taylor. The mine has been on standby status since 1989, and environmental advocates protested at hearings by the New Mexico Mining and Minerals Division in 2015 that the standby licence should not be renewed and the mine should be closed and remediated.

Wyoming: In 2015, the state of Wyoming passed legislation that starts the process of transferring oversight of aspects of the uranium mining industry from the NRC to the state. Regulations would remain the same, but the state would take primacy with regulatory oversight by the NRC. Texas, Utah, and Colorado are currently "agreement states" with regulatory primacy granted by the NRC.

Litigation

A detailed summary of ongoing litigation related to the Secretary of Energy's 2014 determination regarding management of excess uranium inventory is provided in the "National policies relating to uranium" section below. See the legislation section above for information on litigation of land withdrawn from mineral entry near the Grand Canyon.

Regulatory regime

Regulation

Uranium recovery is regulated by the NRC, the EPA and individual states, while mining regulations for federal lands are administered through the federal agency that controls this land (such as the Bureau of Land Management). Before mining commences, Environmental Impact Statements must be completed, adequate bonding must be posted, and additional regulatory requirements specified by federal and state agencies must be satisfied.

The NRC has initiated an effort to update its guidance for uranium recovery facilities. These updates are related to: technical and environmental regulations for conventional, heap leach and ISR facilities; licence application formats; restoration action plans; and pre-licence exploration vs. post-licence operations. Licensing of an ISR facility by the NRC takes on average 3.5 years and costs USD 2.6 million. Duration and cost estimates for licensing by other agencies are not available. The NRC is currently reviewing applications for six new facilities and 14 expansions or restarts (this does not include licensing actions in agreement states such as Texas). Agreement states have the authority to permit and regulate uranium mines and mills, with NRC oversight. Most uranium-producing states are agreement states.

The EPA is reviewing and revising its standards for uranium and thorium milling facilities. The standards apply to by-product material from conventional mills, ISR and heap leach facilities, but not to conventional open-pit or underground mines. Any revisions are expected to address such issues as groundwater protection and significant changes in uranium industry technology, judicial decisions relevant to the regulation, and the need for new assessments to account for unanticipated risks to the public and the environment. The proposed regulation was issued for public comment on 26 January 2015. No date for the issuance of a final rule is available. Any new or revised standards must be adopted by the NRC, its agreement states and DOE.

Uranium requirements

Annual US uranium requirements for the period 2014 to 2035 are projected to decrease from 17 998 tU in 2014 to 17 528 tU in 2035 (high case). This decrease is based on the possibility that some nuclear power plants may retire early because of financial uncertainties in competitive markets, as well as uncertainties related to licence renewals to operate for an 80-year extended life cycle. The projected decrease in requirements is tempered, however, by the expected operations of new reactors such as Vogtle units 3 and 4 (Georgia), Summer units 2 and 3 (South Carolina), and Watts Bar unit 2 (Tennessee).

Supply and procurement strategy

The United States allows supply and procurement of uranium to be driven by market forces with resultant sales and purchases conducted solely in the private sector by firms involved in the uranium mining and nuclear power industries.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

In July 2013, DOE released the revised *DOE Excess Uranium Inventory Management Plan* (Plan). The 2013 Plan identified uranium inventories that have entered the commercial uranium market since the issuance of the December 2008 Plan, as well as transactions that are ongoing or being considered by DOE through 2021. In the 2013 Plan, the guideline that the annual inventory release rate should not exceed 10% of US uranium requirements was removed. Several determinations have been made by the Secretary of Energy since 2008 to assess whether these transactions would have an adverse impact on the domestic uranium mining, conversion or enrichment industries. The determinations are required every two years. The June 2014 Secretarial determination found that continued transfers would have no impact on the domestic industry.

In the most recent determination, issued in May 2015, the Secretary of Energy again found that continued transfers would have no impact on the domestic industry. However, planned annual transfers of excess uranium were reduced from 2 705 tU. The total amount of material transferred by DOE will now not exceed the equivalent of 2 500 tU of natural uranium in 2015 or the equivalent of 2 100 tU of natural uranium in each subsequent year.

Following the release of the 2014 Secretarial determination, ConverDyn sued DOE, claiming that transfers in excess of 10% of US uranium requirements harmed the industry and that the 2015 Secretarial determination is not retroactive. Although DOE maintained that the litigation was moot based on the 2015 Secretarial determination, the US District Court decided to let the case proceed. Litigation is ongoing as of July 2015. Legislation was introduced in Congress in May 2015, limiting annual transfers to 2 100 tU through 2023 and 2 700 tU thereafter.

Uranium stocks

As of 2014, the total inventories (including government, producer and utility stocks) in the United States were 100 108 tU. Of this total, government stocks were 48 410 tU, which includes 12 939 tU of uranium concentrates, 5 471 tU of enriched uranium, and 30 000 tU of depleted uranium. Total commercial inventories (producer and utility stocks) in 2014 were 51 778 tU, a 0.1% increase from the 51 704 tU of inventories held in 2013. Over 86% of the commercial inventories, or 44 637 tU, were held by owners and operators of commercial reactors. This was a 2.6% increase from the 43 495 tU owned by this group at the end of 2013.

Enriched uranium inventories held by utilities (including fuel elements in storage) decreased 3.6% from 2013 to 2014 (56 614 tU in 2013 to 54 574 tU in 2014), whereas natural uranium inventories held by utilities (including UF_6 in storage) increased 9% from 2013 to 2014 (56 463 tU in 2013 to 61 473 in 2014).

Uranium prices

Owners and operators of US civilian nuclear power reactors purchase uranium under spot and long-term contracts. A spot contract is defined as a one-time delivery of the entire contract to occur within one year of contract execution. A long-term contract is defined as one or more deliveries to occur after a year following contract execution.

In 2014, purchases under spot contracts totalled 5 590 tU, a 28% increase from the 4 363 tU purchased under spot contracts in 2013. The weighted average spot price decreased 16% from USD 114/kgU in 2013 to USD 95/kgU in 2014. The uranium purchased under long-term contracts in 2014 totalled 14 920 tU, a 16% decrease from the 17 717 tonnes purchased in 2013. The weighted average price under long-term contracts in 2014 was about USD 129/kgU, a decrease of 8% from the 2013 weighted average price of USD 140/kg.

US-origin uranium accounted for 6% of the uranium delivered in 2014. Foreign-origin uranium accounted for the remaining 94% of deliveries. Australian- and Canadian-origin uranium together accounted for 38% of deliveries. Uranium originating in Kazakhstan, Russia, and Uzbekistan accounted for 39% and the remaining 23% originated from Malawi, Namibia, Niger and South Africa.

Uranium exploration and development expenditures and drilling effort – domestic

(expenditures in USD million)

	2012	2013	2014	2015 (expected)
Industry* exploration expenditures[1]	33.3	21.6	10.7	N/A
Government exploration expenditures	0	0	0	N/A
Industry* development expenditures[2]	132.7	118.9	91.5	N/A
Government development expenditures	0	0	0	N/A
Total expenditures	**166**	**140.5**	**101.2**	**N/A**
Industry* exploration drilling (m)[3]	1 050 646	280 111	W	N/A
Industry* exploration holes drilled[4]	5 112	1 231	W	N/A
Industry exploration trenches (m)	N/A	N/A	N/A	N/A
Industry exploration trenches (number)	N/A	N/A	N/A	N/A
Government exploration drilling (m)	0	0	0	N/A
Government exploration holes drilled	0	0	0	N/A
Government exploration trenches (m)	N/A	N/A	N/A	N/A
Government exploration trenches (number)	N/A	N/A	N/A	N/A
Industry* development drilling (m)[5]	1 130 503	891 845	W	N/A
Industry* development holes drilled[6]	5 970	4 013	W	N/A
Government development drilling (m)	0	0	0	N/A
Government development holes drilled	0	0	0	N/A
Subtotal exploration drilling (m)	1 050 646	280 111	W	N/A
Subtotal exploration holes	5 112	1 231	W	N/A
Subtotal development drilling (m)	1 130 503	891 845	W	N/A
Subtotal development holes	5 970	4 013	W	N/A
Total drilling (m)	**2 181 156**	**1 171 956**	**395 935**	**N/A**
Total number of holes drilled	**11 082**	**5 244**	**1 752**	**N/A**

* Non-government. N/A = Not available.

1. Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 8, Exploration.
2. Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 8, Drilling + Land + Reclamation.
3. Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 1, Exploration, Feet (converted to metres using US EIA Uranium Industry Annual Appendix D Uranium Conversion Guide).
4. Source: US Energy Information Administration Domestic, *Uranium Production Report*, 2014, Table 1, Exploration, Number of Holes.
5. Source: US Energy Information Administration Domestic, *Uranium Production Report*, 2014, Table 1, Development Drilling.
6. Source: US Energy Information Administration Domestic, *Uranium Production Report*, 2014, Table 1, Development Drilling.

Average US uranium prices, 2000-2014

(USD per kilogram U-equivalent)

Year	Spot contracts	Long-term contracts
2014	95.26	129.29
2013	113.95	140.39
2012	132.69	144.68
2011	142.18	145.33
2010	114.36	131.11
2009	120.76	118.91
2008	174.06	108.12
2007	229.44	63.57
2006	102.64	42.59
2005	52.10	35.62
2004	38.40	31.82
2003	26.26	28.44
2002	24.15	27.51
2001	20.59	28.49
2000	22.20	30.42

Source: US Energy Information Administration, *Uranium Marketing Annual Report*, 2014, Table 7.

Reasonably assured conventional resources by deposit type

(in situ tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Unconformity-related	0	0	0	0	N/A
Sandstone	0	17 425	62 890	138 204	N/A
Intrusive	0	0	0	0	N/A
Volcanic and caldera-related	0	0	0	0	N/A
Other*	0	0	0	0	N/A
Total	**0**	**17 425**	**62 890**	**138 204**	**N/A**

* Includes surficial, collapse breccia pipe, phosphorite and other types of deposits, as well as rocks with elevated uranium content. Pegmatite, granites and black shale are not included.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 10.

Reasonably assured conventional resources by production method

(in situ tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Underground mining (UG)	0	W	W	80 199	N/A
Open-pit mining (OP)	0	W	W	See note 1	N/A
In situ leaching alkaline	0	W	W	58 005	N/A
Unspecified	0	0	0	0	N/A
Total	**0**	**17 425**	**62 890**	**138 204**	**N/A**

N/A = Not available. W = Data withheld to avoid disclosure of individual company data.

Note 1: US reserves data do not draw a distinction between UG and OP; the combined value is assigned to UG.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 10.

Reasonably assured conventional resources by processing method

(in situ tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from UG	0	N/A	N/A	N/A	N/A
Conventional from OP	0	N/A	N/A	N/A	N/A
In situ leaching acid	0	N/A	N/A	N/A	N/A
In situ leaching alkaline	0	N/A	N/A	N/A	N/A
In-place leaching*	0	N/A	N/A	N/A	N/A
Heap leaching** from UG	0	N/A	N/A	N/A	N/A
Heap leaching** from OP	0	N/A	N/A	N/A	N/A
Unspecified	0	N/A	N/A	N/A	N/A
Total	**0**	**17 425**	**62 890**	**138 204**	**N/A**

* Also known as stope leaching or block leaching. ** A subset of open-pit and underground mining, since it is used in conjunction with them. N/A = Not available.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 10.

Historical uranium production by deposit type

(tonnes U in concentrate)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Unconformity-related	N/A	N/A	N/A	N/A	N/A	N/A
Sandstone	N/A	N/A	N/A	N/A	N/A	N/A
Hematite breccia complex	N/A	N/A	N/A	N/A	N/A	N/A
Quartz-pebble conglomerate	N/A	N/A	N/A	N/A	N/A	N/A
Vein	N/A	N/A	N/A	N/A	N/A	N/A
Intrusive	N/A	N/A	N/A	N/A	N/A	N/A
Volcanic and caldera-related	N/A	N/A	N/A	N/A	N/A	N/A
Metasomatite	N/A	N/A	N/A	N/A	N/A	N/A
Other*	N/A	N/A	N/A	N/A	N/A	N/A
Total	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

* Includes surficial, collapse breccia pipe, phosphorite and other types of deposits, as well as rocks with elevated uranium content. Pegmatite, granites and black shale are not included. N/A = Not available.

Historical uranium production by production method

(tonnes U in concentrate)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Open-pit mining*	0	0	0	0	0	0
Underground mining*	N/A	W	W	W	W	N/A
In situ leaching	N/A	W	W	W	W	N/A
Co-product/by-product	N/A	W	W	W	W	N/A
Total	**235 479**	**1 667**	**1 761**	**1 889**	**240 797**	**N/A**

Note: Data not available prior to 1968. W = Data withheld to avoid disclosure of individual company data. N/A = Not available. * Pre-2008 totals may include uranium recovered by heap and in-place leaching.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 2.

Historical uranium production by processing method

(tonnes U in concentrate)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	N/A	W	W	W	W	N/A
In-place leaching*	N/A	W	W	W	W	N/A
Heap leaching**	0	0	0	0	0	N/A
In situ leaching	0	0	0	0	0	N/A
U recovered from phosphate rocks	0	0	0	0	0	N/A
Other methods***	0	0	0	0	0	N/A
Total	**367 807**	**1 595**	**1 792**	**1 881**	**373 075**	**N/A**

Note: Data are available from 1947 to present.

W = Data withheld to avoid disclosure of individual company data. N/A = Not available.

* Also known as stope leaching or block leaching.

** A subset of open-pit and underground mining, since it is used in conjunction with them.

*** Includes mine water treatment and environmental restoration.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 3.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
0	0	W	W	0	0	W	W	1 889	100

W = Data withheld to avoid disclosure of individual company data.

Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 2.

Uranium industry employment at existing production centres

(person-years)

	2012	2013	2014	2015 (expected)
Total employment related to existing production centres[1]	1 017	957	626	N/A
Employment directly related to uranium production[2]	856	808	540	N/A

1. Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 6, all sectors except Reclamation.
2. Source: US Energy Information Administration, *Domestic Uranium Production Report*, 2014, Table 6, all sectors except Exploration and Reclamation.

Short-term production capability

(tonnes U/year)

2014				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Re-enriched tails production and use[1]

(tonnes of natural U-equivalent)

Re-enriched tails	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Production	1 939.8	0	3 738.0	0	5 677.8	0
Use	1 567.1	0	372.7	0	1 939.8	0

1. Data provided by Energy Northwest, owner-operator of the Columbia Generating Station.

Net nuclear electricity generation[1]

	2013	2014
Nuclear electricity generated (TWh net)	789	797p

1. NEA (2015), *Nuclear Energy Data*, OECD, Paris. P = provisional data.

Installed nuclear generating capacity to 2035[1]

(MWe net)

2013	2014	2015		2020		2025		2030		2035	
99 200	97 900p	Low	High	Low	High	Low	High	Low	High	Low	High
		99 600	99 600	101 400	101 400	101 400	101 600	101 400	104 500	101 400	110 400

1. NEA (2015), *Nuclear Energy Data*, OECD, Paris. P = provisional data.

Annual reactor-related uranium requirements to 2035 (excluding MOX)[1]

(tonnes U)

2013	2014	2015		2020		2025		2030		2035	
22 250	18 573p	Low	High	Low	High	Low	High	Low	High	Low	High
		18 542	18 542	19 077	19 077	16 131	16 131	16 131	16 530	16 131	17 528

1. NEA (2015), *Nuclear Energy Data*, OECD, Paris. P = provisional data.

Total uranium stocks

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	LWR reprocessed uranium stocks	Total
Government[1]	12 939	5 471	30 000	N/A	48 410
Producer[2]	N/A	N/A	N/A	N/A	7 141
Utility[2]	23 645[3]	20 992[4]	N/A	N/A	44 637
Total	**N/A**	**N/A**	**N/A**	**N/A**	**100 188**

1. US Department of Energy, Excess Uranium Inventory Management Plan, July 2013.
2. US Energy Information Administration, Uranium Marketing Annual Report, 2014, Tables 22 and 23.
3. The value for natural uranium stocks in this table does not include natural uranium hexafluoride (UF_6). Values for total utility natural uranium stocks in the text include natural UF_6.
4. The value for enriched uranium stocks in this table does not include fabricated fuel elements held in storage prior to loading in the reactor. Values for total utility enriched uranium in the text include fabricated fuel elements in storage.

N/A = Not available.

Uzbekistan*

Uranium exploration

Historical review

Uranium exploration in Uzbekistan predates the 1945 start-up of uranium mining at the small vein deposits (Shakaptaz, Uiguz Sai, and others) in the Fergana Valley of Eastern Uzbekistan. Exploration, including airborne geophysical surveys, ground radiometry, underground work, etc. conducted during the early 1950s over the remote Kyzylkum desert in central Uzbekistan, led to the discovery of uranium in the Uchkuduk area. Drilling confirmed the initial discovery and development of the first open-pit mine at Uchkuduk began in 1961.

Development of the in situ leaching (ISL) mining technique for recovery of uranium from sandstone deposits in the early 1970s led to a re-evaluation of previously ignored deposits including Lavlakan and Ketmenchi, and to an increase in exploration efforts in the sedimentary environments of the Kyzylkum desert.

Since 1994, the Navoi Mining and Metallurgical Complex (NMMC) has funded all uranium exploration activities in Uzbekistan. In 1995-1996, Kyzyltepageologia developed the known resources of the Severny (North) Kanimekh, Alendy, Kendykijube and Tokhumbet deposits. In addition, assessments of undiscovered resources were done in the Kyzylkum, the Bukhara-Khiva and Fergana provinces.

Between 1997 and 2000, Kyzyltepageologia evaluated the known resources of the Kendiktyube, Severny Kanimeh, Tokhumbet and Ulus deposits. A portion of the resources of these deposits were turned over to NMMC for development.

In 2002, delineation drilling was carried out on the Kendytyube and Tokhumbet deposits. Part of the resources was transferred to Mining Division No. 5 for commercial development.

In 2003-2004, Kyzyltepageologia made exploration and evaluation works in Kendyktyube and Tokhumbet deposits, Senoman ingress which is converted into small deposit category, the south-western flanks of Sugraly deposit and the western and eastern flanks of Ketmenchi deposit. Kyzyltepageologiya explored the northern and southern areas of the Central Kyzylkum at the expense of the government.

Recent and ongoing uranium exploration and mine development activities

In August 2009, Goscomgeo (State Geology and Mineral Resources Committee) and China Guangdong Nuclear Uranium Corp. (CGN-URC) set up a 50-50 uranium exploration joint venture, Uz-China Uran, to focus on the black shale deposits in the Boztau-skaya area in the Central Kyzylkum Desert of the Navoi region. Some 5 500 tU resources are reported. Over 2011-2013, CGN-URC was to develop technology for the separate production of uranium and vanadium from these black shale deposits with a view to commencing production from them.

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[*] Report prepared by the NEA/IAEA, based on previous Red Books and public data.

In July 2013, the Japan Oil, Gas and Metals National Corporation (JOGMEC) received a five-year licence for uranium exploration at two prospective areas in the country's Navoi region. JOGMEC will implement geological exploration work in the Juzkuduk and Tamdiykuduk-Tulyantash prospective fields upon the terms of business risk for a period of five years. The minimum amount of funding for the first year of operations was USD 3 million. Uranium reserves discovered at the licensed sites total about 13 000 tonnes, according to Uzbek government data.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

All of Uzbekistan's significant resources are located in the Central Kyzylkum area, comprising a 125 km-wide belt extending over a distance of about 400 km from Uchkuduk in the northwest to Nurabad in the southeast. The deposits are located in four districts: Bukantausky or Uchkuduk, Auminza-Beltausky or Zarafshan, West-Nuratinsky or Zafarabad, and Zirabulak-Ziaetdinsky or Nurabad. Uzbekistan's uranium resources occur in sandstone-type and black shale (breccia complex-type) deposits.

As of February 2014, according to the State Committee for Geology and Mineral Resources (Goskomgeo), explored and evaluated resources of uranium in Uzbekistan amounted to 185 800 tU, of which 138 800 tU was of sandstone-type and the other 47 000 tU was of black shale-type. Based on the proven and probable resources, the Navoi GMK was expecting to continue uranium mining for the next 40 years.

Uranium production

Historical review

Uranium production in Uzbekistan began in 1946 at several small volcanic vein deposits in the Fergana valley and Kazamazar uranium district. The mines are no longer in operation and the deposits are depleted. The ore was processed in the Leninabad uranium production centre in Tajikistan.

NMMC is part of the Uzbekistani state holding company Kyzylkumredmetzoloto, and undertakes all uranium mining in the country. Before 1992, all uranium mined and milled in Uzbekistan was shipped to Russia. Since 1992, all Uzbekistani uranium production is exported and sold to the United States and other countries, by Nukem Inc.

NMMC commenced operation focused on uranium and gold at the end of the 1950s in the desert region of Central Kyzylkum province. Early uranium mining was underground (to 1990) and open pit (to 1994). Since 1994, NMMC has been producing uranium using only ISL technology.

In 2008, NMMC started mining the major new Northern Kanimekh deposit, north-west of Navoi. Northern Kanimekh ore occurs 260-600 m deep with 77% of uranium reserves present at 400-500 m depth. NMMC has also started building a pilot plant for ISL at the Alendy and Yarkuduk deposits and has started operation of the Aulbek ISL mine in Central Kyzylkum, and also the Meilysai and Tutlinskaya deposits.

Status of production capability and recent and ongoing activities

Three mining divisions produce uranium by in situ leaching:

- the Northern Mining Unit (Uchkuduk) with an annual production of 700-750 tU;
- the Southern Mining Unit (Nurabad) with an annual production of 600-650 tU;
- the Mining Unit No. 5 (Zafarabad) with an annual production of 1 000-1 200 tU.

All mining units send uranium-bearing solutions to the hydrometallurgical plant No. 1, located in Navoi, by rail for further processing. Uranium concentrates are shipped by rail to St. Petersburg, Russia for ocean transport to western convertors, to Russian conversion/enrichment facilities or to Alashankou, China for delivery to Chinese conversion facilities.

Production in 2013 and 2014 was estimated to amount to 2 400 tU and 2 690 tU, respectively.

Future projects

In 2012, the NMMC invested USD 230.5 million into modernisation of existing uranium processing facilities and was planning to invest USD 55.2 million in two new uranium mines. The first mine at the Aulbek deposit began operations in May; mine construction was continuing, however, and the second stage was expected to be completed in 2013. The total cost of construction was expected to be USD 20.9 million, of which USD 8.9 million would be spent in 2012. Construction of another new mine at the North Kanimekh deposit started in 2012 and was expected to be finished in 2013; the total cost of the project was estimated to be USD 34.3 million. The ores of the two new mines had higher carbonate content and were located deeper underground than were existing mines operated by NMMC.

In April 2015, NMMC announced plans approved by the government to implement 27 projects to modernise its production facilities by 2019, at a total cost of USD 985 million. Among the projects are the construction of a mining and distribution complex in Samarkand region, the development of the main raw material base – the Muruntau mine – and the modernisation and technical re-equipment of other production facilities. NMMC's four metallurgical plants in Navoi, Zarafshan, Uchkuduk and Zarmitan were mentioned.

