FUSION: THE WORLD'S MOST COMPLEX ENERGY PROJECT

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

SECOND SESSION

JULY 11, 2014

Serial No. 113–85

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PRINTING OFFICE
89–414PDF WASHINGTON : 2014

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HON. LAMAR S. SMITH, Texas, *Chair*

DANA ROHRABACHER, California
RALPH M. HALL, Texas
F. JAMES SENSENBRENNER, JR., Wisconsin
FRANK D. LUCAS, Oklahoma
RANDY NEUGEBAUER, Texas
MICHAEL T. McCAUL, Texas
PAUL C. BROUN, Georgia
STEVEN M. PALAZZO, Mississippi
MO BROOKS, Alabama
RANDY HULTGREN, Illinois
LARRY BUCSHON, Indiana
STEVE STOCKMAN, Texas
BILL POSEY, Florida
CYNTHIA LUMMIS, Wyoming
DAVID SCHWEIKERT, Arizona
THOMAS MASSIE, Kentucky
KEVIN CRAMER, North Dakota
JIM BRIDENSTINE, Oklahoma
RANDY WEBER, Texas
CHRIS COLLINS, New York
BILL JOHNSON, Ohio

EDDIE BERNICE JOHNSON, Texas
ZOE LOFGREN, California
DANIEL LIPINSKI, Illinois
DONNA F. EDWARDS, Maryland
FREDERICA S. WILSON, Florida
SUZANNE BONAMICI, Oregon
ERIC SWALWELL, California
DAN MAFFEI, New York
ALAN GRAYSON, Florida
JOSEPH KENNEDY III, Massachusetts
SCOTT PETERS, California
DEREK KILMER, Washington
AMI BERA, California
ELIZABETH ESTY, Connecticut
MARC VEASEY, Texas
JULIA BROWNLEY, California
ROBIN KELLY, Illinois
KATHERINE CLARK, Massachusetts

Subcommittee on Energy

HON. CYNTHIA LUMMIS, Wyoming, *Chair*

RALPH M. HALL, Texas
FRANK D. LUCAS, Oklahoma
RANDY NEUGEBAUER, Texas
MICHAEL T. McCAUL, Texas
RANDY HULTGREN, Illinois
THOMAS MASSIE, Kentucky
KEVIN CRAMER, North Dakota
RANDY WEBER, Texas
LAMAR S. SMITH, Texas

ERIC SWALWELL, California
ALAN GRAYSON, Florida
JOSEPH KENNEDY III, Massachusetts
MARC VEASEY, Texas
ZOE LOFGREN, California
DANIEL LIPINSKI, Illinois
KATHERINE CLARK, Massachusetts
EDDIE BERNICE JOHNSON, Texas

CONTENTS

July 11, 2014

Opening Statements

Witnesses:

Appendix I: Answers to Post-Hearing Questions

Appendix II: Additional Material for the Record

FUSION: THE WORLD'S MOST COMPLEX ENERGY PROJECT

FRIDAY, JUNE 11, 2014

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 9:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Cynthia Lummis [Chairwoman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congreſs of the United States
House of Representatives
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6371
www.science.house.gov

Subcommittee on Energy

Fusion: The World's Most Complex Energy Project

Friday, July 11, 2014
9:00 a.m. – 11:00 a.m.
2318 Rayburn House Office Building

Witnesses

Dr. Frank Rusco, Director, Natural Resources and Environment, GAO

Dr. Patricia Dehmer, Deputy Director for Science Programs, DOE

Dr. Robert Iotti, ITER Council Chair

Dr. Ned Sauthoff, Director, U.S. ITER Project, Oak Ridge National Laboratory

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

Fusion: The World's Most Complex Energy Project

CHARTER

Friday, July 11, 2014
9:00 a.m. – 11:00 a.m.
2318 Rayburn House Office Building

Purpose

The Energy Subcommittee will hold a hearing titled *Fusion Energy: The World's Most Complex Energy Project* starting at 9:00 a.m. on Friday, July 11th in room 2318 of the Rayburn House Office Building. This hearing will examine the Fusion Energy Science (FES) program within the Department of Energy's (DOE's) Office of Science, focusing on the United States' involvement in the International Thermonuclear Experimental Reactor (ITER) project located in Cadarache, France, as well as its current operating status.