In 2015, Uzbekistan's Navoi Mining and Metallurgical Plant (NMMP) was planning to complete the construction of three uranium mines in the Central Kyzylkum Desert, at a cost of USD 75 million. Completion of the Alendy, Aulbek and North Kanimekh mines would allow increasing uranium production at NMMP by 40%. More recently, International Mining (2016) outlined that a uranium production development programme has been developed and is being implemented for the period of 2014-2020. According to this programme, Kendyktyube, Lyavlyakan, Tohumbet, Aksay, Sugrali, Nurbulok, Alendy and Aulbek deposits have been put into operation, the North Kanimekh deposit was brought up to its designed production capacity and uranium mining technology at the Maylisay deposit was optimised.

Ownership structure of the uranium industry

The entire uranium production of the Navoi Mining and Metallurgical Integrated Works (NMMIW) is owned by the government of Uzbekistan.

Employment in the uranium industry

During the Soviet era, Uzbekistan provided much of the uranium to the Soviet military-industrial complex. Five "company towns" were constructed to support uranium production activities: Uchkuduk, Zarafshan, Zafarabad, Nurabad, and Navoi, with a combined population of some 500 000. They remain centres of five mining districts. Uranium industry employment in 2005 was estimated at about 7 000, though some 59 000 were employed by NMMC overall in 2015, including gold mining and other activities (Navoi Mining and Metalurgical Combinat, 2015).

Uranium policies, uranium stocks and uranium prices

Until 1992, all uranium produced in Uzbekistan was shipped to Russia. From 1992 through 2013, practically all Uzbekistan's uranium production has been exported to the United States and other countries through Nukem company. In 2008, Korea's Kepco signed agreements to purchase 2 600 tU over six years to 2015, for about USD 400 million. In 2013, 1 663 tU was supplied to China according to the country's custom import statistics. In May 2014, China's CGN agreed to buy USD 800 million of uranium through to 2021. According to the Indian press, Uzbekistan state-owned NMMC has signed a contract to supply 2 000 tU to India from 2014 through 2018.

Reasonably assured conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone	36 900	36 900	54 600	54 600	70

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
In situ leaching acid	36 900	36 900	54 600	54 600	70

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
In situ leaching acid	36 900	36 900	54 600	54 600	70

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Sandstone	21 280	21 280	42 560	42 560	70
Black shales	0	0	32 900	32 900	70
Total	**21 280**	**21 280**	**75 460**	**75 460**	**70**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
In situ leaching acid	21 280	21 280	42 560	42 560	70
Black shales	0	0	32 900	32 900	70
Total	**21 280**	**21 280**	**75 460**	**75 460**	**70**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
In situ leaching acid	21 280	21 280	42 560	42 560	70
Black shales	0	0	32 900	32 900	70
Total	**21 280**	**21 280**	**75 460**	**75 460**	**70**

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
24 800	24 800	24 800

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
0	0	0

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2011	2015 (expected)
Open-pit mining*	36 249	0	0	0	36 249	0
Underground mining*	19 719	0	0	0	19 719	0
In situ leaching	65 270	2 400	2 400	2 700	72 770	2 400
Total	**121 238**	**2 400**	**2 400**	**2 700**	**128 738**	**2 400**

* Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Ownership of uranium production in 2014

Domestic				Foreign				Totals	
Government		Private		Government		Private			
(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)	(tU)	(%)
2 700	100	0	0	0	0	0	0	2 700	100

Short-term production capability

(tonnes U/year)

2015				2020				2025			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
2 400	2 400	2 400	2 400	2 700	2 700	2 700	2 700	3 000	3 000	3 000	3 000

2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000

Viet Nam

Uranium exploration and mine development

Historical review

The first exploration programmes were started prior to 1955 by French geologists of the Geological Department of Indochina. Beginning in 1978, a systematic regional exploration programme was conducted over the entire country using radiometric methods combined with geological observations. About 25% of the country was also covered by an airborne radiometric/magnetic survey at a scale of 1:25 000 and 1:50 000. This led to the discovery of a large number of promising areas in the provinces of Cao Bang, Lao Cai, Yen Bai and Quang Nam. Uranium mineralisation in Viet Nam is associated with rare earth deposits (Lao Cai province), phosphate deposits (Cao Bang province), and sandstone and coal deposits (Quang Nam province).

Between 1997 and 2002, the Geological Division for Radioactive and Rare Elements (GDRRE) carried out detailed uranium exploration and evaluation (including drilling, trenching and bulk sampling) in the Palua and Parong areas of the Quang Nam province.

Recent and ongoing uranium exploration and mine development activities

Since 2010, the GDRRE in the Ministry of Natural Resources and Environment has been carrying out uranium exploration in the Parong area in the Quang Nam province in central Viet Nam. The project consists of an investigation and evaluation of Triassic sandstone-type deposits.

Exploration activities on the Parong deposit, covering an area of 1.9 km^2, consist of geophysical and geological surveys, trenching, drilling and mining tests. Over the main part of the deposit, 712 holes (60 954 m) have been drilled on a 25 x 25 m^2 grid to depths of between 30 and 150 m. Extensions of the deposit have also been drilled on a more widely spaced grid (between 50 x 50 m^2 and 50 x 25 m^2).

A mining test was conducted via a 130 m adit from which 3 holes have been drilled to 300 m for hydrogeological tests. Results show a limited amount of water in the formations.

Mineralisation at Parong is associated with medium coarse-grained sandstone with organic matter. Three main levels of mineralisation in reduced formations have been defined, separated by oxidised sandstone. Mineralisation over a lateral extension of 200-300 m has been intersected that varies in thickness from a few centimetres to a few metres.

In support of this exploration project, research on leaching ore treatment methods, laboratory and pilot-scale tests, as well as investigations on the management of mining wastes and tailings have been carried out by the Institute for Technology of Radioactive and Rare Elements. The results show that the heap leach method is suitable for the low-grade Parong ore, with uranium recovery greater than 75% achieved.

Uranium resources

Identified conventional resources

In 2011-2012, the uranium potential of part "A" of the Parong area (drilled at a 25 x 25 m^2 grid) was assessed. Uranium resources, estimated using a 0.0085% U cut-off grade, amount to 1 200 tU at an average grade of 0.034% U. These resources can be classified as reasonably assured resources in the highest cost category (<USD 260/kgU or <USD 100/lb U_3O_8).

In 2013-2015, the uranium potential of part "G" of the Parong-Palua area was assessed. Inferred uranium resources are estimated at 1 081 tU.

Currently, estimation of the uranium potential of remaining parts "B", "C", "D" and "F" of the Palua-Parong is continuing.

Results of a previous evaluation (uranium resources as of 31 December 2008) in the main area of the Quang Nam province concluded that:

- the Palua deposit consists of five orebodies with total resources amounting to 4 596 tU, including 984 tU inferred resources;
- the Parong deposit consists of seven orebodies with total resources amounting to 3 867 tU, including 1 200 tU of inferred;
- the Khehoa-Khecao deposit consists of four orebodies with total resources amounting to 5 803 tU, including 1 125 tU inferred;
- the Dong Nam Ben Giang deposit consists of eight orebodies with total resources amounting to 1 556 tU, including 337 tU inferred;
- resources of the An Diem deposit amount to 1 853 tU, including 354 tU inferred.

Undiscovered conventional resources (prognosticated and speculative resources)

The results of geological exploration, which have been conducted by the GDRRE, shows that there are more than ten uranium occurrences and deposits located in the northern provinces (Lai Chau, Lao Cai, Yen Bai, Son La, Ha Giang, Cao Bang, PhuTho and Thai Nguyen), in the highlands and in the central provinces.

Uranium deposits located in the Lai Chau province are associated with rare earth deposits. In the Cao Bang province, uranium mineralisation is associated with phosphate deposits, and in the Quang Nam province uranium is associated with sandstones and in coal deposits.

The undiscovered conventional uranium resources as of 31 December 2008 amounted to a total of 81 200 tU prognosticated and 321 600 tU speculative resources. Some of the prognosticated resources includes: 3 612 tU at Palua; 2 667 tU at Parong; 4 678 tU at Khehoa-Khecao; 1 219 tU at Dong Nam Ben Giang; and 1 499 tU at An Diemand.

Uranium production

No uranium has been produced in Viet Nam.

Future production centres

The objective of the current "Uranium Exploration Project" is to increase the resource base to a total of 5 500 tU_3O_8 (4 665 tU) inferred and 8 000 tU_3O_8 (6 780 tU) prognosticated, as well as determining the feasibility of mining these deposits. The Institute for Technology of Radioactive and Rare Elements has carried out research on ore processing and has started to survey the environmental conditions of future mining operations. As of 31 December 2012, no production centre is planned.

Environmental activities and socio-cultural issues

Environmental activities, such as monitoring the environmental impacts resulting from exploration, are being carried out.

Uranium requirements

Viet Nam has a plan to develop a nuclear power plant that is expected to include 14 nuclear units with a total net nuclear electricity generating capacity of about 15 000 MWe to 16 000 MWe by the year 2030. To date, seven sites for the construction of NPP have been selected with each site having the potential to accommodate four to six units.

In March 2010, the Prime Minister of Viet Nam approved the overall plan for the implementation of the NinhThuan Nuclear Power Project, which includes the PhuocDinh and Vinh Hai NPPs.

Under this plan, the first nuclear plant will consist of two VVER-type PWRs with a total net nuclear electricity generating capacity of about 2 000 MWe, to be built in co-operation with Rosatom. This plant will be located in the PhuocDinh commune, Thuan Nam district, NinhThuan province. The second nuclear plant, built in co-operation with Japan Atomic Power Co. is to have the same generating electricity capacity (2 x 1 000 MWe) and will be located in the Vinh Hai commune, Ninh Hai district, NinhThuan province. The expected annual reactor-related uranium requirements will be satisfied by imports and by domestic production.

However, because of the economic crisis, leading to an overall slowdown in economic growth including growth in electricity, the Viet Nam government has reconsidered and adjusted plans to build a nuclear power plant. Consequently, the construction of the first nuclear plant will be delayed for years.

Uranium exploration and development expenditures and drilling effort –domestic

(Vietnamese dong)

	2010	2011	2012	2013	2014	2015
Industry* exploration expenditures	-	-	-	-		
Government exploration expenditures	59 488 000 000	110 648 637 600	35 476 771 200	30 000 000 000	40 000 000 000	57 000 000 000
Total expenditures	**59 488 000 000**	**110 648 637 600**	**35 476 771 200**	**30 000 000 000**	**40 000 000 000**	**57 000 000 000**
Government exploration drilling (m)	26 086.2	34 867.5	0	N/A	N/A	N/A
Government exploration holes drilled	298	414	0	N/A	N/A	N/A
Total drilling (m)	**26 086.2**	**34 867.5**	**0**	**N/A**	N/A	N/A
Total number of holes drilled	**298**	**414**	**0**	**N/A**	N/A	N/A

* Non-government.

1 USD = 21 500 Vietnamese dong.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	0	1 200
Total	**0**	**0**	**0**	**1 200**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Underground mining (UG)	0	0	0	1 200
Total	**0**	**0**	**0**	**1 200**

* In situ resources.

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Heap leaching* from UG	0	0	0	1 200
Total	**0**	**0**	**0**	**1 200**

* A subset of open-pit and underground mining, since it is used in conjunction with them.

Inferred conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone	0	0	0	4 000
Total	**0**	**0**	**0**	**4 000**

* In situ resources.

Inferred conventional resources by production method

(tonnes U*)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	4 000
Total	**0**	**0**	**0**	**4 000**

* In situ resources.

Inferred conventional resources by processing method

(tonnes U*)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Unspecified	0	0	0	4 000
Total	**0**	**0**	**0**	**4 000**

* In situ resources.

Prognosticated conventional resources

(tonnes U)

Cost ranges		
<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
N/A	N/A	81 200

Speculative conventional resources

(tonnes U)

Cost ranges		
<USD 130/kgU	<USD 260/kgU	Unassigned
N/A	N/A	321 600

Expected installed nuclear generating capacity to 2035

(MWe net)

2020		2025		2030		2035	
Low	High	Low	High	Low	High	Low	High
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Expected annual reactor-related uranium requirements to 2030

(tonnes U)

2020		2025		2030		2035	
Low	High	Low	High	Low	High	Low	High
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Zambia*

Uranium exploration and mine development

Historical review

Uranium was first observed in Zambia (then Northern Rhodesia) at the site of the Mindola copper mine in Kitwe, leading to the mining of this small deposit between 1957 and 1959. A total of 102 tU_3O_8 (86 tU) was produced. Although no uranium has been produced from that mine or from Zambia since then, exploration activity has been carried out periodically by the government and by private companies.

Sporadic uranium exploration activities took place during the 1990s but primary attention was focused on copper. It was only in the mid-2000s that interest in uranium was stimulated by the dramatic rise in the spot market price for uranium.

The exploration environment in Zambia underwent a fundamental change in 1969. Prior to this date, all mineral rights were held privately, but in 1969 these rights reverted to the state. In 1969, the state also effectively nationalised mining by becoming a majority shareholder in all mining companies active in the country (principally copper). Financial realities, including a decline in copper prices, along with recommendations from external bodies such as the World Bank and International Monetary Fund, encouraged the state to enter into a process of privatisation. This became a reality in 1997 with the primary objective of encouraging foreign investment in the country.

Recent and ongoing uranium exploration and mine development activities

Denison completed extensive drilling in 2011 and 2012 on their Mutanga Project and updated the resource estimate to 18 923 tU at an average grade of 252 ppm U (0.0252% U). Airborne geophysics techniques were used to locate anomalies and potential uranium mineralisation. Near-surface mineralisation at Dibwe East zones 1 and 2 is consistent over 4 km, with high-grade ore in its core. Future exploration activities are expected to be focused on field programmes including extensive surficial geochemistry and surface radon surveys, geological mapping and airborne geophysics all of which will be used to assist in defining drill targets.

In September 2013, Denison confirmed the resources for the whole Mutanga Project (Mutanga and Dibwe deposits) as 770 tU of measured resources, 2 235 tU of indicated resources and 16 000 tU of inferred resources. In mid-2011, Equinox Minerals was taken over by Barrick Gold Corp. for CAD 7.3 billion. At that time, a total of 4.2 Mt of uraniferous ore at a grade of 0.118% U_3O_8 (0.1% U) was stockpiled at the Lumwana copper mine which could be processed at a later date if Barrick decides to build a uranium mill for an estimated cost of USD 200 to 230 million. In 2012, drilling programmes at Lumwana were focused on resource definition at Chimiwungo, reserve delineation at Chimiwungo and Malundwe, extension exploration drilling at Chimiwungo and condemnation drilling to test for economic mineralisation in areas of planned mining infrastructure. A total of 237 277 m of diamond drilling and 49 029 m of reverse circulation drilling was completed during 2012 in order to better define the limits of mineralisation and develop an updated,

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* Report prepared by the NEA/IAEA, based on previous Red Books and company reports.

more comprehensive block model of the ore body for mine planning purposes. Total resources, including the uranium ore stockpiled at Malundwe, amounted to 7 492 tU at an average grade of 0.07% U. However, the ore body did not meet economic expectations. The drilling defined significant additional mineralisation, some at higher grades. However, much of this mineralisation was deep and would therefore require a significant amount of waste stripping, making it uneconomic based on the expected operating costs and current market copper prices. Activity continues on a number of key initiatives to lower costs, including improvements to operating systems and processes.

At the end of 2012, African Energy concluded baseline environmental studies for the Chirundu uranium project, the only work completed by African Energy on its uranium projects. The Chirundu Project near the Zimbabwe border is focused on exploring the Njame and Gwabe deposits and reports 4 270 tU as measured, indicated and inferred resources. A mining licence was granted for the project in October 2009, with a view to a 500 tU/yr acid heap leach operation. It includes the Siamboka prospect. A feasibility study was commenced but then deferred because of low uranium prices. The company is also exploring the Chisebuka deposit, 250 km along strike south-west.

Uranium resources

Identified conventional resources (reasonably assured and inferred resources)

Only three properties in Zambia have reached the stage of development where NI 43-101 or JORC compliant resources have been published. Denison's Mutanga Project has a total of 75.4 Mt of measured, indicated and inferred ore at a grade of 0.025% U containing 18 923 tU including inferred resources at Dibwe East. African Energy's Chirundu Project, adjacent to Mutanga, has total measured, indicated and inferred resources of 18.7 Mt at a grade of 0.023% containing 4 270 tU. The third is the Lumwana copper mine, where resources are hosted by mica-quartz-kyanite schists of the Katangan Supergroup. Measured, indicated and inferred resources of 7 492 tU are contained within 11.2 Mt of ore.

Potential for the discovery of additional uranium resources exists in various parts of the country that have been poorly explored. Of particular interest is the Copperbelt where many copper orebodies have known associated uranium mineralisation.

Uranium production

Historical review

A total of 102 tU_3O_8 (86 tU) was produced at the Mindola mine in Kitwe during the late 1950s. Production ceased in 1960 and no uranium has been produced since.

Uraniferous ore was stockpiled at Lumwana while mining the higher-grade Malundwe copper deposit. As of March 2011, the stockpile amounted to 4.2 Mt of ore grading at 0.1% U.

Future projects

Denison Mines of Canada is planning to develop a USD 118 million project at Mutanga, when uranium prices have improved to >USD 65/lb. Following successful licence renewal, a feasibility study has been undertaken for an open-pit mine with acid heap leaching. The project is licensed with a 25-year mining licence, environmental approval and radioactive materials licence. The Mutanga pit would be 750 x 550 m and the Dibwe pit 10 km south-west, would be 1 500 x 300 m.

Uranium production centre technical details

(as of 1 January 2015)

	Centre #1	Centre #2
Name of production centre	Lumwana	Mutanga
Production centre classification	Planned	Planned
Date of first production (year)	N/A	N/A
Source of ore:		
Deposit name(s)	Malundwe-Chimiwungo	Dibwe-Mutanga
Deposit type(s)	Metasomatic (metamorphosed schists)	Sandstone
Recoverable resources (tU)	7 492	18 923
Grade (% U)	0.07	0.025
Mining operation:		
Type (OP/UG/ISL)	OP	OP
Size (tonnes ore/day)	2 800	N/A
Average mining recovery (%)	N/A	N/A
Processing plant:		
Acid/alkaline	Acid	Acid
Type (IX/SX)	SX	HL
Size (tonnes ore/day)		
Average process recovery (%)	93.1	N/A
Nominal production capacity (tU/year)	650	N/A
Plans for expansion (yes/no)		
Other remarks	Mine currently operated by Barrick: uranium bankable feasibility study completed by Equinox Minerals	Mine construction on hold until uranium price increases

Environmental activities and socio-cultural issues

Environmental impact assessments

African Energy has completed environmental baseline studies on their Chirundu Project near the Zimbabwe border, including the Njame and Gwabe deposits.

Waste rock management

Equinox Minerals' original plans in 2003 were to excavate, stockpile and return the uraniferous ore to the Malundwe pit at the Lumwana copper mine, following completion of mining, as it was considered uneconomic at the time to recover the uranium. However, in 2006, with a uranium spot price in excess of USD 50 lb/U_3O_8 (USD 130/kgU), the project was re-evaluated. In January 2011, Equinox Minerals reported that the portion of the stockpile containing 0.09% U and 0.8% Cu may be treated at a later date, if and when a uranium plant is built. The stockpile is currently classified and expensed as "waste" in the copper project.

Environmental activities and socio-cultural issues

The Mines and Minerals Development Act (1995) makes provision for the preparation of a project brief when applying for a mining licence. This must include an environmental impact statement detailing all potential impacts of the project. Annual environmental audits must be carried out to ensure compliance and contributions must be made to an environmental management fund for rehabilitation.

Local inhabitants around the Mutanga Project were involved in public hearings organised by the Environmental Council of Zambia. Agreements were reached regarding the displacement of 107 families in 2 villages to allow for the construction of the mine infrastructure.

African Energy assisted the construction of a community health post at Sikoongo Village near their Chirunda Project.

Barrick have invested in a wide range of sustainable development initiatives in 2012, including funding for infrastructure (such as schools and health centres), literacy and agricultural programmes, community sports and recreation, and an initiative to provide microcredit and small business loans to women.

Uranium requirements

Zambia has no nuclear generating capacity and no formal development plans.

Uranium policies, uranium stocks and uranium prices

National policies relating to uranium

Mining activities in general were regulated by the Mines and Minerals Act (1995), but until recently there was no legislation specifically relating to exploration for and mining of uranium. The act was repealed in 2008 following widespread criticism of what was perceived to be excessive scope for granting tax concessions. This act was replaced by the Mines and Minerals Development Act 2008, which ruled that no special agreements should be entered into by the government for the development of large-scale mining licences. It also effectively ended development agreements concluded under the previous act. The Mines and Minerals Development (Prospecting, Mining and Milling of Uranium Ores and Other Radioactive Mineral Ores) and Regulations of 2008 deal with the mining, storage and export of uranium. Mining and export licences will only be granted when the Radiation Protection Authority is satisfied that the operations pose no environmental and health hazards. Applicants for export licences will also have to prove the authenticity of the importers in terms of IAEA guidelines.

A study by the Council of Churches concluded that current legislation and enforcement was inadequate for uranium mining. They recommended that current regulations be revised to address the concerns of local communities and that educational and awareness programmes be initiated prior to any uranium exploration and mining activities.

In 2011, Zambia and Finland signed co-operating projects aimed at helping the southern African nation review regulations on uranium mining as well as the management of the mineral. The two projects are aimed at evaluating current regulations on uranium and other radioactive minerals as well as developing a modern geo-information infrastructure. These projects are designed to help the country evaluate, update and review regulations regarding the safety of uranium mining.

Reasonably assured conventional resources by deposit type

(tonnes U*)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone			5 846	5 846
Metasomatite			6 469	6 469
Total			**12 315**	**12 315**

* In situ resources.

Reasonably assured conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			12 315	12 315	In situ
Total			**12 315**	**12 315**	**In situ**

Reasonably assured conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			12 315	12 315	In situ
Total			**12 315**	**12 315**	**In situ**

Inferred conventional resources by deposit type

(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Sandstone			17 385	17 385
Metasomatite			1 023	1 023
Total			**18 408**	**18 408**

Inferred conventional resources by production method

(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Open-pit mining (OP)			18 408	18 408	In situ
Total			**18 408**	**18 408**	**In situ**

Inferred conventional resources by processing method

(tonnes U)

Processing method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU	Recovery factor (%)
Conventional from OP			18 408	18 408	In situ
Total			**18 408**	**18 408**	**In situ**

Historical uranium production by deposit type

(tonnes U in concentrates)

Deposit type	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Metasomatite	86	0	0	0	86	0
Total	**86**	**0**	**0**	**0**	**86**	**0**

Historical uranium production by production method

(tonnes U in concentrates)

Production method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Underground mining[1]	86	0	0	0	86	0
Total	**86**	**0**	**0**	**0**	**86**	**0**

1. Pre-2010 totals may include uranium recovered by heap and in-place leaching.

Historical uranium production by processing method

(tonnes U in concentrates)

Processing method	Total through end of 2011	2012	2013	2014	Total through end of 2014	2015 (expected)
Conventional	86	0	0	0	86	0
Total	**86**	**0**	**0**	**0**	**86**	**0**

Short-term production capabilities

(tonnes U/year)

2013				2015				2020			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	0	0	0	0	0

2025				2030				2035			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
0	0	0	0	0	0	0	650	0	0	0	650

Appendix 1. List of reporting organisations and contact persons

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IAEA	International Atomic Energy Agency, Division of Nuclear Fuel Cycle and Waste Technology, Vienna Contact person: Ms Adrienne Hanly *(Scientific Secretary)*
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Appendix 2. Members of the Joint NEA-IAEA Uranium Group participating in 2014-2015 meetings

NEA	Ms L. Grancea *(Scientific Secretary)*	Division of Nuclear Development, Paris
IAEA	Ms A. Hanly *(Scientific Secretary)*	Division of Nuclear Fuel Cycle and Waste Technology, Vienna
Algeria	Mr A. Khaldi Mr S. A. Mokhtar	Centre de Recherche Nucléaire de Draria, Draria
Angola	Mr J. M. Sucumula Diogo	Autoridade Reguladora de Energia Atomica, Yerevan
Australia	Mr A. Barrett Mr A. Cross	Geoscience Australia, Canberra
Belgium	Mr H. De Baenst Mr R. Leclère Ms F. Renneboog	Synatom S.A., Brussels
Brazil	Mr L. Filipe Da Silva	Indústrias Núcleares do Brasil INB-S/A, Rio de Janeiro
Bulgaria	Ms I. Ivanova	Ministry of Energy, Sofia
Canada	Mr T. Calvert *(Vice-chair)* Mr E. Potter	Natural Resources Canada, Ottawa

China	Mr W. Cong	China National Nuclear Corporation, Beijing
	Mr Z. Xigang	China Nuclear Development Corporation, Beijing
Czech Republic	Mr P. Vostarek	DIAMO, State Enterprise, Stráž pod Ralskem
Denmark	Ms K. Thrane	Geological Survey of Denmark and Greenland, Copenhagen
Egypt	Mr A. Assran Mr H. M. A. Abdalla Mr K. Mohamed	Nuclear Materials Authority, Cairo
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France	Mr P. Bongiovanni	Électricité de France, Saint-Denis
	Ms S. Gabriel	Commissariat à l’énergie atomique et aux énergies alternatives, Gif-sur-Yvette
	Mr C. Polak *(Vice-chair)*	AREVA, Paris
Germany	Mr M. Schauer	Federal Institute for Geoscience and Natural Resources, Hannover
India	Mr P. S. Parihar	Department of Atomic Energy, Hyderabad
Indonesia	Mr A. Sumaryanto	National Nuclear Energy Agency, Jakarta
Iran, Islamic Republic of	Mr M. R. Ghaderi Mr A. K. Samani	Atomic Energy Organisation of Iran, Tehran
Iraq	Mr A. A. Hameed	Iraqi National Monitoring, Bagdad

Jordan	Mr K. El-Kaysi	Jordan Energy Resources Incorporation, Amman
Kazakhstan	Mr A. Abdrakhmanov	Joint Venture South Mining and Chemical Company, Almaty
	Ms O. Gorbatenko *(Vice-chair)*	National Atomic Company "KAZATOMPROM", Astana
Mali	Mr E. Thera	Direction Nationale de la Geologie et des Mines, Bamako
Mozambique	Mr M. L. Chenene	National Atomic Energy Agency, Maputo
Namibia	Ms H. Itamba Mr E. Shivolo	Ministry of Mines and Energy, Windhoek
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	Mr M. Naeem	Pakistan Atomic Energy Commission, Islamabad
Poland	Ms G. Zakrzewska-Koltuniewicz	Institute of Nuclear Chemistry and Technology, Warsaw
Romania	Mr D. Constantin Adam Mr A. Voicu	National Uranium Company, Bucharest
	Ms L. Pop	National Commission for Nuclear Activities Control, Bucharest
Russia	Mr A. Boytsov *(Vice-chair)*	Uranium One, Toronto
	Mr A. Tarkhanov	State Atomic Energy Corp. (Rosatom), Moscow
Senegal	Mr M. Kanoute	Ministry of Energy et Renewable Energy Development, Dakar
South Africa	Mr A. O. Kenan	Council for Geoscience, Pretoria

Spain	Mr F. T. Garcia	ENUSA Industrias Avanzadas, S.A., Madrid
Tajikistan	Mr J. Misratov	Nuclear and Radiation Safety Agency of the Academy of Sciences, Dushanbe
Turkey	Mr H. Agrili Mr M. S. Turudu	General Directorate of Mineral Research and Exploration, Ankara
Ukraine	Mr A. Bakarzhiyev Mr Y. Bakarzhiyev	The State Geological Enterprise "Kirovgeology", Kiev
United States	Ms S. Hall *(Chair)* Mr M. J. Mihalasky	US Geological Survey, Denver
Viet Nam	Mr V. L. Than	Institute for Technology of Radioactive and Rare Elements, Hanoi
European Commission	Mr D. Kozak	Euratom Supply Agency, Luxembourg

Appendix 3. Glossary of definitions and terminology

Units

Metric units are used in all tabulations and statements. Resources and production quantities are expressed in terms of tonnes (t) contained uranium (U) rather than uranium oxide (U_3O_8).

1 short ton U_3O_8 = 0.769 tU
1% U_3O_8 = 0.848% U
1 USD/lb U_3O_8 = USD 2.6/kg U
1 tonne = 1 metric ton

Resource terminology

Resource estimates are divided into separate categories reflecting different levels of confidence in the quantities reported. The resources are further separated into categories based on the cost of production.

Definitions of resource categories

Uranium resources are broadly classified as either conventional or unconventional. Conventional resources are those that have an established history of production where uranium is a primary product, co-product or an important by-product (e.g. from the mining of copper and gold). Very low-grade resources or those from which uranium is only recoverable as a minor by-product are considered unconventional resources.

Conventional resources are further divided, according to different confidence levels of occurrence, into four categories. The correlation between these resource categories and those used in selected national resource classification systems is shown in Figure A3.1.

Reasonably assured resources (RAR) refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered within the given production cost ranges with currently proven mining and processing technology, can be specified. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. Reasonably assured resources have a high assurance of existence. Unless otherwise noted, RAR are expressed in terms of quantities of uranium recoverable from mineable ore (see: recoverable resources).

Inferred resources (IR) refers to uranium, in addition to RAR, that is inferred to occur based on direct geological evidence, in extensions of well-explored deposits, or in deposits in which geological continuity has been established but where specific data, including measurements of the deposits, and knowledge of the deposit's characteristics, are considered to be inadequate to classify the resource as RAR. Estimates of tonnage, grade and cost of further delineation and recovery are based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR. Unless otherwise noted, inferred resources are expressed in terms of quantities of uranium recoverable from mineable ore (see: recoverable resources).

Figure A3.1. Approximate correlation of terms used in major resources classification systems

<table>
<tr><th></th><th colspan="3">Identified resources</th><th colspan="3">Undiscovered resources</th></tr>
<tr><td>NEA/IAEA</td><td colspan="2">Reasonably assured</td><td>Inferred</td><td>Prognosticated</td><td colspan="2">Speculative</td></tr>
<tr><td rowspan="2">Australia</td><td colspan="2">Demonstrated</td><td rowspan="2">Inferred</td><td colspan="3" rowspan="2">Undiscovered</td></tr>
<tr><td>Measured</td><td>Indicated</td></tr>
<tr><td>Canada (NRCan)</td><td>Measured</td><td>Indicated</td><td>Inferred</td><td>Prognosticated</td><td colspan="2">Speculative</td></tr>
<tr><td>United States (DOE)</td><td colspan="2">Reasonably assured</td><td colspan="2">Estimated additional</td><td colspan="2">Speculative</td></tr>
<tr><td>Russia, Kazakhstan, Ukraine, Uzbekistan</td><td>A + B</td><td>C1</td><td>C2</td><td>P1</td><td>P2</td><td>P3</td></tr>
</table>

The terms illustrated are not strictly comparable as the criteria used in the various systems are not identical. “Grey zones” in correlation are therefore unavoidable, particularly as the resources become less assured. Nonetheless, the chart presents a reasonable approximation of the comparability of terms.

Work to align the NEA/IAEA and national resource classification systems outlined above with the United Nations Framework Classification system remains under consideration. (For a summary of recent efforts, see: www.unece.org/fileadmin/DAM/energy/se/pdfs/egrc/egrc5_apr2014/ECE.ENERGY.GE.3.2014.L1_e.pdf.)

Prognosticated resources (PR) refers to uranium, in addition to inferred resources, that is expected to occur in deposits for which the evidence is mainly indirect and which are believed to exist in well-defined geological trends or areas of mineralisation with known deposits. Estimates of tonnage, grade and cost of discovery, delineation and recovery are based primarily on knowledge of deposit characteristics in known deposits within the respective trends or areas and on such sampling, geological, geophysical or geochemical evidence as may be available. Less reliance can be placed on the estimates in this category than on those for inferred resources. Prognosticated resources are normally expressed in terms of uranium contained in mineable ore, i.e. in situ quantities.

Speculative resources (SR) refers to uranium, in addition to prognosticated resources, that is thought to exist, mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. The location of deposits envisaged in this category could generally be specified only as being somewhere within a given region or geological trend. As the term implies, the existence and size of such resources are speculative. SR are normally expressed in terms of uranium contained in mineable ore, i.e. in situ quantities.

Cost categories

The cost categories, in United States dollars (USD), used in this report are defined as: <USD 40/kgU, <USD 80/kgU, <USD 130/kgU and <USD 260/kgU. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant.

Note: It is not intended that the cost categories should follow fluctuations in market conditions.

Conversion of costs from other currencies into USD is done using an average exchange rate for the month of June in that year except for the projected costs for the year of the report.

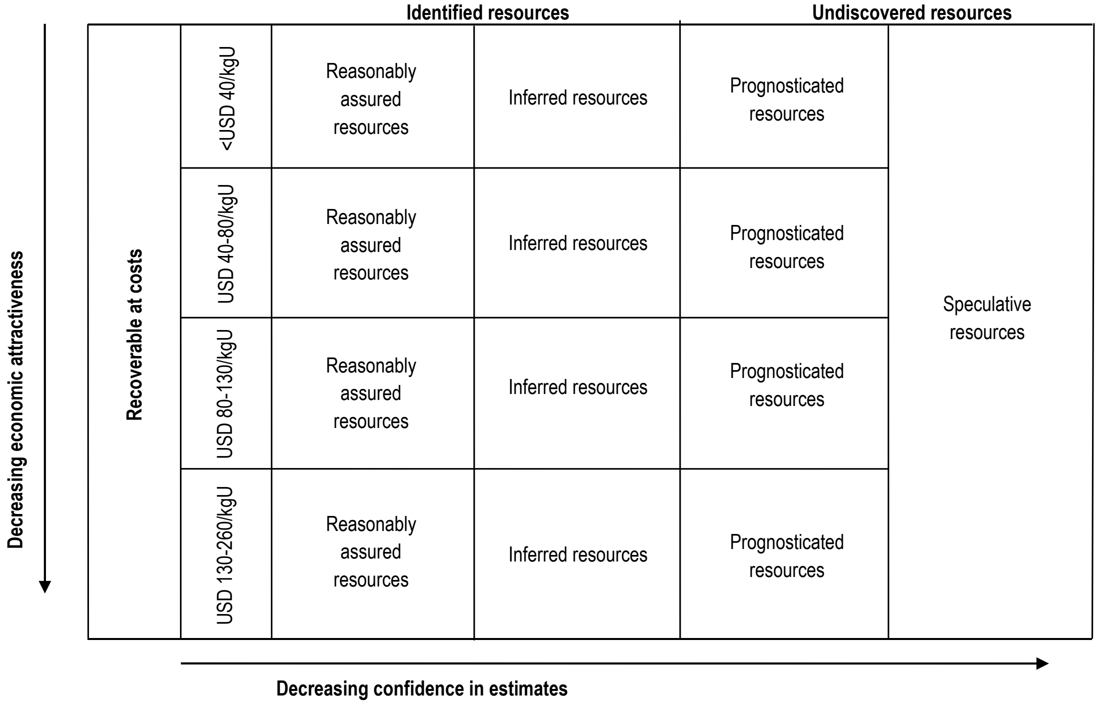
When estimating the cost of production for assigning resources within these cost categories, account has been taken of the following costs:

- the direct costs of mining, transporting and processing the uranium ore;
- the costs of associated environmental and waste management during and after mining;
- the costs of maintaining non-operating production units where applicable;
- in the case of ongoing projects, those capital costs that remain non-amortised;
- the capital cost of providing new production units where applicable, including the cost of financing;
- indirect costs such as office overheads, taxes and royalties where applicable;
- future exploration and development costs wherever required for further ore delineation to the stage where it is ready to be mined;
- sunk costs are not normally taken into consideration.

Relationship between resource categories

Figure A3.2 illustrates the inter-relationship between the different resource categories. The horizontal axis expresses the level of assurance about the actual existence of a given tonnage based on varying degrees of geologic knowledge while the vertical axis expresses the economic feasibility of exploitation by the division into cost categories.

Figure A3.2. NEA/IAEA classification scheme for uranium resources



		Identified resources		Undiscovered resources	
Recoverable at costs	<USD 40/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources	Speculative resources
	USD 40-80/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources	
	USD 80-130/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources	
	USD 130-260/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources	

Recoverable resources

RAR and IR estimates are expressed in terms of recoverable tonnes of uranium, i.e. quantities of uranium recoverable from mineable ore, as opposed to quantities contained in mineable ore, or quantities in situ, i.e. not taking into account mining and milling losses. Therefore both expected mining and ore processing losses have been deducted in most cases. If a country reports its resources as in situ and the country does not provide a recovery factor, the NEA/IAEA assigns a recovery factor to those resources based on geology and projected mining and processing methods to determine recoverable resources. The recovery factors that have been applied are:

Mining and milling method	Overall recovery factor (%)
Open-pit mining with conventional milling	80
Underground mining with conventional milling	75
In situ leaching (acid)	75
In situ leaching (alkaline)	70
Heap leaching	70
Block and stope leaching	75
Co-product or by-product	65
Unspecified method	75

Secondary sources of uranium terminology

Mixed oxide fuel (MOX): MOX is the abbreviation for a fuel for nuclear power plants that consists of a mixture of uranium oxide and plutonium oxide. Current practice is to use a mixture of depleted uranium oxide and plutonium oxide.

Depleted uranium: Uranium where the ^{235}U assay is below the naturally occurring 0.7110%. Natural uranium is a mixture of three isotopes, uranium-238 – accounting for 99.2836%, uranium-235 – 0.7110%, and uranium-234 – 0.0054%. Depleted uranium is a by-product of the enrichment process, where enriched uranium is produced from initial natural uranium feed material.

Production terminology[1]

Production centres

A production centre, as referred to in this report, is a production unit consisting of one or more ore processing plants, one or more associated mines and uranium resources that are tributary to these facilities. For the purpose of describing production centres, they have been divided into four classes, as follows:

- *Existing* production centres are those that currently exist in operational condition and include those plants which are closed down but which could be readily brought back into operation.
- *Committed* production centres are those that are either under construction or are firmly committed for construction.

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[1] IAEA (1984), *Manual on the Projection of Uranium Production Capability,* General Guidelines, Technical Report Series No. 238, IAEA, Vienna.

- *Planned* production centres are those for which feasibility studies are either completed or under way, but for which construction commitments have not yet been made. This class also includes those plants that are closed which would require substantial expenditures to bring them back into operation.
- *Prospective* production centres are those that could be supported by tributary RAR and inferred, i.e. "identified resources", but for which construction plans have not yet been made.

Production capacity and capability

Production capacity: Denotes the nominal level of output, based on the design of the plant and facilities over an extended period, under normal commercial operating practices.

Production capability: Refers to an estimate of the level of production that could be practically and realistically achieved under favourable circumstances from the plant and facilities at any of the types of production centres described above, given the nature of the resources tributary to them. Projections of production capability are supported only by RAR and/or IR. The projection is presented based on those resources recoverable at costs <USD 130/kgU.

Production: Denotes the amount of uranium output, in tonnes U contained in concentrate, from an ore processing plant or production centre (with milling losses deducted).

Mining and milling

In situ leaching (ISL): The extraction of uranium from sandstone using chemical solutions and the recovery of uranium at the surface. ISL extraction is conducted by injecting a suitable uranium-dissolving leach solution (acid or alkaline) into the ore zone below the water table thereby oxidising, complexing, and mobilising the uranium; then recovering the pregnant solutions through production wells, and finally pumping the uranium bearing solution to the surface for further processing. This process is sometimes referred to as in situ recovery (ISR).

Heap leaching (HL): Heaps of ore are formed over a collecting system underlain by an impervious membrane. Dilute sulphuric acid solutions are distributed over the top surface of the ore. As the solutions seep down through the heap, they dissolve a significant (50-75%) amount of the uranium in the ore. The uranium is recovered from the heap leach product liquor by ion exchange or solvent extraction.

In-place leaching (IPL): involves leaching of broken ore without removing it from an underground mine. This is also sometimes referred to as stope leaching or block leaching.

Co-product: Uranium is a co-product when it is one of two commodities that must be produced to make a mine economic. Both commodities influence output, for example, uranium and copper are co-produced at Olympic Dam in Australia. Co-product uranium is produced using either the open-pit or underground mining methods.

By-product: Uranium is considered a by-product when it is a secondary or additional product. By-product uranium can be produced in association with a main product or with co-products, e.g. uranium recovered from the Palabora copper mining operations in South Africa. By-product uranium is produced using either the open-pit or underground mining methods.

Uranium from phosphate rocks: Uranium has been recovered as a by-product of phosphoric acid production. Uranium is separated from phosphoric acid by a solvent extraction process. The most frequently used reagent is a synergetic mixture of tri-m-octyl phosphine oxide (TOPO) and di 2-ethylhexyl phosphoric acid (DEPA).

Ion exchange (IX): Reversible exchange of ions contained in a host material for different ions in solution without destruction of the host material or disturbance of electrical neutrality. The process is accomplished by diffusion and occurs typically in crystals possessing – one or two – dimensional channels where ions are weakly bonded. It also occurs in resins consisting of three-dimensional hydrocarbon networks to which are attached many ionisable groups. Ion exchange is used for recovering uranium from leaching solutions.

Solvent extraction (SX): A method of separation in which a generally aqueous solution is mixed with an immiscible solvent to transfer one or more components into the solvent. This method is used to recover uranium from leaching solutions.

Demand terminology

Reactor-related requirements: Refers to natural uranium acquisitions *not* necessarily consumption during a calendar year.

Environmental terminology[2]

Close-out: In the context of uranium mill tailings impoundment, the operational, regulatory and administrative actions required to place a tailings impoundment into long-term conditions such that little or no future surveillance and maintenance are required.

Decommissioning: Actions taken at the end of the operating life of a uranium mill or other uranium facility in retiring it from service with adequate regard for the health and safety of workers and members of the public and protection of the environment. The time period to achieve decommissioning may range from a few to several hundred years.

Decontamination: The removal or reduction of radioactive or toxic chemical contamination using physical, chemical, or biological processes.

Dismantling: The disassembly and removal of any structure, system or component during decommissioning. Dismantling may be performed immediately after permanent retirement of a mine or mill facility or may be deferred.

Environmental restoration: Clean-up and restoration, according to predefined criteria, of sites contaminated with radioactive and/or hazardous substances during past uranium production activities.

Environmental impact statement: A set of documents recording the results of an evaluation of the physical, ecological, cultural and socio-economic effects of a planned installation, facility, or technology.

Groundwater restoration: The process of returning affected groundwater to acceptable quality and quantity levels for future use.

Reclamation: The process of restoring a site to predefined conditions, which allows new uses.

Restricted release (or use): A designation, by the regulatory body of a country, that restricts the release or use of equipment, buildings, materials or the site because of its potential radiological or other hazards.

Tailings: The remaining portion of a metal-bearing ore consisting of finely ground rock and process liquids after some or all of the metal, such as uranium, has been extracted.

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[2] Definitions based on those published in OECD (2002), *Environmental Remediation of Uranium Production Facilities*, Paris.

Tailings impoundment: A structure in which the tailings are deposited to prevent their release into the environment.

Unrestricted release (or use): A designation, by the regulatory body of a country, that enables the release or use of equipment, buildings, materials or the site without any restriction.

Geological terminology

Uranium occurrence: A naturally occurring, anomalous concentration of uranium.

Uranium deposit: A mass of naturally occurring mineral from which uranium could be exploited at present or in the future.

Geologic types of uranium deposits[3]: uranium resources can be assigned on the basis of the following 15 major categories of uranium ore deposit types (arranged according to their approximate economic significance):

1. Sandstone deposits
2. Proterozoic unconformity deposits
3. Polymetallic Fe-oxide breccia complex deposits
4. Paleo-quartz-pebble conglomerate deposits
5. Granite-related
6. Metamorphite
7. Intrusive deposits
8. Volcanic-related deposits
9. Metasomatic deposits
10. Surficial deposits
11. Carbonate deposits
12. Collapse breccia-type deposits
13. Phosphate deposits
14. Lignite and coal
15. Black shale

Detailed descriptions with examples follow. Note that for Red Book reporting purposes only the major categories are used. However, descriptions of the sub-types for sandstone and Proterozoic unconformity deposits have also been included because of their importance.

1. *Sandstone deposits*: Sandstone-hosted uranium deposits occur in medium- to coarse-grained sandstones deposited in a continental fluvial or marginal marine sedimentary environment. Uranium is precipitated under reducing conditions caused by a variety of reducing agents within the sandstone, such as carbonaceous material, sulphides (pyrite), hydrocarbons and ferro-magnesian minerals (chlorite), bacterial activity, migrated fluids from underlying hydrocarbon reservoirs, and others. Sandstone uranium deposits can be divided into five main sub-types (with frequent transitional types between them):

    - *Basal channel deposits*: Paleodrainage systems consist of wide channels filled with thick, permeable alluvial-fluvial sediments. The uranium is predominantly associated with detrital plant debris in orebodies that display, in a plan view, an elongated lens or ribbon-like configuration and, in a section-view, a lenticular or, more rarely, a roll shape. Individual deposits can range from several hundred to 20 000 t of uranium, at grades ranging from 0.01% to 3%. Examples are the deposits of Dalmatovskoye (Transural Region), Malinovskoye (West Siberia), Khiagdinskoye (Vitim District) in the Russia, deposits of the Tono District (Japan), Blizzard (Canada) and Beverley (Australia).