Witnesses

- **Dr. Frank Rusco**, Director, Natural Resources and Environment, GAO
- **Dr. Patricia Dehmer**, Deputy Director for Science Programs, DOE
- **Dr. Robert Iotti**, ITER Council Chair
- **Dr. Ned Sauthoff**, Director, U.S. ITER Project, Oak Ridge National Laboratory

Background

The mission of DOE's Fusion Energy Sciences program is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source.[1] The pursuit of fusion energy is an attempt to replicate the energy-producing power of a star on earth. The potential benefits from a workable fusion energy source are incalculable, but it is also one of the most challenging programs of scientific research and development that has ever been undertaken. Such an energy system would utilize seawater as the primary fuel, produce modest radioactive bi-products, and

---

[1] U.S. Department of Energy, Office of Science, Fusion Energy Sciences Mission, Available at: http://science.energy.gov/fes/about/

emit zero carbon emissions. FES also supports discovery science related to understanding the behavior of plasmas – the primary constituent matter of most stars.[2]

The International Thermonuclear Experimental Reactor (ITER) project is a collaboration to design, build, and operate a first-of-a-kind research facility to achieve and maintain a burning plasma with a peak output of 500 MW thermal power driven by 50 MW input power.[3]

In 2003, President George W. Bush announced the United States' intention to join ITER describing it as "an ambitious international research project to harness the promise of fusion energy."[4] Congress then authorized U.S. participation in the project through the Energy Policy Act of 2005 (EPAct05). In 2006, the United States signed the ITER agreement. DOE fulfills this obligation by: (1) supplying personnel; (2) providing cash contributions to the ITER Organization; and (3) delivering 12 assigned hardware components.[5]

The seven member countries of ITER are China, India, Japan, the European Union, the Russian Federation, the United States, and South Korea. The European Union is obligated to contribute 45.46 percent of the construction cost of the ITER project, while the other countries, including the United States, are each to provide 9.09 percent. The United States is also obligated to provide 13 percent of the costs for operating, deactivating, and decommissioning the facility. The ITER organization is led by a Director-General and governed by the ITER Council, composed of government officials from each of the ITER members. The ITER Council has authority to appoint senior staff, amend regulations, decide on budgeting issues, and allow additional states or organizations to participate in ITER.[6] In 2010, the ITER Council appointed Professor Osamu Motojimi as Director-General of the ITER project.[7]

At the time of the 2006 agreement, DOE estimated that construction would cost approximately $5 billion (in 2002 US Dollars, no adjustments for inflation). These figures are not comparable to a DOE construction project cost estimate, but were meant to establish contribution expectations for ITER members. Last month, U.S. Government Accountability Office (GAO) concluded that since the 2006 agreement the DOE's estimated cost of the United States' commitment to the ITER project has grown by almost $3 billion and the schedule for completion has been delayed up to 20 years. The report also points out that DOE's current cost and schedule estimates for the project cannot be used to set a performance baseline because they are linked to factors that DOE can only partially influence. The GAO also found that DOE has taken several actions to reduce the ITER project's costs by approximately $388 million (as of February 2014), but that DOE has not yet adequately planned for the potential impact of those costs on FES. Through March of 2014, DOE has spent approximately $692 million on ITER.

---

[2] U.S. Department of Energy, Office of Science, Fusion Energy Sciences, Available at: http://science.energy.gov/fes/

[3] International Thermonuclear Experimental Reactor, Available at: http://www.iter.org/

[4] White House Archives, Available at: http://georgewbush-whitehouse.archives.gov/news/releases/2003/01/20030130-18.html

[5] United States International Thermonuclear Experimental Reactor Project, Available at: https://www.usiter.org/

[6] International Thermonuclear Experimental Reactor, the ITER Council, Available at: https://www.iter.org/org/council

[7] International Thermonuclear Experimental Reactor, Director General, Available at: https://www.iter.org/org/io/dg

The Consolidated Appropriations Act of 2014 (P.L. 113-76) provided $199.5 million for ITER with a stipulation that "not more than $22,790,000 may be available for U.S. cash contributions to the International Thermonuclear Experimental Reactor project until its governing Council adopts the recommendations of the Third Biennial International Organization Management Assessment Report." The Act also provided the Secretary with an opportunity to waive this requirement upon a determination that the Council is making satisfactory progress towards adoption of such recommendations.