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[3] This classification of the geological types of uranium deposits was updated in 2011-2012 through a number of IAEA consultancies that included an update of the World Distribution of Uranium Deposits (UDEPO).

- *Tabular deposits* consist of uranium matrix impregnations that form irregularly shaped lenticular masses within reduced sediments. The mineralised zones are largely oriented parallel to the depositional trend. Individual deposits can contain several hundred tons up to 150 000 tons of uranium, at average grades ranging from 0.05% to 0.5%, occasionally up to 1%. Examples of deposits include Hamr-Stráz (Czech Republic), Akouta, Arlit, and Imouraren (Niger) and those of the Colorado Plateau (United States).
- *Roll-front deposits*: The mineralised zones are convex in shape, oriented down the hydrologic gradient. They display diffuse boundaries with reduced sandstone on the down-gradient side and sharp contacts with oxidised sandstone on the up-gradient side. The mineralised zones are elongate and sinuous approximately parallel to the strike, and perpendicular to the direction of deposition and groundwater flow. Resources can range from a few hundred tons to several thousands of tons of uranium, at grades averaging 0.05% to 0.25%. Examples are Budenovskoye, Tortkuduk, Moynkum, Inkai and Mynkuduk (Kazakhstan); Crow Butte and Smith Ranch (United States) and Bukinay, Sugraly and Uchkuduk (Uzbekistan).
- *Tectonic/lithologic deposits* are discordant to strata. They occur in permeable fault zones and adjacent sandstone beds in reducing environments created by hydrocarbons and/or detrital organic matter. Uranium is precipitated in fracture or fault zones related to tectonic extension. Individual deposits contain a few hundred tons up to 5 000 tons of uranium at average grades ranging from 0.1-0.5%. Examples include the deposits of the Lodève District (France) and the Franceville basin (Gabon).
- *Mafic dykes/sills* in Proterozoic sandstones: mineralisation is associated with mafic dykes and sills that are interlayered with or crosscut Proterozoic sandstone formations. Deposits can be subvertical along the dyke's borders, sometime within the dykes, or stratabound within the sandstones along lithological contacts (Westmoreland District, Australia; Matoush, Canada). Deposits are small to medium (300-10 000 t) with grades low to medium (0.05-0.40%).

2. *Proterozoic unconformity deposits*: Unconformity-related deposits are associated with and occur immediately below and above an unconformable contact that separates Archean to Paleoproterozoic crystalline basement from overlying, redbed clastic sediments of Proterozoic age. In most cases, the basement rocks immediately below the unconformity are strongly hematised and clay altered, possibly as a result of paleoweathering and/or diagenetic/hydrothermal alteration. Deposits consist of pods, veins and semimassive replacements consisting of mainly pitchblende. They are preferentially located in two major districts, the Athabasca Basin (Canada) and the Pine Creek Orogen (Australia). The unconformity-related deposits include three sub-types:

   - *Unconformity-contact deposits*: Except for the low-grade Karku deposit (Russia), these all occur in the Athabasca Basin (Canada). Deposits develop at the base of the sedimentary cover directly above the unconformity. They form elongate pods to flattened linear orebodies typically characterised by a high-grade core surrounded by a lower grade halo. Most of the orebodies have root-like extensions into the basement. While some mineralisation is open space infill, much of it is replacement style. Often, mineralisation also extends up into the sandstone cover within breccias and fault zones forming "perched mineralisation". Deposits can be monometallic (McArthur River) or polymetallic (Cigar Lake). Deposits are medium to large to very large (1 000-200 000 t) and are characterised by their high grades (1-20%).

- *Basement-hosted deposits* are strata-structure bound in metasediments below the unconformity on which the basinal clastic sediments rest. The basement ore typically occupies moderately to steeply dipping brittle shear, fracture and breccia zones hundreds of metres in strike length that can extend down-dip for several tens to more than 500 m into basement rocks below the unconformity. Disseminated and vein uraninite/pitchblende occupies fractures and breccia matrix but may also replace the host rock. High-grade ore is associated with brecciated graphitic schists. These deposits have small to very large resources (300-200 000 t), at medium grade (0.10-0.50%). Examples are Kintyre, Jabiluka and Ranger in Australia, Millennium and Eagle Point in the Athabasca Basin and Kiggavik and Andrew Lake in the Thelon Basin (Canada).

- *Stratiform structure-controlled deposits*: low-grade (0.05-0.10%), stratabound, thin (1-5 m) zones of mineralisation are located along the unconformity between Archean, U-Th-rich granites and Proterozoic metasediments with minor enrichments along fractures. This type of deposit (Chitrial and Lambapur) has only been observed in the Cuddapah basin (India). Resources of individual deposits range between 1 000-8 000 t.

3. *Polymetallic iron-oxide breccia complex deposits*: This type of deposit has been attributed to a broad category of worldwide iron oxide-copper-gold deposits. Olympic Dam (Australia) is the only known representative of this type with significant by-product uranium resources. The deposit contains the world's largest uranium resources with more than 2 Mt of uranium. Deposits of this group occur in hematite-rich granite breccias and contain disseminated uranium in association with copper, gold, silver and rare earth elements. At Olympic Dam, this breccia is hosted within a Mesoproterozoic highly potassic granite intrusion that exhibits regional Fe-K-metasomatism. Significant deposits and prospects of this type occur in the same region, including Prominent Hill, Wirrda Well, Carrapeteena, Acropolis and Oak Dam as well as some younger breccia-hosted deposits in the Mount Painter area.

4. *Paleo-quartz pebble conglomerate deposits*: Deposits of this type contain detrital uranium oxide ores which are found in quartz pebble conglomerates deposited as basal units in fluvial to lacustrine braided stream systems older than 2 400-2 300 Ma. The conglomerate matrix is pyritic and contains gold, as well as other accessory and oxide and sulphide detrital minerals that are often present in minor amounts. Examples include deposits in the Witwatersrand basin, South Africa, where uranium is mined as a by-product of gold as well as deposits in the Blind River/Elliot Lake area of Canada.

5. *Granite-related deposits* include: *i)* true veins composed of ore and gangue minerals in granite or adjacent (meta-) sediments and *ii)* disseminated mineralisation in granite as episyenite bodies. Uranium mineralisation occurs within, at the contact or peripheral to the intrusion. In the Hercynian belt of Europe, these deposits are associated with large, peraluminous two-mica granite complexes (leucogranites). Resources range from small to large and grades are variable, from low to high.

6. *Metamorphite deposits* correspond to disseminations, impregnations, veins and shear zones within or affecting metamorphic rocks of various ages. These deposits are highly variable in sizes, resources and grades.

7. *Intrusive deposits* are contained in intrusive or anatectic igneous rocks of many different petrochemical compositions (granite, pegmatite, monzonite, peralkaline syenite and carbonatite). Examples include the Rossing and Rossing South (Husab) deposits (Namibia), the deposits in the Bancroft area (Canada), the uranium occurrences in the porphyry copper deposits of Bingham Canyon and Twin Butte (United States), the Kvanefjeld and Sorensen deposits (Greenland) and the Palabora carbonatite complex (South Africa).

8. *Volcanic-related deposits* are located within and near volcanic calderas filled by mafic to felsic, effusive and intrusive volcanic rocks and intercalated clastic sediments. Uranium mineralisation is largely controlled by structures as veins and stockworks with minor stratiform lodes. This mineralisation occurs at several stratigraphic levels of the volcanic and sedimentary units and may extend into the basement where it is found in fractured granite and metamorphic rocks. Uranium minerals (pitchblende, coffinite, U6+ minerals, less commonly brannerite) are associated with Mo-bearing sulphides and pyrite. Other anomalous elements include As, Bi, Ag, Li, Pb, Sb, Sn and W. Associated gangue minerals comprise violet fluorite, carbonates, barite and quartz. The most significant deposits are located within the Streltsovska caldera in the Russia. Other examples are known in China (Xiangshan District), Mongolia (Dornot and Gurvanbulag Districts), United States (McDermitt caldera), and Mexico (Pena Blanca District).

9. *Metasomatite deposits* are confined to Precambrian shields in areas of tectono-magmatic activity affected by intense Na-metasomatism or K-metasomatism which produced albitised or illitised facies along deeply rooted fault systems. In Ukraine, these deposits are developed within a variety of basement rocks, including granites, migmatites, gneisses and ferruginous quartzites which produced albitites, aegirinites, alkali-amphibolic, as well as carbonate and ferruginous rocks. Principal uranium phases are uraninite, brannerite and other Ti-U-bearing minerals, coffinite and hexavalent uranium minerals. The reserves are usually medium to large. Examples include Michurinskoye, Vatutinskoye, Severinskoye, Zheltorechenskoye, Novokonstantinovskoye and Pervomayskoye deposits (Ukraine), deposits of the Elkon District (Russia), Espinharas and Lagoa Real (Brazil), Valhalla (Australia), Kurupung (Guyana), Coles Hill (United States), Lianshanguan (China), Michelin (Canada) and small deposits of the Arjeplog region in the north of Sweden.

10. *Surficial deposits* are broadly defined as young (Tertiary to Recent), near-surface uranium concentrations in sediments and soils. The largest of the surficial uranium deposits are in calcrete (calcium and magnesium carbonates) found mainly in Australia (Yeelirrie deposit) and Namibia (Langer Heinrich deposit). These calcrete-hosted deposits mainly occur in valley-fill sediments along Tertiary drainage channels and in playa lake sediments in areas of deeply weathered, uranium-rich granites. Carnotite is the main uraniferous mineral. Surficial deposits also occur less commonly in peat bogs, karst caverns and soils.

11. *Carbonate deposits* are hosted in carbonate rocks (limestone, dolostone). Mineralisation can be syngenetic stratabound or more commonly structure-related within karsts, fractures, faults and folds. The only example of a stratabound carbonate deposits is the Tumalappalle deposit in India which is hosted in phosphatic dolostone. At Mailuu-Suu, Kyrgyzstan and Todilto, United States. Another example includes deposits developed in solution collapse breccias occurring in limestone with intercalations of carbonaceous shale such as the Sanbaqi deposit, China.

12. *Collapse breccia-type deposits* occur in cylindrical, vertical pipes filled with down-dropped fragments developed from karstic dissolution cavities in underlying thick carbonate layers. The uranium is concentrated as primary uranium ore, mainly uraninite, in the permeable breccia matrix, and in the arcuate, ring-fracture zone surrounding the pipe. The pitchblende is intergrown with numerous sulphide and oxide minerals variably containing Cu, Fe, V, Zn, Pb, Ag, Mo, Ni, Co, As, and Se. Type examples are the deposits in the Arizona Strip north of the Grand Canyon and those immediately south of the Grand Canyon in the United States. Resources are small to medium (300-2 500 t) with grades around 0.20-0.80%.

13. *Phosphate deposits* are principally represented by marine phosphorite of continental-shelf origin containing synsedimentary, stratiform, disseminated uranium in fine-grained apatite. Phosphorite deposits constitute large uranium resources (millions of

tons), but at a very low grade (0.005-0.015%). Uranium can be recovered as a by-product of phosphate production. Examples include the Land Pebble District, Florida (land-pebble phosphate) (United States), Gantour (Morocco) and Al-Abiad (Jordan). Another type of phosphorite deposits consists of organic phosphate, including argillaceous marine sediments enriched in fish remains that are uraniferous (Melovoye, Kazakhstan). Deposits in continental phosphates are not common.

14. *Lignite-coal deposits* consist of elevated uranium contents in lignite/coal mixed with mineral detritus (silt, clay), and in immediately adjacent carbonaceous mud and silt/sandstone beds. Pyrite and ash contents are high. Lignite-coal seams are often interbedded or overlain by felsic pyroclastic rocks. Examples are deposits of the south-western Williston basin, North and South Dakota (United States), Koldjat and Nizhne Iliyskoe (Kazakhstan), Freital (Germany), Ambassador (Australia) and the Serres basin (Greece).

15. *Black shale deposits* include marine, organic-rich shale or coal-rich pyritic shale, containing synsedimentary, disseminated uranium adsorbed onto organic material, and fracture-controlled mineralisation within or adjacent to black shale horizons. Examples include the uraniferous alum shale in Sweden and Estonia, the Chattanooga shale (United States), the Chanziping deposit (China), and the Gera-Ronneburg deposit (Germany).

Appendix 4. List of abbreviations and acronyms

APM	Adaptive phased management
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
BOO	Build, own, operate
CCHEN	Chilean Nuclear Energy Commission
CGNPC	China General Nuclear Power Group
CNEA	National Atomic Energy Commission (Argentina)
CNEN	National Nuclear Energy Commission (Brazil)
CNNC	China National Nuclear Corporation
CNSC	Canadian Nuclear Safety Commission
DGR	Deep geological repository
DIP	Decision in principle
DOE	Department of Energy (United States)
DU	Depleted uranium
EIA	Environmental impact assessment
ENAMI	National Mining Company (Chile)
ENUSA	Empresa Nacional del Uranio, S.A. (Spain)
EPA	Environmental Protection Agency (United States)
EPL	Exclusive prospecting licence
ERA	Energy Resources of Australia
ESA	Euratom Supply Agency
ESIA	Environmental and social impact assessment
EU	European Union
FBR	Fast breeder reactor
Ga	Giga-years
GDR	German Democratic Republic
GIF	Generation IV International Forum
GWe	Gigawatt electric
ha	Hectare
HEU	Highly enriched uranium

HL	Heap leaching
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
INB	Industrias Núcleares do Brasil S.A
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
IPEN	Peruvian Institute of Nuclear Energy
IPL	In-place leaching
IR	Inferred resources
ISL	In situ leaching
ISR	In situ recovery
IX	Ion exchange
JAEA	Japan Atomic Energy Agency
JAEC	Jordan Atomic Energy Commission
JEN	Junta de Energía Nuclear (Portugal)
JORC	Joint Ore Reserves Committee
kg	Kilogram
km	Kilometre
lb	Pound
LEU	Low-enriched uranium
LWR	Light-water reactor
MINETUR	Ministry of Industry, Energy and Tourism (Spain)
MoU	Memorandum of Understanding
MOX	Mixed oxide fuel
MSR	Molten salt reactor
MWe	Megawatt electric
MWS	Mine Waste Solutions
NMMC	Navoi Mining and Metallurgical Complex
NatU	Natural uranium
NEA	Nuclear Energy Agency
NORM	Naturally occurring radioactive material
NPP	Nuclear power plant
NRC	Nuclear Regulatory Commission (United States)
NWMO	Nuclear Waste Management Organization (Canada)
OECD	Organisation for Economic Co-operation and Development
OP	Open pit

PFS	Preliminary feasibility study
PHWR	Pressurised heavy-water reactor
ppm	Parts per million
PR	Prognosticated resources
Pu	Plutonium
PWR	Pressurised water reactor
RAR	Reasonably assured resources
REE	Rare earth element
RepU	Reprocessed uranium
RUN	Reptile Uranium Namibia Ltd
SAMREC	South African Mineral Resource Committee
SEA	Strategic environmental assessment
SEMP	Strategic Environmental Management Plan
STUK	Finnish Radiation and Nuclear Safety Authority
SR	Speculative resources
SWU	Separative work unit
SX	Solvent extraction
t	Tonnes (metric tons)
Th	Thorium
tHM	Tonnes heavy metal
TOE	Tonnes oil equivalent
tU	Tonnes uranium
tU_3O_8	Tonnes triuranium octoxide
tUnat	Tonnes natural uranium equivalent
TVA	Tennessee Valley Authority
TVO	Teollisuuden Voima
TWh	Terawatt-hour
U	Uranium
UCIL	Uranium Corporation of India Limited
UG	Underground mining
USEC	United States Enrichment Corporation
USGS	United States Geological Survey
US EIA	United States Energy Information Administration
WNA	World Nuclear Association

Appendix 5. Energy conversion factors

The need to establish a set of factors to convert quantities of uranium into common units of energy has become increasingly evident with the growing frequency of requests in recent years in relation to the various types of reactors.

Conversion factors and energy equivalence for fossil fuel for comparison

1 cal = 4.1868 J

1 J = 0.239 cal

1 tonne of oil equivalent (TOE) (net, lower heating value [LHV]) = 42 GJ[*] = 1 TOE

1 tonne of coal equivalent (TCE) (standard, LHV) = 29.3 GJ[*] = 1 TCE

1 000 m^3 of natural gas (standard, LHV) = 36 GJ

1 tonne of crude oil = approx. 7.3 barrels

1 tonne of liquid natural gas (LNG) = 45 GJ

1 000 kWh (primary energy) = 9.36 MJ

1 TOE = 10 034 Mcal

1 TCE = 7 000 Mcal

1 000 m^3 natural gas (atmospheric pressure) = 8 600 Mcal

1 tonne LNG = 11 000 Mcal

1 000 kWh (primary energy) = 2 236 Mcal[**]

1 TCE = 0.698 TOE

1 000 m^3 natural gas (atmospheric pressure) = 0.857 TOE

1 tonne LNG = 1.096 TOE

1 000 kWh (primary energy) = 0.223 TOE

1 tonne of fuelwood = 0.3215 TOE

1 tonne of uranium: light-water reactors = 10 000-16 000 TOE

open cycle = 14 000-23 000 TCE

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[*] World Energy Council standard conversion factors (from WEC, 1998 Survey of Energy Resources, 18th Edition).

[**] With 1 000 kWh (final consumption) = 860 Mcal as WEC conversion factor.

Appendix 6. List of all Red Book editions (1965-2016) and national reports

Listing of Red Book editions (1965-2016)

OECD/ENEA[1]	World Uranium and Thorium Resources, Paris, 1965
OECD/ENEA	Uranium Resources, Revised Estimates, Paris, 1967
OECD/ENEA-IAEA	Uranium Production and Short-Term Demand, Paris, 1969
OECD/ENEA-IAEA	Uranium Resources, Production and Demand, Paris, 1970
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1973
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1976
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1977
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1979
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1982
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1983
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1986
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1988
OECD/NEA-IAEA	Uranium Resources, Production and Demand, Paris, 1990
OECD/NEA-IAEA	Uranium 1991: Resources, Production and Demand, Paris, 1992
OECD/NEA-IAEA	Uranium 1993: Resources, Production and Demand, Paris, 1994
OECD/NEA-IAEA	Uranium 1995: Resources, Production and Demand, Paris, 1996
OECD/NEA-IAEA	Uranium 1997: Resources, Production and Demand, Paris, 1998
OECD/NEA-IAEA	Uranium 1999: Resources, Production and Demand, Paris, 2000
OECD/NEA-IAEA	Uranium 2001: Resources, Production and Demand, Paris, 2002
OECD/NEA-IAEA	Uranium 2003: Resources, Production and Demand, Paris, 2004
OECD/NEA-IAEA	Uranium 2005: Resources, Production and Demand, Paris, 2006
OECD/NEA-IAEA	Uranium 2007: Resources, Production and Demand, Paris, 2008
OECD/NEA-IAEA	Uranium 2009: Resources, Production and Demand, Paris, 2010
OECD/NEA-IAEA	Uranium 2011: Resources, Production and Demand, Paris, 2012
OECD/NEA-IAEA	Uranium 2014: Resources, Production and Demand, Paris, 2014
OECD/NEA-IAEA	Uranium 2016: Resources, Production and Demand, Paris, 2016

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[1] ENEA: European Nuclear Energy Agency; former name of the Nuclear Energy Agency (NEA).

Index of national reports in Red Books

(The following index lists all national reports by the year in which these reports were published in the Red Books. A listing of all Red Book editions is shown at the end of this Index.)

	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Algeria						1976	1977	1979	1982				
Argentina		1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Armenia													
Australia		1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Austria							1977						
Bangladesh											1986	1988	
Belgium									1982	1983	1986	1988	1990
Benin													1990
Bolivia							1977	1979	1982	1983	1986		
Bophuthatswana[2]									1982				
Botswana								1979		1983	1986	1988	
Brazil				1970	1973	1976	1977	1979	1982	1983	1986		
Bulgaria													1990
Cameroon							1977		1982	1983			
Canada	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Central African Republic				1970	1973		1977	1979			1986		
Chad													
Chile							1977	1979	1982	1983	1986	1988	
China													1990
Colombia							1977	1979	1982	1983	1986	1988	1990
Congo		1967											
Costa Rica									1982	1983	1986	1988	1990
Côte d'Ivoire									1982				
Cuba												1988	
Czech Republic													
Czech and Slovak Rep.													1990
Denmark (Greenland)	1965	1967		1970	1973	1976	1977	1979	1982	1983	1986		1990
Dominican Republic									1982				
Ecuador							1977		1982	1983	1986	1988	
Egypt							1977	1979			1986	1988	1990
El Salvador										1983	1986		
Estonia													
Ethiopia								1979		1983	1986		
Finland					1973	1976	1977	1979	1982	1983	1986	1988	1990
France	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Gabon		1967		1970	1973				1982	1983	1986		
Germany				1970		1976	1977	1979	1982	1983	1986	1988	1990

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[2] Bophuthatswana is a former republic, dissolved in 1994, in the north-western region of South Africa.

Index of national reports in Red Books (*cont'd*)

1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	
					2002	2004	2006	2008		2012	2014	2016	**Algeria**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Argentina**
				2000	2002	2004	2006		2010	2012	2014	2016	**Armenia**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Australia**
													Austria
													Bangladesh
1992	1994	1996	1998	2000	2002	2004	2006	2008					**Belgium**
													Benin
													Bolivia
													Bophuthatswana
									2010	2012	2014	2016	**Botswana**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Brazil**
1992	1994	1996	1998					2008	2010				**Bulgaria**
													Cameroon
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Canada**
													Central African Republic
											2014	2016	**Chad**
1992	1994	1996	1998	2000	2002	2004	2006	2008		2012	2014	2016	**Chile**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**China**
		1996	1998					2008					**Colombia**
													Congo
													Costa Rica
													Côte d'Ivoire
1992		1996	1998										**Cuba**
	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Czech Republic**
													Czech and Slovak Rep.
1992		1996	1998			2004			2010	2012	2014	2016	**Denmark (Greenland)**
													Dominican Republic
													Ecuador
1992	1994	1996	1998	2000		2004	2006	2008	2010				**Egypt**
													El Salvador
			1998			2004							**Estonia**
										2012			**Ethiopia**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Finland**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**France**
		1996	1998	2000	2002	2004	2006						**Gabon**
1992	1994	1996	1998	2000	2002		2006	2008	2010	2012	2014	2016	**Germany**

Index of national reports in Red Books (*cont'd*)

	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Ghana							1977			1983			
Greece							1977	1979	1982	1983	1986	1988	1990
Guatemala											1986	1988	
Guyana								1979	1982	1983	1986		
Hungary													
India	1965	1967		1970	1973	1976	1977	1979	1982	1983	1986		1990
Indonesia							1977				1986	1988	1990
Iran, Islamic Republic of							1977						
Iraq													
Ireland								1979	1982	1983	1986		
Italy		1967		1970	1973	1976	1977	1979	1982	1983	1986	1988	
Jamaica									1982	1983			
Japan	1965	1967		1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Jordan							1977				1986	1988	1990
Kazakhstan													
Korea						1976	1977	1979	1982	1983	1986	1988	1990
Kyrgyzstan													
Lesotho												1988	
Liberia							1977			1983			
Libyan Arab Jamahiriya[3]										1983			
Lithuania													
Madagascar						1976	1977	1979	1982	1983	1986	1988	
Malawi													
Malaysia										1983	1986	1988	1990
Mali											1986	1988	
Mauritania													1990
Mexico				1970	1973	1976	1977	1979	1982		1986		1990
Mongolia													
Morocco	1965	1967				1976	1977	1979	1982	1983	1986	1988	1990
Namibia								1979	1982	1983	1986	1988	1990
Netherlands									1982	1983	1986		1990
New Zealand		1967					1977	1979					
Niger		1967		1970	1973		1977				1986	1988	1990
Nigeria								1979					
Norway								1979	1982	1983			
Pakistan		1967											
Panama										1983		1988	
Paraguay										1983	1986		
Peru							1977	1979		1983	1986	1988	1990
Philippines							1977		1982	1983	1986		1990
Poland													

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[3] Libya as of 2011.