Additional Reading

- United States Government Accountability Office, *Fusion Energy: Actions Needed to Finalize Cost and Schedule Estimates for U.S. Contributions to an International Experimental Reactor,* June 2014, available at: http://www.gao.gov/products/GAO-14-499
- Madia & Associates LLC, *2013 ITER Management Assessment,* October 18, 2013.

Chairwoman LUMMIS. Good morning. The Subcommittee on Energy will come to order. Welcome to today's hearing, entitled "Fusion: The World's Most Complex Energy Project," which a week ago I didn't even know existed, and now I feel pretty well informed about this. In front of you are packets containing the written testimony, biographies, and truth in testimony disclosures for today's witnesses. And I now recognize myself for an opening statement. In order to ensure that everybody gets to ask questions, I am going to keep my statement brief, because we anticipate that we are going to have votes in about 70 minutes.

I want to welcome everyone to today's hearing on the Department of Energy, Fusion Energy Sciences program, specifically focused on the United States participation in the International Thermonuclear Experimental Reactor, also known as ITER. Today the Energy Subcommittee will discuss the projected costs and schedule associated with ITER, as well as the massive potential that fusion energy represents.

This project is one of the most complex scientific and engineering undertakings in history. As we will hear today, ITER has, and continues to face, management challenges, lacks a credible schedule, and the United States program needs a reliable budget. This Committee has an oversight responsibility to ensure that the United States efficiently accomplishes its obligations in accordance with the ITER agreement, and that the ITER organization continues to remain a solid investment.

We have an excellent panel of witnesses to testify on the history, challenges, and proposed solutions associated with ITER. I want to thank our witnesses for participating in today's hearing, and look forward to their testimony.

[The prepared statement of Mrs. Lummis follows:]

PREPARED STATEMENT OF SUBCOMMITTEE CHAIRMAN CYNTHIA LUMMIS

Good morning. In an effort to ensure that all Members are able to ask their questions I will keep my statement brief.

I would like to welcome everyone to today's hearing on the Department of Energy's Fusion Energy Sciences program, specifically focusing on the United States' participation in the International Thermonuclear Experimental Reactor, also known as "ITER."

Today, the Energy Subcommittee will discuss the projected costs and schedule associated with ITER as well as the massive potential that fusion energy represents. This project is one of the most complex scientific and engineering undertakings in history—and as we will hear today, ITER has and continues to face management challenges, lacks a credible schedule, and the United States' program needs a reliable budget.

This Committee has an oversight responsibility to ensure that the United States efficiently accomplishes its obligations in accordance with the ITER agreement—and that the ITER organization continues to remain a solid investment.

We have an excellent panel of witnesses to testify on the history, challenges, and proposed solutions associated with ITER. I want to thank the witnesses for participating in today's hearing and look forward to their testimony

Chairwoman LUMMIS. I now recognize the Ranking Member, the gentleman from California, Mr. Swalwell, for an opening statement.

Mr. SWALWELL. Thank you, Chairman Lummis, for holding this hearing, and I also want to thank our excellent panel of witnesses for being here this morning.

Fusion holds the promise of providing a practically limitless supply of clean energy to the world. We are actually already dependent upon it every day from that great energy source in the sky, the fusion reactor in the sky, better known as the sun. It is essential to the existence—for life here on Earth for all of us. And, of course, it is a bit trickier for people to replicate what the stars are able to do with sheer gravity.

But from my conversations with some of the top fusion researchers across the world, not just at Lawrence Livermore National Laboratory, which is in my Congressional District, and their National Ignition Facility, which I happen to represent, I have learned that the support of fusion energy research is something that is critical at this day and age, and now is the right time to build and operate experiments that can finally demonstrate that a man-made fusion system can consistently produce far more energy than it takes to fuel it.