Index of national reports in Red Books *(cont'd)*

1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	
													Ghana
1992	1994	1996	1998										**Greece**
													Guatemala
													Guyana
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Hungary**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**India**
1992	1994	1996	1998	2000	2002	2004	2006		2010	2012	2014	2016	**Indonesia**
			1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Iran, Islamic Republic of**
												2016	**Iraq**
1992			1998										**Ireland**
1992	1994	1996	1998	2000						2012	2014	2016	**Italy**
													Jamaica
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Japan**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Jordan**
	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Kazakhstan**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010				**Korea**
		1996			2002								**Kyrgyzstan**
													Lesotho
													Liberia
													Libyan Arab Jamahiriya
	1994	1996	1988	2000	2002	2004	2006	2008					**Lithuania**
													Madagascar
				2000				2008	2010	2012	2014	2016	**Malawi**
1992	1994	1996	1998	2000	2002								**Malaysia**
											2014	2016	**Mali**
												2016	**Mauritania**
1992	1994	1996	1998	2000						2012		2016	**Mexico**
	1994	1996	1998						2010	2012	2014	2016	**Mongolia**
			1998										**Morocco**
	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Namibia**
1992	1994	1996	1998	2000	2002								**Netherlands**
													New Zealand
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Niger**
													Nigeria
1992		1996	1998										**Norway**
	1994		1998	2000									**Pakistan**
													Panama
													Paraguay
1992	1994	1996	1998	2000		2004	2006	2008	2010	2012	2014	2016	**Peru**
	1994	1996	1998	2000	2002	2004	2006						**Philippines**
				2000	2002			2008	2010	2012	2014	2016	**Poland**

Index of national reports in Red Books *(cont'd)*

	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Portugal	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Romania													
Russia													
Rwanda											1986		
Senegal									1982				
Slovak Republic													
Slovenia													
Somalia							1977	1979					
South Africa	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986		
Spain	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Sri Lanka							1977		1982	1983	1986	1988	
Sudan							1977						
Surinam									1982	1983			
Sweden	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Switzerland						1976	1977	1979	1982	1983	1986	1988	1990
Syrian Arab Republic									1982	1983	1986	1988	1990
Tajikistan													
Tanzania													1990
Thailand							1977	1979	1982	1983	1986	1988	1990
Togo								1979					
Turkey					1973	1976	1977	1979	1982	1983	1986	1988	1990
Turkmenistan													
Ukraine													
United Kingdom						1976	1977	1979	1982	1983	1986	1988	1990
United States	1965	1967	1969	1970	1973	1976	1977	1979	1982	1983	1986	1988	1990
Uruguay							1977		1982	1983	1986	1988	1990
USSR (former)													
Uzbekistan													
Venezuela											1986	1988	
Viet Nam													
Yugoslavia					1973	1976	1977		1982				1990
Zaire[4]					1973		1977					1988	
Zambia											1986	1988	1990
Zimbabwe									1982			1988	

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[4] Zaire is the former name – between 1971 and 1997 – of the Democratic Republic of the Congo.

Index of national reports in Red Books *(cont'd)*

1992	**1994**	**1996**	**1998**	**2000**	**2002**	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**	
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Portugal**
1992	1994	1996	1998	2000	2002								**Romania**
	1994		1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Russia**
													Rwanda
													Senegal
	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Slovak Republic**
	1994	1996	1998		2002	2004	2006	2008	2010		2014	2016	**Slovenia**
													Somalia
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**South Africa**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Spain**
													Sri Lanka
													Sudan
													Surinam
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Sweden**
1992	1994	1996	1998	2000	2002	2004	2006	2008					**Switzerland**
	1994												**Syrian Arab Republic**
					2002								**Tajikistan**
									2010	2012	2014	2016	**Tanzania**
1992	1994	1996	1998	2000	2002		2006				2014	2016	**Thailand**
													Togo
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Turkey**
						2004							**Turkmenistan**
	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**Ukraine**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010		2014	2016	**United Kingdom**
1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	**United States**
													Uruguay
1992													**USSR (former)**
	1994	1996	1998	2000	2002	2004	2006			2012		2016	**Uzbekistan**
													Venezuela
1992	1994	1996	1998	2000	2002	2004	2006	2008			2014	2016	**Viet Nam**
1992													**Yugoslavia**
													Zaire
1992	1994	1996	1998							2012	2014	2016	**Zambia**
1992	1994	1996	1998										**Zimbabwe**

Appendix 7. Groups of countries and areas with uranium-related activities

The countries and geographical areas referenced in this report are listed below. Countries followed by an asterisk (*) are OECD members.

North America

Canada*
Mexico*
United States*

Central and South America

Argentina
Bolivia
Brazil
Chile*
Colombia
Costa Rica
Cuba
Ecuador
El Salvador
Guatemala
Jamaica
Paraguay
Peru
Uruguay
Venezuela

Western Europe

Austria*
Belgium*
Denmark*
Finland*
France*
Germany*
Ireland*
Italy*
Netherlands*
Norway*
Portugal*
Spain*
Sweden*
Switzerland*
United Kingdom*

Central, Eastern and Southeast Europe

Armenia
Bulgaria
Croatia
Czech Republic*
Estonia*
Greece*
Hungary*
Lithuania
Poland*
Romania
Russia
Slovak Republic*
Slovenia*
Turkey*
Ukraine

Africa

Algeria
Botswana
Central African Republic
Congo, Democratic Rep.
Egypt
Gabon
Ghana
Lesotho
Libya
Madagascar
Malawi
Mali
Morocco
Namibia
Niger
Nigeria
Somalia
South Africa
Zambia
Zimbabwe

Middle East, Central and Southern Asia

Bangladesh
India
Iran, Islamic Republic of
Israel*
Jordan
Kazakhstan
Kyrgyzstan
Pakistan
Sri Lanka
Syria
Tajikistan
Turkmenistan
Uzbekistan

Southeast Asia

Indonesia
Malaysia
Philippines
Thailand
Viet Nam

Pacific

Australia*
New Zealand*

East Asia[1]

China
Japan*
Korea, Democratic People's Republic of
Korea*
Mongolia

The countries associated with other groupings of nations used in this report are listed below.

Commonwealth of Independent States (CIS) or Newly Independent States (NIS)

Armenia
Azerbaijan
Belarus
Georgia
Kazakhstan
Kyrgyzstan
Tajikistan
Turkmenistan
Moldavia
Russia
Ukraine
Uzbekistan

European Union

Austria*
Belgium*
Bulgaria
Croatia
Cyprus
Czech Republic*
Denmark*
Estonia*
Finland*
France*
Germany*
Greece*
Hungary*
Ireland*
Italy*
Latvia*
Lithuania
Luxembourg*
Malta
Netherlands*
Poland*
Portugal*
Romania
Slovak Republic*
Slovenia*
Spain*
Sweden*
United Kingdom*

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[1] Includes Chinese Taipei.

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Visit us on **Facebook** at www.facebook.com/OECDNuclearEnergyAgency or follow us on **Twitter** @OECD_NEA.

OECD/NEA PUBLISHING, 2 rue André-Pascal, 75775 PARIS CEDEX 16

Uranium 2016: Resources, Production and Demand

Uranium is the raw material used to produce fuel for long-lived nuclear power facilities, necessary for the generation of significant amounts of baseload low-carbon electricity for decades to come. Although a valuable commodity, declining market prices for uranium in recent years, driven by uncertainties concerning evolutions in the use of nuclear power, have led to the postponement of mine development plans in a number of countries and to some questions being raised about future uranium supply. This 26th edition of the "Red Book", a recognised world reference on uranium jointly prepared by the Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA), provides analyses and information from 49 producing and consuming countries in order to address these and other questions. The present edition provides the most recent review of world uranium market fundamentals and presents data on global uranium exploration, resources, production and reactor-related requirements. It offers updated information on established uranium production centres and mine development plans, as well as projections of nuclear generating capacity and reactor-related requirements through 2035, in order to address long-term uranium supply and demand issues.

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92100 Boulogne-Billancourt, France
Tel.: +33 (0)1 45 24 10 15
nea@oecd-nea.org www.oecd-nea.org

NEA No. 7301

MINERALS COUNCIL OF AUSTRALIA

SUBMISSION TO THE UNITED STATES DEPARTMENT OF COMMERCE SECTION 232 NATIONAL SECURITY INVESTIGATION OF IMPORTS OF URANIUM

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10 SEPTEMBER 2018

Attention: Mr. Michael Vaccaro, Acting Director

Office of Technology Evaluation
Bureau of Industry and Security
U.S. Department of Commerce
1401 Constitution Avenue NW, Room 1093,
Washington, DC 20230

Uranium232@bis.doc.gov

TABLE OF CONTENTS

INTRODUCTION

The Minerals Council of Australia (MCA) welcomes the opportunity to provide comment on the section 232 National Security Investigation into uranium imports into the United States.

The MCA is the peak industry organisation representing Australia’s exploration, mining and minerals processing industry, nationally and internationally in their contribution to sustainable development and society.

MCA member companies represent more than 85 per cent of Australia’s annual minerals industry production and a higher share of minerals exports.

The MCA includes a Uranium Forum which comprises 10 full members and two associate members covering Australia’s uranium producers, major developers, explorers and service providers to the industry.

The primary aim of the MCA Uranium Forum is to ensure the uranium industry is able to operate and expand safely and efficiently in an environment of:

- Policy certainty and a stable investment climate
- Fit-for-purpose regulatory and compliance arrangements based on the best available scientific evidence
- Recognition as an operationally responsible industry, including in its relationships with Indigenous communities, environmental management and occupational health and safety
- Public confidence and acceptance.

EXECUTIVE SUMMARY

The MCA submits that it would be contrary to the national security interests of the United States to impose restrictions on imports of uranium, particularly from reliable, stable and market-based suppliers such as Australia.

The MCA submits that such measures would be counter-productive and potentially harmful to US national security interests by increasing the level of uranium investment uncertainty in market based jurisdictions such as Australia, which are important producers of competitive, reliable uranium supply to America’s civilian nuclear power industry.

Such uncertainty may over time see global uranium production growth shift from market based jurisdictions such as Australia, which receive no financial support from governments, to other supply basins which are government sponsored or supported.

The MCA recommends that long term US national security interests are best served by focusing on the downstream stages of the nuclear fuel cycle – conversion, enrichment and fuel fabrication.

Although reliable uranium remains a critical initial component of the nuclear fuel cycle, US development and long term competitiveness in the downstream fuel cycle stages ensures that the global uranium industry delivers a substantial portion of its output to the US to be processed into fuel for use in reactors both in the US and abroad.

US competitiveness in downstream nuclear fuel cycle activities has:

- Underpinned the security of its nuclear industry and its historic leadership in the global nuclear sector
- Enabled the US to play a critical and preeminent role in ensuring international non-proliferation and safeguards requirements are met.

The MCA encourages the Department of Commerce to reject the petition for quota protection measures for US domestic uranium producers.

OVERVIEW

Australian uranium production

There are currently three uranium producers operating in Australia:

- Energy Resources Australia (Ranger, Northern Territory) - ERA is 68.4 per cent owned by Rio Tinto and is listed on the ASX (ASX: ERA)[1]
- BHP (Olympic Dam, South Australia) produces copper, uranium, gold and silver at its mine in South Australia (ASX: BHP)
- Heathgate Resources (Beverley and Beverley North, South Australia). Heathgate is wholly owned by US parent company General Atomics.

All Australian uranium is produced for export markets.

Total annual Australian uranium exports since Jun 2013 are shown below:[2]

Australian total uranium exports (all countries) Year	Tonnes
2013-14	6,701
2014-15	5,515
2015-16	8,417
2016-17	7,081

In addition to current production, there is the fully permitted Honeymoon Uranium Project in South Australia owned by Boss Resources Limited in care and maintenance and positioning to return to production following improved market conditions.

There are also three other uranium projects in Western Australia with environmental approval to proceed by state and federal governments owned by publicly listed companies (ASX: VMY, ASX: TOE, TSE: CCO).[3] A fourth project, also owned by Canadian-listed Cameco (CCO) approved by the Western Australia state government is awaiting federal approval.

There are several other uranium explorers and developers seeking to follow these well progressed projects.

US utilities uranium procurement from Australia

Australian uranium production has been an important source of supply to US civilian nuclear utilities.

Total Australian uranium purchases by owners and operators of US civilian nuclear power reactors are shown below:[4]

Year	'000 lbs	Tonnes	Share of US purchases
2013	10,741	4,872	19%
2014	10,511	4,768	20%
2015	9,678	4,390	17%
2016	8,963	4,066	18%
2017	8,129	3,687	19%

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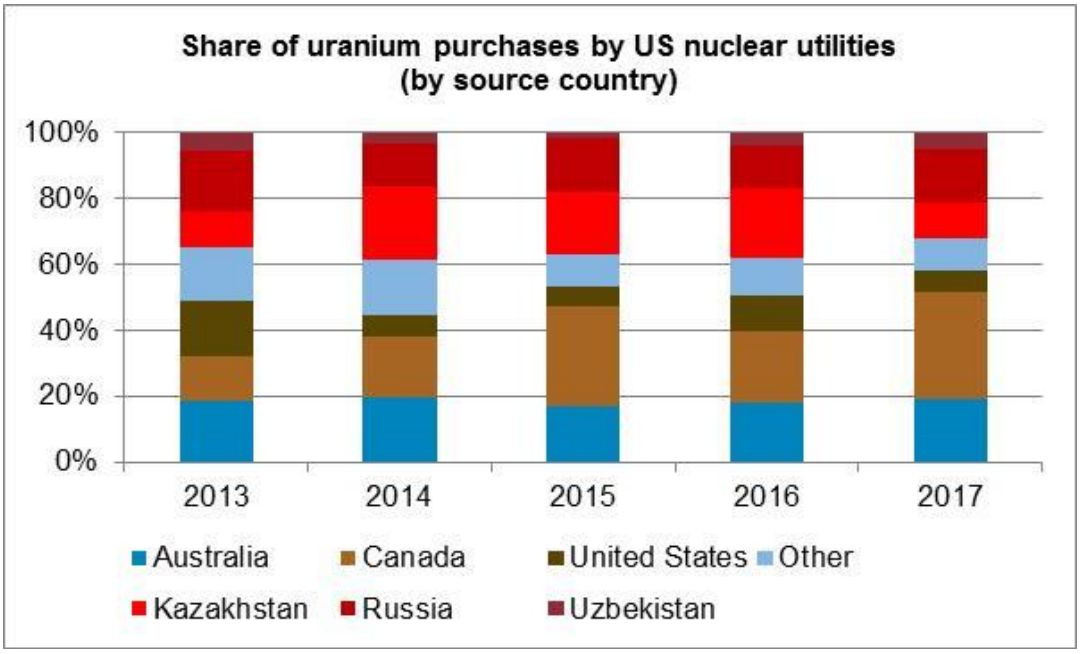
[1] ASX denotes Australian Stock Exchange

[2] Australian Government, Australian Safeguards and Non-Proliferation Office, Annual Reports

[3] TSE denotes Toronto Stock Exchange

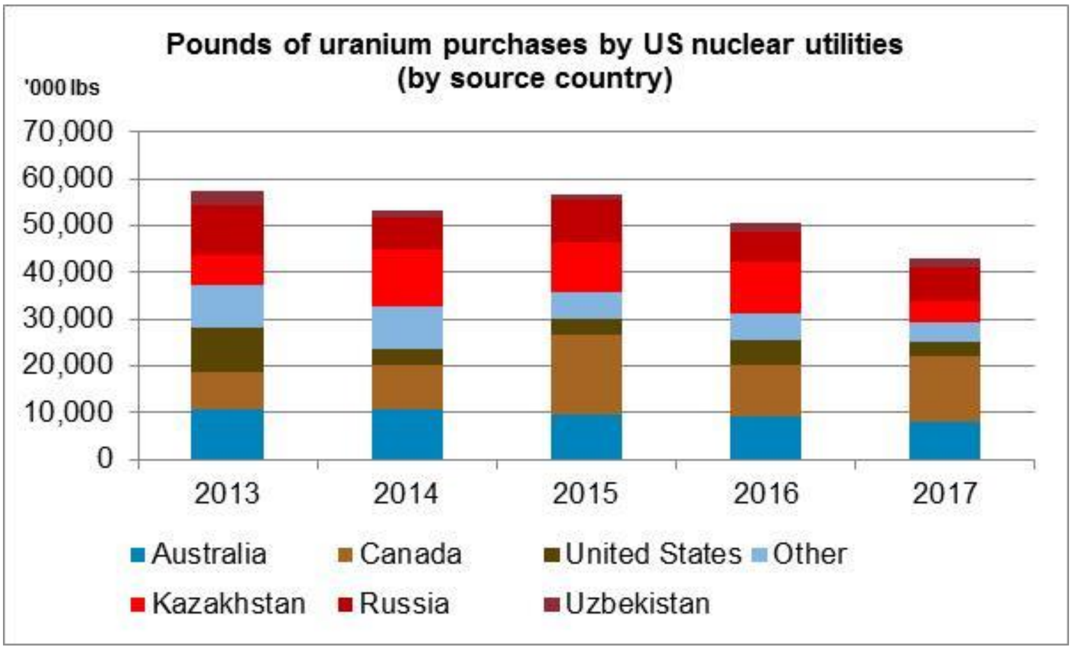
[4] US Energy Information Administration, Uranium Marketing Annual Report, 31 May 2018

Data from the US Energy Information Administration shows that market share of the various country sources to US nuclear utilities can vary substantially from year to year. However, over the last five years, Australian uranium supply has consistently been between 17 and 20 per cent of total uranium purchased by owners and operators of US civilian nuclear power reactors.[5]



Source: US Energy Information Administration

Data from the US Energy Information Administration also shows that total US utility uranium requirements have reduced significantly over the last three years.[6] This reflects some nuclear reactor closures and the low cost of enrichment services incentivising uranium underfeeding.



Source: US Energy Information Administration

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[5] Ibid

[6] Ibid

The data indicates that there has been no ‘surge’ or significant change in the share of the US market met through imports from Australia. In fact, in volume terms, imports of Australian uranium to the US have declined slightly over the last four years.

Australia’s long term reliable supply of uranium to the US

Australia has been a long term reliable supplier of uranium to the US.

Australian uranium has been delivered to US converters for decades. Sales via industry standard ‘book transfer’ at the US converter have been made to both US and international nuclear utilities.

Currently, Australia has three uranium operations in production. ERA’s Ranger mine in the Northern Territory is one of the longest continually operating uranium producers in the world. BHP’s Olympic Dam mine in South Australia has a projected mine life of over a century and with multi-commodity output is not completely dependent on the uranium market for its commercial viability. And Heathgate Resources, owned by US parent General Atomics, operates world class in-situ recovery fields in the Flinders Ranges, South Australia.

In addition, Australia is highly prospective for uranium with several other projects either ready to come back into the market (Boss Resources’ Honeymoon operation), or either partly or entirely approved (Vimy Resources’ Mulga Rock project, Cameco Australia’s Kintyre and Yeelirrie projects, Toro Energy’s Wiluna project) and awaiting market incentive to invest, construct and operate. In addition, other explorers and developers such as Cauldron Energy and Manhattan Corporation are preparing to follow these.

Australian supply has looked to US markets to be a source of sales contract support to underpin project development, as well as a source of foreign direct investment.

This has worked to US national interests in providing a secure, market-based, reliable source of supply from a jurisdiction which welcomes US investment and involvement in the development of uranium supplies.