For the magnetic fusion approach, the next step is clearly ITER. ITER is designed to produce at least 10 times the energy it consumes, and would be the first experiment of its kind that enables us to provide researchers the opportunity to explore and test the behavior of a system where the fusion process itself provides the primary heat source to sustain its high fusion reaction rate, also called a burning plasma. As discussed in a seminal report by the National Academies entitled, “Burning Plasma, Bringing a Star to Earth”, as well as subsequent reports, this experiment is absolutely essential to proving that magnetically confined fusion can be a viable clean energy source.

That said, I have several concerns, which I hope we can address in this hearing. By all accounts, the U.S. ITER Project Office, under the direction of Dr. Ned Sauthoff, who is here today, is very well managed, and doing everything it can to contain costs, and maintain an aggressive schedule. I am also concerned about the administration’s proposed $225 million cap on annual funding for the U.S. contribution to ITER, which they have justified solely by saying that this allows sufficient funding for the remainder of the Office of Science’s fusion program.

This justification, however, falsely assumes that the administration couldn’t simply request a higher budget for fusion in a particular year as it does for other programs when they have projects with significant cost profiles. The $225 million cap was not based on a bottom up project estimate that minimizes the total cost for the U.S. ITER contribution, but, rather, a political calculation, and this level falls well below what is necessary to optimize the project schedule, and minimize the cost to taxpayers.

Given the critical importance of ITER to determining the viability of fusion as a clean energy source, and the major contributions of U.S. researchers to advancing the science and engineering of the field up to this point, I maintain strong support for this project, along with other key components of the broader U.S. based fusion research program.

However, this does not mean, of course, that we can provide an unconditional blank check. The U.S. must maintain vigorous oversight, and use every means available, with our international partners, to contain costs and schedule, all while keeping an unwavering focus on achieving the project's incredibly important goals for our world's energy future.

Thank you, and I yield back the balance of my time.

[The prepared statement of Mr. Swalwell follows:]

PREPARED STATEMENT OF SUBCOMMITTEE MINORITY RANKING MEMBER ERIC SWALWELL

Thank you Chairman Lummis for holding this hearing, and I also want to thank this excellent panel of witnesses for their testimony and for being here today.

Fusion holds the promise of providing a practically limitless supply of clean energy to the world. We're actually already dependent on it—the energy we get from that fusion reactor in the sky, better known as the sun, is essential to the existence of life on Earth, including us. Of course, it's a bit trickier for people to replicate what the stars are able to do with sheer gravity. But from my conversations with some of the top fusion researchers in the world—and not just at Lawrence Livermore's National Ignition Facility, which I happen to represent - I believe we're getting there. This is why I am such a strong supporter of fusion energy research, and I believe that now is the right time to build and operate experiments that can finally demonstrate that a man-made fusion system can consistently produce far more energy than it takes to fuel it.

For the magnetic fusion approach, that next step is clearly ITER. ITER is designed to produce at least ten times the energy it consumes, and would be the first experiment of its kind that enables our researchers to explore and test the behavior of a system where the fusion process itself provides the primary heat source to sustain its high fusion reaction rate, also called a "burning plasma." As discussed in a seminal report by the National Academies entitled Burning Plasma-Bringing a Star to Earth, as well as subsequent reports, this experiment is absolutely essential to proving that magnetically confined fusion can be a viable clean energy source.

That said, I have several concerns which I hope we can address in this hearing. By all accounts, the U.S. ITER Project Office, under the direction of Dr. Ned Sauthoff who is here today, is very well managed and doing everything it can to contain costs and maintain an aggressive schedule. But the 2013 ITER Management Assessment to the project's governing ITER Council found serious issues with the international organization's management practices, including an overall "lack of urgency" to complete the project on time and on budget due to various cultural and accounting practices among a number of the project's partners. I'm told that the new ITER Council Chair, Dr. Robert Iotti, who is also here today, is taking this Assessment very seriously, and working to adopt its recommendations and address the issues that the review identified. I look forward to learning more about Dr. Iotti's progress toward these goals shortly. I am also concerned about the Administration's proposed $225 million cap on annual funding for the U.S. contribution to ITER, which they have justified solely by stating that this allows sufficient funding for the remainder of the Office of Science's fusion program. This justification, however, falsely assumes that the Administration couldn't simply request a higher budget for fusion in a particular year, as it does for other programs when they have projects with significant construction cost profiles. The $225 million cap was not based on a bottom-up project estimate that minimizes the total cost for the U.S. ITER contribution, but rather a political calculation.