ISSUES RAISED IN THE US URANIUM PRODUCERS' PETITION

Assertion	**MCA comment**
'Foreign state-owned companies have targeted the US'[7]	Australia's current supply is neither state-owned nor the recipient of government subsidy. It competes in an open, global market, and operates in accordance with sound market principles. Two companies are transparently listed on stock exchanges while the third is privately owned by a US parent company. There are no Australian uranium operations which are owned or operated by state or federal governments. There are no uranium projects in Australia being developed by state or federal governments. Australia welcomes foreign investment in its mining sector including its uranium sector.
'The entire US nuclear industry in crisis'[8]	Uranium operations around the world are experiencing challenging market conditions with several in multiple jurisdictions reducing production and even moving into care and maintenance. Similarly, other sectors of the fuel cycle are also experiencing difficult commercial conditions.
'The threat comes from Russia, Kazakhstan, and China'[9]	Greater than 50 per cent of uranium imports come from Canada and Australia. Australia hosts several important market based suppliers making long term investment decisions based on market principles and assuming effectively minimal US sovereign risk to market access. Australia is not a threat but rather an important supplier and import restrictions would have significant implications for long term investment in Australian uranium supply and ultimately be a risk to US national security interests.
US domestic producers 'face increasing financial pressure' and 'have laid off more than 50 per cent of their workforce'[10]	This is not unique to US producers. The global uranium market has yet to fully recover from the demand response following Fukushima in 2011 even though there has been substantial growth in demand, in particular from China. Nevertheless, demand growth and recovery are underway and investor interest in the uranium sector is returning. That investor interest is focused on market friendly jurisdictions such as Australia. Investment will proceed to lowest cost projects with open access to the key markets. Australia welcomes foreign investment, provides several stable state and territory jurisdictions for uranium investment and development, and a respected and workable federal safeguards regime to facilitate responsible exports.
'US defence needs require US uranium'[11]	The Australian uranium industry appreciates the strong validation of international safeguards expressed in the petition. The strength of

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[7] Energy Fuels Resources (USA) Inc and Ur-Energy USA Inc, *Petition for relief under section 232 of the Trade Expansion Act of 1962 from imports of uranium products that threaten national security*, 16 Jan 2018, p1

[8] Ibid p1

[9] Ibid p2

[10] Ibid p3

[11] Ibid p5

	safeguards and non-proliferation treaties are sometimes portrayed cynically by anti-nuclear activists. The petition makes clear that the US cannot use imported uranium in defence industries. For Australian uranium producers (which are all for export only), this is important for Australian public acceptance. However, it is not accurate to suggest or imply that any defence needs for uranium require a civilian nuclear industry and indeed a guaranteed share of any domestic civilian industry demand. The US developed it's deterrence before a civilian nuclear industry was established. Some other countries have done the same.
'Critical infrastructure requires a secure supply of uranium'[12]	International market based uranium supply from countries like Australia, which has close economic, political and strategic relationships with the United States, has been very reliable. Indeed, several major countries reliant on nuclear power have no domestic uranium production. France relies on nuclear power for over 70 per cent of its electricity and has no uranium mining. South Korea relies on nuclear power for over 25 per cent of its electricity and has no uranium mining.[13] France has significant fuel cycle industries.[14] South Korea is developing some fuel fabrication capability.[15] Uranium is extremely energy dense and conducive to the stockpiling of strategic reserves without requiring large excessive land and space. It is described in Japan as 'quasi-domestic' power source. [16] Countries and companies can easily store several years' worth of requirements if they concerned about supply. In terms of supply security and exposure to the possible impacts on supply from volatile market pricing, Australian supply has been very reliable through the cycle. Australia's largest producer supplies uranium from a polymetallic ore-body. Olympic Dam produces approximately 4,000 tonnes per annum of Uranium Oxide Concentrates (UOC) as a co-product to a predominantly copper mining operation. The bigger issue for critical infrastructure in the US is the economic viability of US nuclear plants in the face of competition from low cost gas and subsidized renewable. Higher uranium prices due to quotas or other barriers or restrictions on imports will if anything, make this even worse.
'Foreign nationalistic interests increase the national security threat'[17]	The US nuclear industry is more dependent on a well-functioning global uranium market than on foreign nationalistic interest. Secure, reliable long term uranium supply for US nuclear utilities requires a country like Australia, with its enormous uranium reserves, to continue to create a stable domestic and foreign investment climate, and to retain strong diplomatic, trade and cultural relations with the US. US trade

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[12] Ibid p5
[13] World Nuclear Association, *World Nuclear Power Reactors and Uranium Requirements*, August 2018
[14] World Nuclear Association, *Nuclear Power in France*, August 2018
[15] World Nuclear Association, *Nuclear Power in South Korea*, December 2017
[16] World Nuclear Association, *Nuclear Power in Japan*, August 2018
[17] Energy Fuels Resources (USA) Inc and Ur-Energy USA Inc, Op Cit, p6

	restrictions would create uncertainty for that investment. Greater than 50 per cent of US uranium imports come from Canada and Australia. Long term supply from these market based supply sources is susceptible to sovereign risk in the importing country that comes with domestic industry protection and can persist even after removal of protection. Australia has moved several projects through environmental approval and developed local community support. Project owners are essentially awaiting market signals to move projects into construction and then to market. This pathway for new projects to move into production is threatened by the imposition of US import restrictions, which ultimately pose a risk to long term security of market supply to the US.
‘If the US is no longer a leading source of nuclear goods and technology, it will lose the ability to insist that nuclear energy be developed responsibly and to minimise the potential for further proliferation of nuclear weapons’[18]	Imposing import restrictions at the request of domestic uranium producers will do very little to assist the US maintaining its vital role in global non-proliferation, and its important role as an innovator and supplier of nuclear technology in the world. If anything, such import restrictions may even harm this effort. If such protection helps force further nuclear plant closures by passing higher uranium input costs on to them, any benefit from assisting domestic uranium production will be off-set by the cost of plant closures. US nuclear industries are facing fierce competition from Russian, Chinese and other technology suppliers around the world. Forcing them to buy more expensive uranium due to restrictions on imports would merely add to their burden and constrain their ability to compete. The role the US plays in supporting global non-proliferation efforts is assisted by its dominant position in the global nuclear power industry. It is the largest nuclear power generator in the world. This position may soon be overtaken by China as it ramps up its nuclear power generation capacity. Concerns regarding potential declining US influence in non-proliferation would be better directed towards to ensuring the US nuclear sector remains the pre-eminent nuclear sector in the world.
‘The proposed relief is both essential and reasonable’[19]	The proposed relief would distort the international market. It would force US domestic nuclear utilities to pay more for their uranium than their international counterparts. These additional costs are likely to increase electricity costs for US electricity consumers and/or reduce nuclear generation’s share of US electricity supply. Both impacts would be negative for US jobs and competitiveness. It would artificially distort investment towards extracting higher cost US uranium over potentially lower cost foreign uranium, thereby consuming a finite domestic resource that is claimed to be ‘strategic’, faster than it otherwise would. In effect, current international market dynamics are ‘conserving’ higher cost US domestic uranium resources and allowing American industry

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[18] Ibid p7

[19] Ibid p7

	and consumers to consume and benefit from foreign sources of uranium.
The 'petition seeks protection against overwhelming imports'[20]	The Australian uranium industry empathises with US uranium producers as both face the exact same market conditions. The uranium market is essentially a global market – even with the heavily overseen safeguards and government monitoring of uranium trade and material movements. As noted above, the data shows that there has been no significant change in the US market share of Australian uranium imports. In fact, in volume terms, the amount of Australian uranium imported to the US has declined slightly in recent years. However, the notion that the US is seeing overwhelming imports can just as easily be interpreted as positive for US interests in that such imports are conserving US domestic uranium resources. Australian uranium producers also face competition from sources which are either state-owned or potentially state-sponsored. There is some ambiguity around the sustainability and proper accounting of production costs in some competitor jurisdictions. Unlike the US however, Australia does not have a large off-setting benefit from obtaining low cost uranium imports to a large nuclear power sector.
The petition does not 'harm international uranium markets'[21]	On the contrary, this petition introduces sovereign risk in the largest nuclear fuel market in the world. The proper functioning of the US market has underpinned rational investment in key market based uranium production basins such as Australia. US utilities have provided contract support for mine expansions and new projects which has benefitted developers and US utilities. Consequently, acting on this petition as proposed introduces a new risk to the market based supply side of the international uranium industry. And the Australian uranium industry contends that this is contrary to the long term interests of the US.

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[20] Ibid p8
[21] Ibid p9

RECOMMENDATION

Australian uranium industry recommends the US Department of Commerce reject the petition by domestic uranium producers for quota (or any other industry) protection measures.

Access to market based imported uranium from Australia provides additional security of supply for US civilian nuclear power plants and imposing domestic protection, will threaten on-going investment in Australian uranium by introducing unnecessary risk to market access – such risk could jeopardise US long-term security of supply in the future, potentially leaving the US more reliant on supply from jurisdictions with less business and political stability and with direct or indirect government subsidies for local producers.

Should the Department of Commerce consider that further support is needed for US nuclear fuel supply, the Australian uranium industry recommends that focus should be on the extensive fuel cycle activities which occur post-mining on US soil; namely conversion, enrichment, and fuel fabrication.

Those activities have traditionally been undertaken on US soil, ensuring that imported uranium is delivered well in advance of fuel consumption to US facilities for treatment.

It is in those areas that the US has had particular international competitiveness in decades past, which along with reliable supply from countries like Australia, has underpinned the security of fuel supply for the US civilian nuclear power industry.

COMMENTS BY THE GOVERNMENT OF CANADA TO THE U.S. DEPARTMENT OF COMMERCE

REQUEST FOR COMMENT:
THE EFFECT OF IMPORTS OF URANIUM ON NATIONAL SECURITY, AN INVESTIGATION UNDER SECTION 232(B) OF THE TRADE EXPANSION ACT OF 1962, AS AMENDED
U.S. FEDERAL REGISTER

Submitted by:
The Government of Canada
September 25, 2018

Introduction

Canada shares the U.S. industry's concerns regarding the current state of the global uranium market. Reduced demand and oversupply have resulted in low global prices for uranium. Global oversupply largely reflects the trade distorting practices of certain state-owned enterprises, primarily in Central Asia, which have negatively impacted the market-based producers in Canada and the United States, and have contributed to depressed market conditions. Consequently, both the Canadian and U.S. uranium industries have been forced to close mines and significantly reduce staff.

Canada supports resolution of these issues in the global uranium market in order to ensure the survival of this industry in North America, and is ready to work with the United States to address them. However, any measure that negatively impacts the mutually beneficial Canada-U.S. uranium trade risks greater dependence on uranium imports from non-market based producers in non-allied countries. This would tend to erode, rather than enhance, U.S. national security.

Maintaining open trade in uranium between our two countries is crucial to the economic well-being of both of our industries, workers and communities, which in turn supports our collective security. Canadian companies have been significant investors, contributors, and collaborators across the uranium fuel cycle in the United States, from mining and enrichment to production and fuel fabrication, in support of nuclear power generation.

Canada has always been a trusted security partner of the United States. Canada and the United States share the world's largest and most integrated bilateral energy relationship, which contributes significantly to U.S. national and energy security. Uranium from Canada is a secure, reliable and market-based input supporting U.S. national and energy security. Canadian uranium exports to the United States are used only for peaceful purposes and offer a steadfast support to U.S. energy security. Based on our mutually reinforcing security and trade relationship, there is no basis for import restrictions against uranium from Canada for national security purposes.

Uranium Trade with Canada Supports U.S. National Security

Open uranium trade with Canada strengthens U.S. national security by allowing the U.S. nuclear power industry to purchase uranium from a secure trading partner. For more than 75 years, Canada has been a stable and reliable source of uranium to the United States. Canadian uranium is sold to U.S. utilities through long-term contracts, which provide the supply and price stability needed to make sound economic decisions on their operations. Canadian uranium also supports U.S. industries that provide uranium conversion, enrichment and fuel fabrication services.

The Canadian and U.S. uranium and nuclear energy industries are closely integrated, offering considerable mutual benefit through the cooperation and two-way trade that takes place in this sector every day. Canadian uranium companies are major investors in the United States. For example, Cameco Corporation, based in Saskatchewan, Canada, has invested more than $1 billion in its mining operations in Wyoming and Nebraska, in addition to its interest in other prospective technologies further along the nuclear fuel cycle. At the same time, since 2011 Cameco has purchased about $360 million worth of goods and services from more than 920 U.S. vendors for use at its Canadian operations. On top of supplying uranium, Canadian companies also supply services, such as uranium conversion, for the U.S. nuclear power industry.

Common Challenges Faced by the Canadian and U.S. Uranium Industries

a) <u>Low prices</u>

The main problem facing the uranium industry is continued low global prices. Uranium prices have dropped 70 percent since 2011. Only one-third of the world’s mines can produce uranium profitably at current spot prices. Due to low prices, both the Canadian and U.S. uranium industries have been forced to reduce costs by closing mines and reducing staff.

The first factor causing reduced prices is lower demand. Since the 2011 Fukushima Daiichi accident, certain countries, in particular Japan and Germany, have shut down nuclear power plants, resulting in a lower global demand for uranium. Other countries have put future nuclear plant developments on hold or have announced a phasing-out of nuclear power altogether.

The second factor affecting the uranium price is the increase in uranium production in Central Asia, which has led to excess supply in the global uranium market. Together, Kazakhstan, Uzbekistan, Russia and China now account for over 50 percent of global uranium production. In contrast, Canadian producers provided 22 percent of global uranium output in 2017.

b) State-owned enterprises (SOEs)

The prevalence of SOEs in Central Asia has contributed significantly to the current problematic market conditions. At best, they simply lack commercial discipline because of government guarantees or financial bailouts. At worst, they pursue “loss leader” strategies to dominate the nuclear industry for the geopolitical aims or foreign policy influence of the state, forcing out commercial producers in the process.

Many of these SOEs have been selling large amounts of uranium at spot market prices regardless of production costs – often even at a loss – which has reduced long-term contract prices on which the Canadian and U.S. uranium industries rely.

Shielded from market discipline, these SOEs can continue to produce, unabated, even through the most unfavourable economic conditions the industry has seen in decades. Market-based producers in the United States and Canada cannot operate this way. Cameco, traded on both the New York and Toronto stock exchanges, is the world’s largest private sector uranium producer. Similar to the difficult decisions that have been made by U.S. uranium companies, depressed market conditions have forced Cameco to halt production and suspend activity at several of its mining and milling operations in Canada and the United States. The shutdown of these operations, on both sides of the border, has resulted in more than 1,500 North American workers losing their jobs.

Until 2016, Cameco was the largest U.S. uranium producer. However, the company has also been forced to curtail its U.S. operations due to low prices. Cameco remains an active member of the Uranium Producers of America, and constructively engages in the identification of solutions to the current challenges that the industry faces.

c) Secondary uranium supplies

Increased uranium production is not the only factor that contributes to the current oversupply in the market. Secondary uranium supplies, primarily from excess military stockpiles in Russia and the United States, have had a significant negative effect on the uranium market. While Canada is supportive of the U.S. Department of Energy's recent efforts to reduce fissile material stockpiles, secondary supplies should complement available sources of uranium from mine production and not be released in a manner which causes harm to the industry.

d) Lack of a global level-playing field

Canada and the United States have higher environmental standards than many other uranium producing countries. This provides the Canadian and U.S. public with assurance that uranium is mined sustainably. However, countries that have less stringent environmental standards are able to avoid environmental costs through mining practices that are harmful to the environment. Globally, the uranium industry is not a level-playing field. Canada believes that this needs to be addressed cooperatively by working together with like-minded countries such as the United States.

Trade Restrictions on Uranium from Canada Would Harm the United States

Uranium imported from Canada does not threaten U.S. national security. In fact, the opposite is true: restricting Canada-U.S. uranium trade could harm the U.S. economy and weaken U.S. national security.

The petition from the two U.S. uranium companies that initiated this Section 232(b) investigation contained a warning about growing U.S. dependence on production from SOEs in countries not aligned with U.S. policy interests. If trade action is taken as a result of this investigation that restricts the free flow of trade between the Canadian and U.S. nuclear industries, this situation could in fact worsen, having the exact opposite effect to what U.S. stakeholders are seeking.

Broader consideration should be given to the significant geopolitical and strategic implications of any market restrictions that affect Canadian uranium producers. Such restrictions have the potential to create additional unintended challenges for North American-based producers that must maintain their profitability and respond to shareholder expectations. SOEs that are backed by their governments and are able to supply low-cost uranium should not be able to increase their share of global uranium production at the expense of market-based producers in North America.

NAFTA Energy Chapter

In a similar 1989 investigation under Section 232(b) of the *Trade Expansion Act of 1962* on the effects of uranium imports, the Department of Commerce concluded that Article 907 of the Canada-U.S. Free Trade Agreement exempted Canadian energy products from national security-related trade restrictions, as long as those energy products are used for non-military purposes. NAFTA Article 607 (National Security Measures) places the same limits on the use of national security trade restrictions for energy sector products. Canadian uranium exported to the United States is used only for peaceful purposes such as electrical power generation; it is never used for defense or national security-related purposes. The NAFTA provision underscores the importance of open trade in North American energy that is beneficial to all parties.

Essential Security Partners

Beyond our role as a supplier of energy to the U.S., Canada is also an essential partner in U.S. national security. Our bilateral cooperation in foreign relations, defense and security relations, defense industrial cooperation, and public safety is longstanding and codified by many bilateral agreements and arrangements – including the North Atlantic Treaty Organization and the North American Aerospace Defense Command – that touch on every element of national security. Given these arrangements, Canadian uranium supply for U.S. energy requirements can only be understood as a steadfast support to U.S. national security interests.

U.S. law recognized Canada as the only foreign country to be part of the U.S. National Technology and Industrial Base (NTIB) from 1993 until 2016, when the United Kingdom and Australia were added. Canada was further recognized as a close and important ally when the U.S. Congress directed the Secretary of Defense to develop a plan to facilitate the seamless integration between the persons and organizations that comprise the NTIB in its *National Defense Authorization Act* for Fiscal Year 2017 (NDAA 2017). NDAA 2018 and NDAA 2019 also include measures specifically aimed at strengthening the NTIB.

Our close defense industrial base cooperation ensures our mutual security, helps avoid the duplication of efforts, increases interoperability and provides a surge production capacity, all of which contribute to our respective national security. For the past 150 years, in times of war and national emergencies, Canada has always been a secure and trusted partner and ally of the United States.

Conclusion

The Canada-U.S. economic, defense, and security relationships highlighted in this submission demonstrate that Canada is a key security and defense partner of the United States. Canada stands with the United States in our collective desire to address common challenges faced by our respective uranium industries in relation to the stubbornly depressed global uranium market, and to otherwise bolster national security in both Canada and the United States.

In conducting this Section 232(b) investigation, we urge the Department of Commerce to recognize these longstanding and mutually beneficial trade and security relationships as well as the importance of secure, reliable and market-based uranium supplies to both of our countries' security interests. Such recognition would, by necessity, conclude that uranium imports from Canada do not threaten to impair U.S. national security. Open uranium trade with Canada strengthens U.S. national security by allowing the U.S. nuclear power industry to purchase uranium from its most trusted, stable, and reliable trading partner. Overlooking this reality could leave the United States even more dependent on state-owned production from non-allied countries, increasing the influence of those governments whose actions are destabilizing the market.

URANIUM

Import quota battle heats up

Dylan Brown, E&E News reporter

Published: Monday, February 11, 2019

A worker holding a billet of highly enriched uranium. Department of Energy/Wikipedia

Uranium miners and importers, former allies turned rivals, both say national security is on the line in the Trump administration's upcoming decision over whether to impose restrictions on uranium imports.

The Commerce Department is considering a 25 percent quota for domestic uranium under Section 232 of the Trade Expansion Act, following a public comment period last year. A recommendation is due April 14, then Trump will have 90 days to make a decision, though government shutdowns may upend that timeline.

American uranium mining companies want the president to protect their industry like he did steel and aluminum, but nuclear power advocates say a "buy American" mandate threatens power plants already at risk of closure. Attacks between the two industries, which belong to some of the same trade groups, continue to escalate.

According to preliminary data from the U.S. Energy Information Administration, last year's U.S. uranium production was at the lowest level since 1950. The nation's six active uranium extraction operations employ fewer than 500 people. U.S. mining firms argue they could easily supply a quota, since active operations run well under capacity and permitted mines sit idle.

"Without some level of support, licenses and permits will be lost and uranium production facilities will go into reclamation, likely never to return in the future," Energy Fuels Inc. and Ur-Energy Inc., the companies that **petitioned** for the federal investigation, wrote in a recent press release.

Utilities counter that unused capacity and a Department of Energy stockpile can easily weather any foreign attempt to disrupt the uranium supply chain. The federal government only stopped selling excess nuclear fuel last year after a protest by Sen. John Barrasso, a Republican from Wyoming — the nation's top uranium-producing state.

Now is not the time to raise fuel costs, according to Ad Hoc Utilities Group (AHUG), the organization major nuclear power generators formed to fight the quotas (***E&E News PM***, Sept. 28, 2018). An AHUG-commissioned study estimated that a 25 percent quota would cost $500 million to $800 million a year. "The closure of one plant would lead to a loss of more jobs than the entire U.S. uranium mining industry," the Nuclear Energy Institute wrote in **comments** submitted to the Commerce Department.

But Energy Fuels and Ur-Energy said the annual cost increase would be just $300 million, offset by a less than 1 percent increase in the average electric bill. "This is a small price to pay for national and energy security," the companies wrote last year.

According to EIA, the U.S. purchased 93 percent of its uranium overseas in 2017. Energy Fuels and Ur-Energy expect imports to reach 99 percent this year.

The governments of **Canada** and **Australia** have each lodged objections to the import quotas with the Commerce Department. Australia exports 60 percent of its uranium to the U.S.

"This development harms trade, growth and jobs in the U.S. and abroad, weakens the bonds with friends and allies, and shifts attention away from the shared strategic challenges that genuinely threaten the market-based Western economic model," the **European Union** told the Commerce Department.

AHUG noted that 52 percent of U.S.-used uranium came from Canada and Australia in 2017, compared with 16 percent from Russia and none directly from China. Canada has only one active uranium operation after McArthur River, the world's largest uranium mine, suspended operations last year. In Australia, the Ranger mine announced it will close by 2021.

Nevertheless, Energy Fuels and Ur-Energy accuse Russia and China of "flooding" the market to drive "free market" uranium out of business. "These utilities choose to irresponsibly ignore the glaring evidence that our nation's rivals are pursuing deliberate strategies to undermine the U.S.," the mining companies wrote in a press release last week.

The pair also said that Russia and state-run nuclear corporation Rosatom are exerting control in countries like Kazakhstan, the world's top uranium producer, and Uzbekistan. Those two countries accounted for 16 percent of U.S. imports in 2017. "Directly or indirectly, these enterprises take their marching orders from Vladimir Putin, who has a history of using natural resources as a weapon," they wrote.

Kazakhstan rebuked claims that its state-run company manipulated prices and markets. "Kazatomprom operates on market conditions, in a competitive environment, does not need government support, and conducts its operational activities on an equal business basis," the **Ministry of National Economy** wrote.

Russia's Rosatom submitted an extensive critique via American fuel subsidiary **Tenam Corp.**

Complicating the matter, another subsidiary of Rosatom, Uranium One Inc., actually owns one of the last six American uranium operations. The Obama administration's approval of the Russian entity taking over the Wyoming operation launched a controversy that plagued former Secretary of State Hillary Clinton during her bid for president (***Greenwire***, Sept. 25, 2018).

Utah-based environmental group **Uranium Watch** told the Commerce Department that Uranium One's Russian ownership undermines the justification for a U.S. uranium quota. "Why would the U.S. allow a company that is owned by Russia to produce uranium in the U.S.?"

Energy Fuels Inc. and Ur-Energy Inc. are incorporated in Canada but say all their operations and most shareholders are American.

But others argued their motives are conflicted. "Two foreign-owned uranium mining companies are unfairly using the [Commerce] 232 process," said David Tamasi, a spokesman for AHUG. Tamasi, a former Trump Victory Fund finance chairman, said a "thirst for profits" could raise nuclear fuel costs and "immediately threaten 100,000 good-paying domestic jobs" in nuclear power.

Opposition to the 25 percent quota dominated the public comments submitted by individuals and organizations ranging from the U.S. Chamber of Commerce to the Sierra Club.

A majority of opposition comments came as part of an online campaign of people who said they are concerned about renewed uranium mining near the Grand Canyon, where Energy Fuels owns several idled mines (***E&E News PM***, Oct. 25, 2018).

Free trade advocates also condemned import quotas. Heritage Foundation policy analyst Katie Tubb called uranium imports "irrelevant" to military uranium needs and of "little risk" to nuclear power. "Trade has given U.S. nuclear companies access to new markets and enabled them to shop for affordable components, including uranium," Tubb wrote.

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Politics

Uranium Imports Aren't a Threat, Obama's Energy Chief Says

By Ari Natter

April 16, 2019, 3:03 PM EDT

Updated on April 16, 2019, 4:25 PM EDT

Ernest Moniz *Photographer: Patrick T. Fallon/Bloomberg*

A former U.S. energy secretary dismissed the idea that an influx of foreign uranium imports is a threat to national security, rejecting what could be a justification for future import quotas to protect domestic suppliers.

“I have never considered uranium to be a major security issue,” Ernest Moniz, who led the Department of Energy under former President Barack Obama, said in an interview. “I think uranium supply -- especially a commodity like that, that you can store lots and lots of it -- I don’t consider it to be a driving national security issue.”

The Commerce Department, at the behest of two small domestic uranium producers, Energy Fuels Inc. and Ur-Energy Inc., recently concluded an investigation of whether imports of the radioactive metal harm national security. Moniz said the ability to stockpile uranium undercuts the argument from domestic miners that the U.S. relies too heavily on foreign producers for its future supply.

These two companies asked the White House to reserve 25 percent of the domestic market for U.S. producers using the same law the Trump administration cited last year to bypass Congress to levy tariffs on steel and aluminum imports.

Nuclear reactor operators, which import nearly all of their uranium from countries including Canada, Russia, and Kazakhstan, argue that such a move could increase their costs by as much as $800 million a year. That would translate send about 6.7 gigawatts of nuclear capacity into negative margins, according to research published today by BloombergNEF.

If the Commerce Department finds imports of uranium threaten national security, President Donald Trump would have authority to impose an import quota or some other trade remedy -- or do nothing at all.

(Adds Bloomberg New Energy Finance research in penultimate paragraph.)

In this article

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BACKGROUNDER

No. 3360 | NOVEMBER 2, 2018

National Security Imperative Lacking, Protectionism Abounding in Section 232 Uranium Case

Katie Tubb

Abstract
The Trump Administration has opened a national security investigation of uranium imports under Section 232 of the Trade Expansion Act of 1962. Uranium imports are irrelevant to the military's current and expected needs, and action under Section 232 would be misapplied. There is also little risk to civilian customers from imported uranium, such as the nuclear power industry. Although imposing tariffs may give the short-term impression of helping the uranium-mining industry, doing so ignores the longer history of damage inflicted to the industry by protectionist policies.

KEY POINTS

- The civilian nuclear industry today is inherently international in scope. Trade has given U.S. nuclear companies access to new markets and enabled them to shop for affordable components, including uranium.
- Contrary to the premise in the current Section 232 petition, the Department of Energy has determined its uranium inventory currently meets all government requirements.
- What the Section 232 petition frames as a national security threat is actually a massive correction in international markets stemming from short-term contractions in uranium demand and longer-term developments in uranium production and use.
- Action by the President and Department of Commerce under Section 232 of the Trade Expansion Act would misuse the law and exacerbate problems in the greater domestic nuclear industry.
- The Trump Administration should recognize the value of international markets to the U.S. nuclear industry and encourage greater competition.

The Department of Commerce is progressing through a national security investigation of uranium imports under Section 232 of the Trade Expansion Act of 1962.[1] The petitioners—uranium-mining companies Energy Fuels and Ur-Energy—argue that the small domestic uranium industry is threatened by unfair competition from Russia, Kazakhstan, and Uzbekistan, and that reliance on these countries threatens surety of supply for uranium-dependent defense assets like the Navy's nuclear-powered submarines and civilian nuclear power reactors.

Despite these claims, the petition lacks a clear national security imperative and, in fact, would implicate some of the United States' strategic allies and major uranium suppliers, principally Australia and Canada. There is no compelling evidence that foreign-sourced uranium places current or future military operations at risk. Protectionism, as conceived by the petitioners, would also levy undue costs on the greater nuclear industry while providing no sustainable, long-term solution for uranium miners in what is clearly a situation

This paper, in its entirety, can be found at **http://report.heritage.org/bg3360**

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of economic hardship. Today's commercial uranium-mining industry is in some sense a victim of the very protectionist policies that reigned through 1984.

The Trump Administration should quickly address regulatory issues so that the uranium-mining industry can nimbly respond when domestic and international markets recover. To address any real trade abuses, the U.S. should present a united front with allies. However, action under Section 232 is misdirected and misapplied.

Section 232 and the Petition

The Constitution empowers Congress with the authority to regulate international trade. However, Section 232 of the Trade Expansion Act of 1962 delegates extensive authority to the President to determine whether a product "is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security."[2]

Once an investigation is opened, the Department of Commerce has 270 days to recommend whether the President should take action. There have been 30 investigations under Section 232, only eight of which resulted in action by the President; of these, five were related to crude oil and petroleum. According to the Congressional Research Service, the President has not acted under Section 232 since 1986—a decade before the World Trade Organization's creation—until the Trump Administration's most recent tariffs on steel and aluminum imports.[3]

Among the factors considered by the Department of Commerce in an investigation are:

- Defense and related civilian industry needs, both current and future,
- Quality and availability of imports, and
- The effect of imports on supporting civilian industry.

If the Secretary of Commerce concludes that imports threaten national security, the President has 90 days to decide whether and how to act.[4]

The Department of Commerce opened an investigation on uranium imports on July 18, 2018, in response to a petition by uranium-mining companies Energy Fuels and Ur-Energy. According to the petitioners, "Our country cannot afford to depend on foreign sources—particularly Russia, and those in its sphere of influence, and China—for the element that provides the backbone of our nuclear deterrent, powers the ships and submarines of America's nuclear Navy[,] and supplies 20 percent of the nation's electricity."[5] Russia, Kazakhstan, and Uzbekistan supplied 32 percent of the uranium delivered to U.S. nuclear power reactors in 2017, compared to the 7 percent from U.S. suppliers.[6] The petitioners have requested limits on imports to guarantee roughly 25 percent of the domestic market for U.S. uranium miners and "Buy American" provisions for government purchases.[7]

Four Points to Consider

Action by the President and Department of Commerce under Section 232 of the Trade Expansion Act would misuse the law and exacerbate problems in the greater domestic nuclear industry.

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1. News release, "U.S. Department of Commerce Initiates Section 232 Investigation into Uranium Imports," U.S. Department of Commerce, July 18, 2018, https://www.commerce.gov/news/press-releases/2018/07/us-department-commerce-initiates-section-232-investigation-uranium (accessed October 2, 2018).
2. 19 U.S. Code § 1862.
3. Rachel F. Fefer, Vivian C. Jones, Keigh E. Hammond, Brandon J. Murrill, Michaela D. Platzer, and Brock R. Williams, "Section 232 Investigations: Overview and Issues for Congress," Congressional Research Service *Report for Congress*, September 11, 2018, https://fas.org/sgp/crs/misc/R45249.pdf (accessed October 10, 2018).
4. Ibid.
5. "Petition for Relief Under Section 232 of the Trade Expansion Act of 1962 from Imports of Uranium Products that Threaten National Security," January 16, 2018, p. 2, http://www.energyfuels.com/wp-content/uploads/2018/01/2017.01.16-Signed-Petition.pdf (accessed October 22, 2018).
6. U.S. Energy Information Administration, "2017 Domestic Uranium Production Report," May 2018, https://www.eia.gov/uranium/production/annual/pdf/dupr.pdf (accessed October 2, 2018).
7. News Release, "Energy Fuels and Ur-Energy Jointly File Section 232 Petition with U.S. Commerce Department to Investigate Effects of Uranium Imports on U.S. National Security," Energy Fuels, January 16, 2018, http://www.energyfuels.com/news-pr/energy-fuels-ur-energy-jointly-file-section-232-petition-u-s-commerce-department-investigate-effects-uranium-imports-u-s-national-security/ (accessed October 2, 2018).

1. Sourcing Domestic Uranium Is Not an Immediate or Pressing National Security Issue.

Critical defense-related assets—principally nuclear-powered submarines, aircraft carriers, and weapons—require domestically sourced uranium, processing, and enrichment facilities that are not "obligated" or "encumbered" by international nonproliferation agreements or peaceful-use restrictions. Most of these needs are met through the stockpile of highly enriched uranium managed by the National Nuclear Security Administration within the Department of Energy (DOE).

Contrary to the premise of a Section 232 petition (and the claims of the petitioners), the DOE has determined its uranium inventory currently meets all government requirements. Future defense-related uranium needs are well known: The most immediate need is unencumbered tritium production reactor fuel in the range of 2038 to 2041, and new fuel sources for naval reactors are not needed until 2060.[8] If anything, it could be argued that domestic uranium resources should be reserved exclusively for meeting these national security needs rather than subsidized for consumption by commercial entities.

Further, Congress created tools to provide for the national defense in extreme economic cases should a critical defense shortage arise. Principally, the Defense Production Act (DPA) authorizes limited industry protections in order to ensure the military's strategic needs are met. The DPA defines three criteria for federal action in the face of a strategic shortage in the defense industrial base:

1. The resource or product must be "essential for national defense";
2. The private sector "cannot be expected" to meet national security needs in the time required; and
3. Action taken to address the shortage must be "the most cost effective, expedient, and practical alternative."[9]

Appropriately then, under the DPA *taxpayers* pay the premium for a national security benefit rather than *ratepayers* shouldering the costs for everyone, as the petitioners propose.

On the civilian side, there is little risk of supply shock to nuclear power plants that would induce the sort of emergency the petitioners imagine. Undeniably, Russia has manipulated energy markets in the past to leverage politics. But rather than dependence on any one supplier, American nuclear power operators purchased uranium from 11 countries in a variety of long-term and spot-price contracts. Longtime allies Canada and Australia supplied 52 percent of the uranium delivered to U.S. reactors in 2017.[10] Comparatively, Russia supplied 16 percent, Kazakhstan 11 percent, and Uzbekistan 5 percent. China supplied zero percent. Throughout the fuel cycle, nuclear power today is inherently an endeavor in international trade. Far from being a threat, inexpensive uranium imports have helped nuclear power companies in the U.S. to be more competitive in tight electricity markets.

Some in the domestic uranium-mining industry have tried to leverage a national security angle before, but with different targets. In the late 1980s, the mining industry unsuccessfully attempted to use a variety of legal, legislative, and trade measures to target Canada and Australia. At the time, the Uranium Producers Association stated that a statutorily mandated study of the uranium industry "will highlight the risks involved in letting one or two foreign governments, however friendly, dominate the domestic uranium market."[11] The study did not lead to executive action, and in the 30 years since, neither Canada nor Australia has presented a national security threat,

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[8] U.S. Department of Energy, "Tritium and Enriched Uranium Management Plan Through 2020," Report to Congress, October 2015, http://fissilematerials.org/library/doe15b.pdf (accessed September 7, 2018).

[9] Katie Tubb, Nicolas Loris, and Rachel Zissimos, "Taking the Long View: How to Empower the Coal and Nuclear Industries to Compete and Innovate," Heritage Foundation *Backgrounder* No. 3341, September 5, 2018, https://www.heritage.org/energy-economics/report/taking-the-long-view-how-empower-the-coal-and-nuclear-industries-compete.

[10] U.S. Energy Information Administration, "2017 Uranium Marketing Annual Report," May 2018, https://www.eia.gov/uranium/marketing/pdf/umar2017.pdf (accessed September 7, 2018).

[11] James R. Wilch, "GATT and the Half-Life of Uranium Industry Protection," *Northwestern Journal of International Law and Business*, Vol. 10, No. 1 (Spring 1989), p. 173, https://scholarlycommons.law.northwestern.edu/cgi/viewcontent.cgi?article=1277&context=njilb (accessed September 7, 2018).

but rather have been reliable suppliers of affordable uranium for commercial needs. Today, as then, the issue is not about national security needs but international competition.

2. Uranium Markets Are Oversupplied and Highly Competitive.

What the Section 232 petition frames as a national security threat is actually a massive correction in international markets stemming from short-term contractions in uranium demand and longer-term developments in uranium production and use. The uranium-mining industry in the U.S. has experienced a prolonged decline since its peak in 1980. Since then, the U.S. Energy Information Administration reports reduced investment in employment, land, exploration, drilling, and production that has been almost uninterrupted.[12] This domestic experience has been mimicked globally.[13]

In the more recent past, the hoped for increase in uranium demand failed to appear with the "nuclear renaissance" of the early 2000s. The Nuclear Energy Agency's latest review of global uranium resources, production, and demand (also known as the 2016 "Red Book") is littered with revisions to adjust for unanticipated slow growth across the nuclear industry, particularly in response to the Fukushima Daiichi accident in 2011.[14] Contributing to this unexpected downturn in global uranium demand were a number of other factors that depressed markets in the U.S.: the 2008 financial crisis, flat electricity demand, nuclear power plant closures, increased fuel and reactor operations efficiencies, and the natural gas boom.[15] Accordingly, domestic licensed mine capacity more than tripled since 2004 in anticipation of growth, but only a small handful of mines are actually operating given market conditions.[16] On the demand side, commercial inventories of uranium are one-and-a-half times larger than in 1994.[17]

Looking at long-term trends, the American uranium industry has been struggling for decades. It enjoyed favorable contracts with the federal government through 1970, when the Atomic Energy Commission (DOE's predecessor) ended its procurement program for natural uranium.[18] Not long after, a burgeoning civilian nuclear-power sector was bogged down in overregulation after the Three Mile Island accident in 1979, leaving in its wake a drought in new construction. U.S. uranium production peaked in 1980 and, like the rest of the U.S. nuclear industry, began a slow, steady decline.

Concurrently, weapons programs during World War II and the Cold War created large strategic demand for uranium and consequently massive stockpiles of uranium that far exceeded world demand for the past half century.[19] Though global demand increased as more countries adopted nuclear power, these secondary sources of uranium—notably peaceful repurposing of excess military uranium inventories—have fed into civilian markets, meeting anywhere from 1 percent to 50 percent of global uranium requirements.[20] Since the end of the Cold War, strategic stockpiles from the U.S. and Russia—large enough to meet several years of global demand—gradually have been made available to civilian markets, underscoring the challenging civilian market conditions for uranium mining and creating uncertainty for market investments.[21]

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[12] U.S. Energy Information Administration, "2017 Domestic Uranium Production Report."

[13] Nuclear Energy Agency and International Atomic Energy Agency, *Uranium 2016: Resources, Production, and Demand* (Organization for Economic Co-operation and Development: Paris, 2016), https://www.oecd-nea.org/ndd/pubs/2016/7301-uranium-2016.pdf (accessed September 7, 2018), pp. 114–115.

[14] See, for example, ibid., p. 70.

[15] Ibid., p. 93

[16] U.S. Energy Information Administration, "2017 Domestic Uranium Production Report."

[17] Ibid., p. 11.

[18] Nuclear Energy Agency and International Atomic Energy Agency, *Uranium 2016*, p. 408, and U.S. Department of Energy, "Tritium and Enriched Uranium Management Plan."

[19] Nuclear Energy Agency and International Atomic Energy Agency, *Uranium 2016*, pp. 104 and 114.

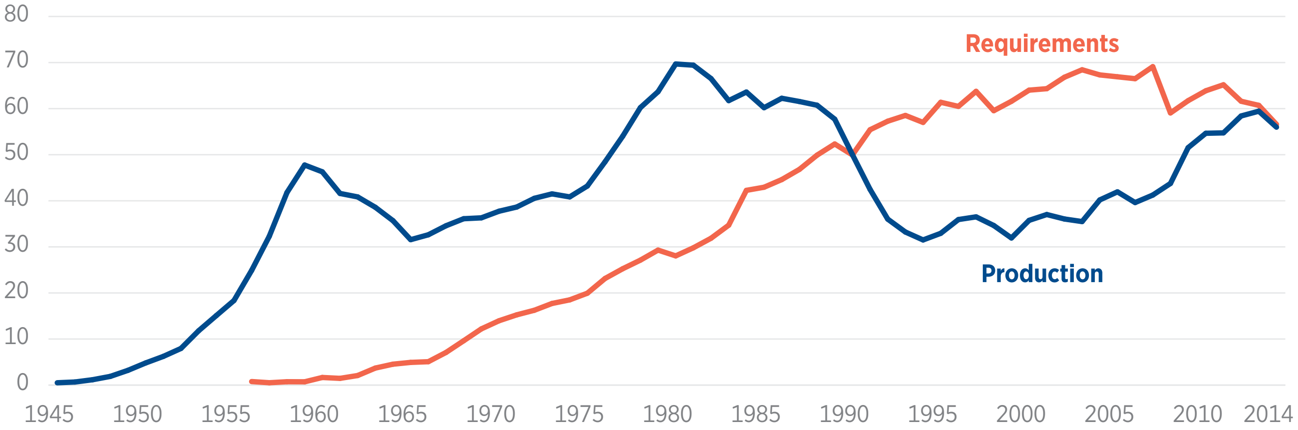
[20] Ibid., pp. 102 and 104–105.

[21] Ibid., pp. 104 and 108.

CHART 1

Uranium Markets Are Oversupplied and Highly Competitive

IN THOUSANDS OF METRIC TONS OF URANIUM



NOTE: Figure for 2005 was interpolated
SOURCE: Nuclear Energy Agency, "Nuclear Development Publications," http://www.oecd-nea.org/tools/publication?query=&div=NDD&lang=English&period=2y&sort=date&filter=1 (accessed October 22, 2018). NEA numbers correspond to the following years: 2005—6098; 2007—6345; 2009—6891; 2011—7059; 2014—7209; 2016—7301.

BG3360 heritage.org

3. Federal and State Governments Have Made the U.S. a Volatile and Sometimes Hostile Place for Uranium Mining and the Civil Nuclear Industry in General.

The uranium-mining industry, like the rest of the nuclear industry, faces regulatory barriers that tamp down demand and could keep it from nimbly responding when markets recover. Both Energy Fuels and the Department of Commerce identified multi-year permitting delays to open or re-open mines as a challenge for uranium miners.[22] State and federal governments have also restricted access to resources. For example, in 2012, the Obama Administration denied access to over 1 million acres of federal land in Arizona in 2012, and the State of Virginia has a ban on uranium mining that is being contended in the Supreme Court.[23] The DOE has distorted uranium markets and production through uranium transfers and special deals for DOE contractors.[24]

Too often in the nuclear sector the government has chosen to subsidize specific companies or technologies rather than address the regulatory challenges and government-induced uncertainties that reverberate throughout the nuclear industry. Just one example is the federal government's willful failure to finish the licensing review of a possible nuclear-waste repository at Yucca Mountain. Otherwise legitimate licensing activities were halted during the hailed

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[22] News release, "UR-Energy and Energy Fuels: Utility-Sponsored Paper Misses the Mark on Economic Impact of Remedies Proposed in Section 232 Petition," July 17, 2018, http://www.energyfuels.com/news-pr/ur-energy-and-energy-fuels-utility-sponsored-paper-misses-the-mark-on-economic-impact-of-remedies-proposed-in-section-232-petition/ (accessed September 7, 2018), and news release, "U.S. Department of Commerce Initiates Section 232 Investigation into Uranium Imports," U.S. Department of Commerce, July 18, 2018, https://www.commerce.gov/news/press-releases/2018/07/us-department-commerce-initiates-section-232-investigation-uranium (accessed September 7, 2018).

[23] Timothy Gardner, "U.S. Miners Seek Reversal of Uranium Mining Ban near Grand Canyon," Reuters, March 9, 2018, https://www.reuters.com/article/us-usa-uranium-grandcanyon/u-s-miners-seek-reversal-of-uranium-mining-ban-near-grand-canyon-idUSKCN1GM001 (accessed September 7, 2018).

[24] See, for example, Jack Spencer and Daniella Markheim, "Protectionism Won't Fuel a Nuclear Renaissance," Heritage Foundation *Backgrounder* No. 2221, December 16, 2008, http://s3.amazonaws.com/thf_media/2008/pdf/bg2221.pdf.

"nuclear renaissance" as a result,[25] and the nuclear waste issue has discouraged states and localities from maintaining or introducing nuclear power.[26] Naturally, this failure indirectly impacts commercial uranium demand. The nuclear industry cannot grow with one-third of its business suspended by government inaction and no clear pathway for waste management.

Perhaps more egregious, however, is the legacy of past protectionist policies. Through 1984, the Atomic Energy Commission (AEC) maintained policies that effectively prevented imported uranium from entering U.S. markets—principally through denying uranium-enrichment services. The policy succeeded in forcing U.S. nuclear power plants to use domestic uranium because at that time the Soviet Union housed the only other enrichment capabilities needed to fabricate nuclear fuel. The expressed intent of these policies was to temporarily block competition in order to help launch a civilian nuclear industry independent from strategic wartime infrastructure.[27]

Instead, these policies distorted markets and grossly misinformed the uranium-mining industry as to what constituted actual demand. AEC policies set off a mad dash for its enrichments services by nuclear-power operators anxious to secure reliable fuel for their reactors, ballooning uranium prices within the U.S. and ultimately creating civilian stockpiles large enough to cover years' worth of demand.[28] Protectionism also pushed the limits of reciprocal trade agreements with allies, mobilizing nations like France, Great Britain, Germany, and the Netherlands to break the AEC's monopoly on enrichment.

International trade with more flexibility in contracts replaced the AEC's centralized approach as it phased out its protectionist policies by 1984. But decades of protectionism created a glut in domestic supply, left the domestic uranium industry ill-prepared, and mobilized its greatest competitors.

4. Action Under Section 232 Is Misapplied.

As discussed previously, there is no national security case to warrant targeting uranium imports under Section 232. To the extent that there are legitimate, provable violations of international agreements by trading partners, there are far better policy tools that directly address those concerns—rather than negatively impacting companies and countries that have competed in good faith to win customers in America. For example, the Office of the United States Trade Representative can file country-specific disputes through the World Trade Organization, an avenue through which the U.S. has had success in pursuing other trade disputes.[29]

The U.S. should also present a united front with allies to address any real violations by trading partners. As Heritage's Tori Whiting writes, "The goal of trade cases should not be to 'punish' other countries. Using broad trade measures to target the actions of one country might seem like firing a missile at a target, but the shrapnel can have a devastating effect on bystanders."[30]

No Tariff Winners

There are no long-term winners should the Trump Administration impose tariffs on uranium imports under Section 232. Tariffs on uranium imports do not address the military's need for domestic enrichment capabilities and are otherwise irrelevant. Restricting access to the most competitive materials makes nuclear power plants and other uranium users less competitive. While tariffs may give the short-term

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[25] In September 2014, the Nuclear Regulatory Commission determined that dry-cask storage was safe indefinitely and restarted licensing activities. Katie Tubb and Jack Spencer, "Real Consent for Nuclear Waste Management Starts with a Free Market," Heritage Foundation *Backgrounder* No. 3107, March 22, 2016, http://www.heritage.org/environment/report/real-consent-nuclear-waste-management-starts-free-market.

[26] National Conference of State Legislators, "State Restrictions on New Nuclear Power Facility Construction," May 2017, http://www.ncsl.org/research/environment-and-natural-resources/states-restrictions-on-new-nuclear-power-facility.aspx (accessed September 7, 2018).

[27] Wilch, "GATT and the Half-Life of Uranium Industry Protection."

[28] Ibid., pp. 171 and 189.