This level falls well below what is necessary to optimize the project schedule and minimize the total cost to taxpayers. As I believe both Dr. Sauthoff and Dr. Dehmer would agree, such underfunding inevitably leads to larger total project costs because the highly skilled teams required for management and construction of our components are essentially "standing armies" that need significant annual resources even if budget reductions force the project schedule to be extended. Moreover, even though some other ITER partners are not currently meeting their deadlines, my understanding is that much of what the U.S. is responsible for is or can be decoupled from their activities. So we could have a far more aggressive, cost-effective schedule to fabricate our components and have them stored until they are ready to be integrated into the reactor complex. I look forward to discussing the potential for this path forward with the panel as well.

Given the critical importance of ITER to determining the viability of fusion as a clean energy source, and the major contributions of U.S. researchers to advancing the science and engineering of the field to this point, I maintain strong support for this project along with the other key components of the broader U.S.-based fusion research program. However, this does not mean we can support an unconditional blank check. The U.S. must maintain vigorous oversight and use every means available with our international partners to contain cost and schedule, all while keeping an unwavering focus on achieving the project's incredibly important goals for our and the world's energy future.

Thank you, and with that I yield back the balance of my time.

Chairwoman LUMMIS. I thank Mr. Swalwell, and now recognize the Chairman of the full Committee, Mr. Smith.

Chairman SMITH. Thank you, Madam Chair. Let me say at the outset that I appreciate the concerns expressed by you and the Ranking Member, and I happen to agree with them as well.

Madam Chair, the Energy Subcommittee will hear from a panel of experts with collectively over a century of experience in science and engineering. We look forward to their testimony, and the prospects of nuclear fusion as a future energy source.

Fusion energy research attempts to achieve an invaluable reward for humankind, a sustainable, renewable, zero emissions energy source. It also represents one of the greatest scientific challenges in history. This scientific undertaking of creating the power source of a star on Earth will require persistence and commitment. The next step towards achieving this goal is the International Thermonuclear Experimental Reactor, called ITER. And, by the way, I hope someone will explain why we don't call it ITER, even though I know we commonly accept it as ITER.

The Obama Administration has chosen to underfund ITER in its Fiscal Year 2015 request. Instead of adequately supporting ITER, which could eventually lead to global energy security, the administration's budget request cuts this project by $50 million. The Administration instead prioritizes late stage, unreliable renewable energy, such as wind and solar. Fusion energy is in the early stages of research, but experts predict that it could someday provide a solution to the challenges of climate change. This is because fusion energy has the potential to power the world for millions of years, is reliable, and yields zero carbon emissions. Still, the Administration refuses to adequately support this science.

Depriving the U.S. ITER program of the funds it needs to accomplish its goals is not good policy. To maintain our competitive advantage, we must continue to support fundamental basic research that encourages the creation and design of next generation technologies. Fusion energy is the sort of high risk, high reward research that will benefit future generations, if we are bold enough to pursue it.

Thank you, Madam Chair, but before I yield back, I would like unanimous consent to put into the record a letter from the American Security Project, which highlights fusion energy's importance for innovation and global energy security.

Chairwoman LUMMIS. Without objection, so ordered.

[The information apperas in Appendix II]

Chairman SMITH. I thought I had yielded back, but I will be happy to do so.

[The prepared statement of Chairman Smith follows:]

PREPARED STATEMENT OF FULL COMMITTEEE CHAIRMAN LAMAR S. SMITH

Today the Energy Subcommittee will hear from a panel of experts with collectively over a century of experience in science and engineering.

We look forward to their testimony on the prospects of nuclear fusion as a future energy source. Fusion energy research attempts to achieve an invaluable reward for humankind—a sustainable, renewable, zero-emissions energy source. It also represents one the greatest scientific challenges in history.

This scientific undertaking of creating the power source of a star on earth will require persistence and commitment. The next step towards achieving this goal is the International Thermonuclear Experimental Reactor (ITER).