[29] Tori Whiting, "Tariffs Make for a Poor Negotiating Tactic: The Trump Administration Should Abandon Them Without Delay," Heritage Foundation *Issue Brief* No. 4848, April 26, 2018, https://www.heritage.org/trade/report/tariffs-make-poor-negotiating-tactic-the-trump-administration-should-abandon-them.

[30] Tori Whiting, "Four Guidelines for the President When Considering Tariffs," Heritage Foundation *Issue Brief* No. 4811, January 22, 2018, https://www.heritage.org/trade/report/four-guidelines-the-president-when-considering-tariffs.

impression of helping the uranium-mining industry, doing so ignores the history of damage done by earlier protectionist policies—as well as anti-competitive policies in the more recent past. Perhaps the only winners in a tariff situation are foreign competitors who may be able to raise their own prices to just below the tariff-inflated price for American customers with whatever market share remains to them, should the Department of Commerce act.

The civilian nuclear industry today is inherently international in scope. Trade has given U.S. nuclear companies access to new markets and enabled them to shop for affordable components, including uranium. The Trump Administration should recognize the value of international markets to the U.S. nuclear industry and encourage greater competition.

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FEB. 21, 2018, AT 12:01 PM

It’s One Thing For Trump To Like Uranium. It’s Another For Him To Save It.

By Maggie Koerth-Baker

Filed under The Trump Administration

PHOTO ILLUSTRATION BY FIVETHIRTYEIGHT ; GETTY IMAGES

Stop me if you’ve heard this one before: A mining industry is trapped in a state of slow economic decline and looks to the Trump administration to reverse its fortunes.

That could be the lead-in to a story about coal — an industry the administration has made a point of promoting. But it’s also similar to the story of uranium, the radioactive mineral that serves as a raw material for manufacturing fuel for nuclear power plants and the explosive cores of nuclear weapons. The key difference: Although coal companies have pushed for reduced regulation, representatives of uranium mining companies told me in an interview that they don’t want less environmental protection. They want protection of a different kind, however.

In its efforts to make coal great again, the Trump administration has made a point of embracing the industry, cutting regulations and talking up the mineral’s importance. Uranium hasn’t gotten quite the same level of personal attention from the president. (There’s been a distinct lack of “Trump Digs Uranium” signs, for instance.) But his administration has made several moves in the past year that seem to favor uranium mining interests: It shrunk the Bears Ears National Monument in Utah in a way that would make it easier for companies to mine uranium on hundreds of previously established claims in the area; it proposed ending a ban on uranium mining near the Grand Canyon; it moved forward on a proposed uranium mine near the Black Hills; it nominated a deputy administrator for the Environmental Protection Agency who used to be a lobbyist for a uranium mining company; and it left an Obama-era proposal about groundwater protections at uranium mining sites in limbo — neither approving the proposed rule nor rejecting it.

But while it’s taken outside economists to point out that environmental protection rollbacks aren’t going to save the coal industry, uranium industry insiders say they have little interest in taking advantage of the loosened environmental protections the Trump administration has offered them. “There’s not a big push to start up new mines [on former federal lands]; the price is way too low,” said John Cash, vice president for regulatory affairs at the uranium mining company Ur-Energy. “The market is really oversupplied at this point.” He said uranium mining companies don’t want to roll back environmental regulation. Instead, they’d rather the government block foreign competition.

There was a time when it was good to be a U.S. uranium mining company. During the Cold War, the federal government set up a series of policies that had the effect of guaranteeing uranium miners a high price for their product, said Luke Danielson, president of the Sustainable Development Strategies Group, which consults on minerals development projects around the world. “People made massive amounts of money in this boom,” he said. “But in the mid-’60s, the government realized we had enough uranium stockpiled to last a really long time, and it pulled the plug.” Production rebounded in the 1970s — a time of optimism about the future of nuclear energy — but the output of the U.S. uranium industry has been on the decline since 1980.

U.S. uranium production has been on the decline

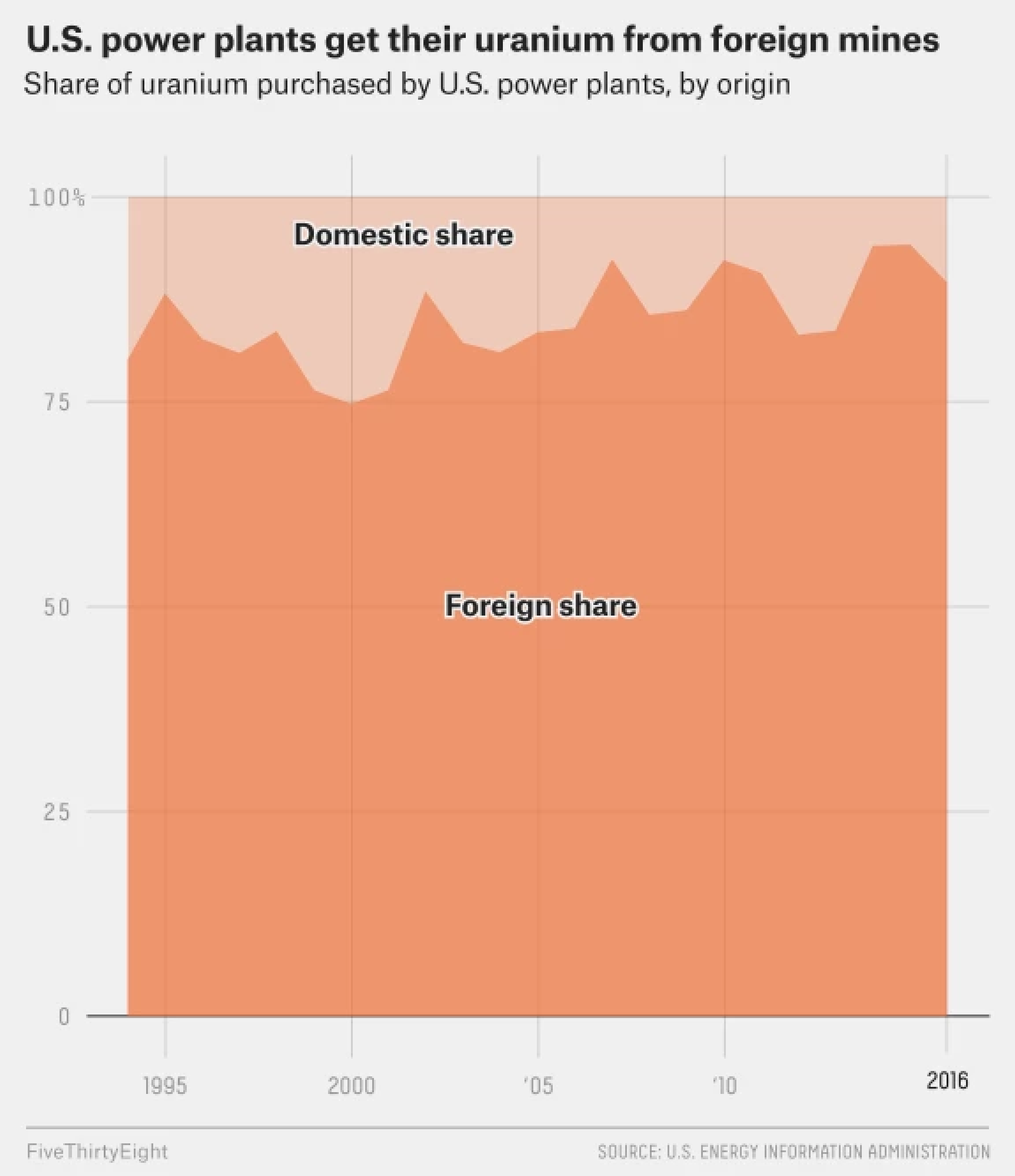
Uranium oxide produced in the U.S.

FiveThirtyEight

SOURCE: U.S. ENERGY INFORMATION ADMINISTRATION

That trend continues as old nuclear power plants close and aren't replaced. Meanwhile, contrary to the collective wisdom of the 20th century, demand for electricity doesn't seem to have to go up, exponentially, forever. Back then, the industry believed that there would always be new demand and that new power plants would have to be built to meet it, said Nick Carter, executive vice president for uranium at the UX Consulting Co., a nuclear industry data and consulting firm. But demand has stagnated, and the nuclear industry hasn't had much luck competing, cost-wise, against cheaper natural gas, wind and solar resources. So when utility companies buy nuclear fuel, they are focused on keeping costs low and are looking for the best deal. And that usually isn't coming from the U.S.

In 2016, just 10 percent of the uranium purchased by the owners of nuclear power plants was domestically sourced. That's why Cash and Paul Goranson, chief operating officer for Energy Fuels, another uranium mining company, want help on the demand side of the equation. In January, their two companies filed a petition with the U.S. Commerce Department asking for an investigation into whether the industry needs government protection against foreign competitors. Only 14 of these investigations have taken place since 1980, and it’s rarer still for the government to take action. Ultimately, though, Cash and Goranson would like to see the administration mandate that 25 percent of all the uranium purchased by U.S. electric utility companies come from U.S. uranium mines. Fighting foreign competition would matter more, they say, than repealing environmental protections.



SOURCE: U.S. ENERGY INFORMATION ADMINISTRATION

But it still might not be enough to rebound the industry to its previous highs or keep it solvent over the long term.

The international market for uranium has been decidedly less grim — at least, it was up until the 2011 Fukushima nuclear disaster in Japan (and the subsequent closure of power plants there and in Germany). That event sent the price of uranium into a tailspin and left the world with large stockpiles of uranium and little demand for it. Even countries usually seen as the big winners in the global uranium mining industry have scaled back production. There are new nuclear power plants being built in China, India, Russia and other countries, said Keith Florig, who is a research scholar at the University of Florida and studies risk and the nuclear energy industry. But those countries’ power plants are primarily buying uranium from domestic mines or from mines they have developed and control in other countries. Worldwide demand for uranium could go up and still leave U.S. producers behind.

One reason that U.S. companies would have trouble competing with producers from those other countries is the difference in environmental regulations. In 2014, the most recent year for which data is available, around 40 percent of the world’s uranium came from Kazakhstan, a country that, according to experts, can offer its uranium at a very cheap price because it’s not doing much in the way of environmental protection. Kazakhstan mines uranium by pumping a sulfuric acid solution into the ground and processing the uranium that binds to it. In the U.S., this process, called in-situ mining, is less toxic, but more expensive, using a sodium bicarbonate solution. U.S. uranium miners also have to remediate the groundwater at in-situ leaching sites, something that Cash and Goranson said isn’t required in Kazakhstan.

Kazakhstan is the world’s uranium miner

Top 10 uranium-producing countries and their share of resources in the ground, as of Jan. 1, 2015

	SHARE OF GLOBAL URANIUM	
COUNTRY	PRODUCTION	RESOURCES IN THE GROUND
Kazakhstan	**41%**	**13%**
Canada	16	9
Australia	9	29
Niger	7	5
Namibia	6	5
Russia	5	9
Uzbekistan	4	2
United States	**3**	**1**
China	3	5

	SHARE OF GLOBAL URANIUM	
COUNTRY	PRODUCTION	RESOURCES IN THE GROUND
Ukraine	2	2

SOURCES: OECD NUCLEAR ENERGY AGENCY, INTERNATIONAL ATOMIC ENERGY AGENCY

Uranium producers and politicians from uranium-producing states have pushed back against recent EPA efforts to increase groundwater protections at in-situ mining sites, but Cash said the U.S. uranium industry doesn't want to mine the way that Kazahkstan does. "We want to protect the environment," he said. "We think we should be good stewards of the environment." But that lack of environmental protection in Kazhkstan makes a difference on price — $10 per pound according to calculations put together by his engineers. Cash framed the 25 percent purchase mandate that he and Goranson have requested as a way to make up for that price difference between the two countries.

Of course, the catch is that while the Ur-Energy and Energy Fuels plan would help prop up the American uranium industry in the short term, it doesn't account for the fact that the nuclear power industry here isn't growing. In fact, it's contracting. The U.S. Energy Information Administration's projections for nuclear power demand are even worse than for coal. By 2050, the agency expects the U.S. electric system to use about 20 percent less nuclear power than it did in 2016. Uranium mining companies are asking for a guaranteed slice of an ever-shrinking pie.

The New York Times was wrong; Russian uranium deals don’t threaten world supply security.

By Steve Fetter, Erich Schneider, May 19, 2015

A recent article in the *New York Times* notes that the Russian state nuclear corporation Rosatom and associated firms are gaining control of a growing number of uranium resources and mining operations. The article, headlined "Cash Flowed to Clinton Foundation Amid Russian Uranium Deal," focuses on donations to charities connected to former US President Bill Clinton and his family, made by businessmen who stood to profit from the sale of Uranium One, a Canadian company with worldwide uranium-mining interests. Because uranium is a strategic commodity and some of the company's holdings are located in the United States, the Uranium One deal had to be approved by several US agencies, including the State Department, then headed by Hillary Clinton.

Notably, the deal highlighted in the article—which took place in three separate transactions between 2009 and 2013—gave the Russians ownership of 20 percent of the uranium reserves located under US soil. The *New York Times* article was premised on the suggestion that the Uranium One sale might pose a strategic threat to the US and other countries that rely on nuclear power for electricity production, if Russia were to use its control of the market to increase prices or restrict production or export of uranium for political purposes. The *Times* article contends that "[t]he deal made Rosatom one of the world’s largest uranium producers and brought [Russian President Vladimir] Putin closer to his goal of controlling much of the global uranium supply chain" and calls Putin "a man known to use energy resources to project power around the world."

A multi-player, boom-bust market. Russia is a significant but not dominant player in uranium markets. Less than four percent of current world uranium production and nine percent of world uranium reserves are on Russian soil. Adding foreign mines and deposits that are controlled by Russia increases this total to about 14 percent of production and 12 percent of reserves, but these foreign assets—particularly those in the United States—are far less susceptible to political or economic manipulation by Russia than are its domestic resources.

Uranium is widely viewed as a strategic commodity, and actions to secure resources beyond state borders are far from unique to Russia. In the past decade, China has purchased stakes in uranium deposits in Africa, Central Asia, and Australia representing some 500,000 metric tons (or tonnes) of uranium in the ground. The French multinational AREVA has a long history of investing in uranium projects across the world, notably in sub-Saharan Africa. In fact, AREVA and the Chinese National Nuclear Corporation are negotiating a partnership at one planned mine, Imouraren in Niger. Plans to begin producing from this 210,000-tonne deposit are on hold, however, due to excess supply and falling prices. To put these resources in perspective, total world uranium demand is

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year.

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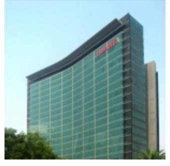

The 10-minute interview: Joy Dantong Ma on why Trump is targeting Huawei

By Matt Field | Analysis, Interviews

In general, attempts to control access to strategic commodities are self-defeating because they raise prices, stimulating more efficient use in the short term and additional production in the longer term. This has been true even for commodities with no readily available substitutes. OPEC's attempts to control oil markets led to a tenfold increase in the real price of oil between 1970 and 1980, but the high price stimulated the development of oil resources in other countries, as well as technological innovations, such as the horizontal drilling and hydraulic fracturing techniques which have made the United States the world's largest oil producer. More recently, China's attempts to limit export of rare earth elements led to renewed production in the United States and Australia and increased production by other countries, resulting in price drops of 70 percent to 90 percent from peak values reached in 2010 and 2011. Domestic production, which was essentially zero as recently as 2011, supplied 41 percent of US demand in 2014.

The world uranium market has exhibited similar behavior. A commodity market for uranium began to emerge in the 1970s. Since then, the uranium industry has undergone two boom-bust cycles. Early expectations for the rapid growth of nuclear power drove the uranium spot price to an inflation-adjusted high of $350 per kilogram of uranium in 1977 before gradually collapsing to less than a tenth of that value 15 years later. (All prices are adjusted to 2015 dollars, using the US Bureau of Labor Statistics Consumer Price Index.) A second boom, induced in part by exhaustion of stockpiles built up as long ago as the 1970s and expectations of a nuclear renaissance, saw uranium spot prices briefly touch nearly $400 per kilogram in 2007. Prices quickly declined from this peak, reaching $110 in 2009. The spot price as of the end of April 2015 was $100. (US utilities satisfy 80 percent to 90 percent of their requirements through long-term contracts, which are substantially less volatile. The average price utilities paid for their uranium during this period did not exceed $150 per kilogram.)

This cyclical behavior is typical of commodity markets; in the case of uranium, there is no evidence of the sustained upward trend in prices that would be expected were the global resource becoming scarce or increasingly costly to prospect and extract.

US uranium production did not rise substantially in response to this price boom, but domestic production has long played a minor role in meeting US uranium demand. According to the Organization for Economic Cooperation and Development (OECD) and International Atomic Energy Agency (IAEA) uranium industry surveys—the so-called Redbooks—annual production in the US peaked in 1981 at 17,000 tonnes and has generally remained below 2,000 tonnes since 2000. This decline is not associated with the depletion of US uranium deposits. To the contrary, at 472,000 tonnes, US reasonably assured uranium resources–a standard measure for such deposits—are the second largest in the world. Only in Australia is more uranium—1,208,000 tonnes—known to exist in this highest-confidence resource tier.

The US is not currently a major producer of uranium for two reasons. First, from the dawn of the nuclear era through the early 1980s, world uranium production consistently outstripped demand. In 1980, nearly 70,000 tonnes were being produced annually while annual civilian plus naval military demand was around 40,000 tonnes. As uranium demand leveled off in the late 1980s and early 1990s, uranium prices collapsed, followed shortly by a corresponding collapse in uranium production. By 1992, world annual production had dropped to less than half of its peak value. As noted above, the inflation-adjusted uranium spot price had also fallen from over $350 per kilogram in the late 1970s to less than $40 in 1992.


Financial system could be destabilized by stranded carbon-intensive assets, warns Bank of Canada

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This price crash led to a sharp reduction in uranium mining in the United States because producing uranium from most US uranium deposits is a relatively costly proposition. Less than 10 percent of US reasonably assured uranium resources can be mined at a cost of less than $80 per kilogram, compared to 70 percent for Canada and 54 percent for Kazakhstan, the world's two largest producers, according to the 2014 Redbook. As a result, only a few US uranium mines remained competitive at low prices. Although it did lead to substantial expenditures on exploration, the uranium price boom of the last decade was too short-lived to justify tapping costlier-to-mine US deposits and ushering in a new era of large-scale US production.

In the short to medium term, it is unlikely that US uranium production will expand substantially. Discoveries of high-grade deposits in other countries have more than kept pace with extraction. Since reliable record keeping began in 1965, identified uranium reserves have increased by over 4 million tonnes, even as more than 2 million tonnes of uranium were extracted. Identified reserves stand at 7.6 million tonnes as of 2014, according to the 2014 Redbook. These reserves would be enough to satisfy world demand for over 100 years at current rates of consumption.

Uranium is not likely to become scarce or controlled by one country. In spite of this evidence of past and present abundance, are there signs that uranium may become scarce? If uranium were becoming scarcer, it should be increasingly difficult and costly to find more of it. Likewise, deposits being mined should be of lower quality over time, as the most attractive resources are exhausted and not replaced with high-quality discoveries. Neither of these trends is observed.

The average cost of discovering a kilogram of identified reserves can be inferred from Redbook data on exploration expenditures, reserves, and production over time. Between 1972 and 2013, the average cost of discovering a kilogram of proven reserves was just $6 per kilogram (in constant 2015 dollars). This cost has declined over time, from an average of about $7 per kilogram from 1972 to 1992 to $5 per kilogram from 1993 to 2013, according to the Redbook Retrospective and more recent Redbooks. The average uranium oxide content of ore being mined around the world has held nearly steady at 0.1 percent since the 1950s. If new discoveries of attractive deposits were not keeping pace with extraction, the ore grade would be dropping over time.

Past experience does not guarantee future abundance, and existing identified reserves could be depleted in several decades if nuclear power were to expand dramatically around the globe. But the existing identified reserves do not constitute all the uranium that is available. In the 1970s, geologists Kenneth Deffeyes and Ian MacGregor published an estimate of the distribution of the roughly 80 trillion tonnes of uranium in the upper 25 kilometers of the Earth's crust. Their estimate, which is still widely cited, established a relationship between the concentration of the uranium in ore and the amount available at that concentration. Subsequent analyses refined and updated this work and show that if the average grade of uranium being mined fell by a factor of three—probably with a commensurate rise in production costs and prices—the resource base would expand by a factor of 10 to 30. This would be achieved by tapping into deposits that are currently uneconomic and therefore poorly prospected, such as phosphates and shales.

Finally, research and development of technologies for recovering uranium from seawater continues in the United States, Japan, and China. The 4 billion tonnes of uranium in seawater constitute an essentially limitless resource, and one that would be available to most countries. Because the uranium is present at a very per billion—innovative passive collection techniques using uranium-selective adsorbents are being developed. Recent estimates place the cost of recovering uranium from the oceans at several hundred to $1,000 per kilogram of uranium. Costs would be expected to decline as the technologies advance.

For all of the aforementioned reasons, a future of sustained uranium scarcity is extremely unlikely. The impact of a moderate price rise, if temporary and due to an attempt to control the market, or even if sustained due to resource pressures, would be modest. Uranium represents a small fraction of the cost of nuclear-generated electricity—about $4 per megawatt-hour at current uranium prices, with reasonable assumptions about average fuel enrichment, burn-up rates, and other variables associated with nuclear generation of electricity. Thus, a doubling of the price of uranium would in fact add less than $4 per megawatt-hour to the cost of nuclear electricity as utilities would adopt efficiency measures discussed below. For comparison, the average retail price of electricity in the United States (and most countries with nuclear reactors) is more than $100 per megawatt-hour. Therefore, even if a sustained, moderate increase in the price of uranium did occur, it would not significantly affect the economics of nuclear power relative to other technologies, and it would have little or no impact on the price of electricity paid by consumers.

An attempt to restrict production or export of uranium could lead to a price rise in the short run. But this would trigger increased production at existing mines as well as efficiency measures that could be put in place almost immediately. The most notable efficiency measure is to lower the "tails assay," that is, the amount of easily fissile uranium 235 in the depleted uranium that is rejected from an enrichment plant. Around the world, the average uranium 235 content of such depleted-uranium tails stood at around 0.33 percent in 2004. (The U-235 content of natural uranium, in weight percent, is 0.711 percent.) By 2011, in the immediate wake of the price boom, it had fallen to 0.22 percent. By letting less uranium 235 pass into the tails waste stream, utilities and uranium enrichers reduced their natural uranium requirements by 20 percent in a very short time.

In the longer term, an increase in the price of uranium would encourage exploration and development of new mines around the world, undercutting any attempt to control the market. Therefore, although expanded control by one country can lead to short-term price spikes, such a spike in uranium prices would not present a danger to the economy as a whole, or even to utilities that are heavily dependent on nuclear power. Globally, uranium supply and reserves are adequate and will remain so. Market forces will act over the medium to long term to expand production, exploit existing reserves, discover new resources, and reduce prices. The Russian government will have little control over these dynamics.

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