The Obama Administration has chosen to underfund ITER in its fiscal year 2015 request. Instead of adequately supporting ITER, which could eventually lead to global energy security, the Administration's budget request cuts this project by $50 million. The Administration instead prioritizes late stage, unreliable renewable energy, such as wind and solar.

Fusion energy is in the early stages of research. But experts predict that it could someday provide a solution to the challenges of climate change. This is because fusion energy has the potential to power the world for millions of years, is reliable, and yields zero carbon emissions. Still, the Administration refuses to adequately support this science.

Depriving the U.S. ITER program of the funds it needs to accomplish its goals is not good policy. To maintain our competitive advantage, we must continue to support fundamental basic research that encourages the creation and design of next generation technologies.

Fusion energy is the sort of high-risk, high-reward research that will benefit future generations if we are bold enough to pursue it.

Chairwoman LUMMIS. I may not be awake yet, Mr. Chairman. I now yield to the Ranking Member, Mrs. Johnson of Texas.

Ms. JOHNSON. Thank you very much, Madam Chairperson Lummis for calling this hearing today, and I would also like to thank the witnesses for being here. Nuclear fusion has the potential to provide the world with a clean, safe, and practically inexhaustible source of energy. Producing reliable electric power from fusion would undoubtedly serve as one of the biggest and most important scientific achievements in the history of mankind. That is why I am so supportive of a strong research program that can help us overcome the remaining scientific and engineering challenges for this potential to become a reality.

The ITER project is the next and largest step toward this goal. For more than 50 years scientists at our top universities, national labs, and in the private sector, as part of a truly global research community, have been conducting experiments and performing research that has brought the team to a point where they are confident it is now possible to actually build a full scale test reactor that produces far more energy than it uses.

However, it is highly unlikely that a research project of this size can be achieved by one institution, lab, company, or, in this fiscal environment, even by a single country. This is why wthe ITER project has brought together the best scientists and engineers from the world's largest and most advanced nations to carry out this experiment.

But managing the dynamics of multiple countries working together toward a common goal, especially one as complex as this, is rarely easy, and ITER has proved to be no exception. Recent reports have documented several issues with the International Organization's management, which must be addressed if this project is to succeed.

I look forward to hearing from our witnesses about how these problems are being dealt with, and to further discussing ways we can ensure that ITER achieves incredibly important goals. I thank you, Ms. Chairman, and I yield back the balance of my time.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF FULL COMMITTEEE
RANKING MEMBER EDDIE BERNICE JOHNSON

Thank you Chairman Lummis for holding this hearing today, and I would also like to thank the witnesses for being here.

Nuclear fusion has the potential to provide the world with a clean, safe, and practically inexhaustible source of energy. Producing reliable electric power from fusion would undoubtedly serve as one of the biggest and most important scientific achievements in the history of humankind. This is why I am so supportive of a strong research program that can help us overcome the remaining scientific and engineering challenges for this potential to become a reality.

The ITER project is the next, and largest, step toward this goal. For more than fifty years, scientists at our top universities, national labs, and in the private sector—as part of a truly global research community—have been conducting experiments and performing research that has brought the teams to a point where they are confident it is now possible to actually build a fullscale test reactor that produces far more energy than it uses. However, it is highly unlikely that a research project of this size can be achieved by one institution, lab, company, or, in this fiscal environment, even by a single country. That is why the ITER project has brought together the best scientists and engineers from the world's largest and most advanced nations to carry out this experiment.

But managing the dynamics of multiple countries working together toward a common goal, especially one as complex as this, is rarely easy, and ITER has proved to be no exception. Recent reports have documented several issues with the international organization's management which must be addressed if this project is to succeed. I look forward to hearing from our witnesses about how these problems are being dealt with, and to further discussing ways we can ensure that ITER achieves its incredibly important goals.

Thank you, and with that I yield back the balance of my time.

Chairwoman LUMMIS. I thank the Ranking Member. And if there are other Members who wish to submit additional opening statements, your statements will be added to the record at this point.

Thank you very much again, witnesses. And before I introduce you, I will tell you that I had a very lengthy conversation, very lengthy conversation last night with an old friend from high school by the name of Jeff Hoy. And who would have thought—yeah, I can see you all know him. I used to sneak into his back yard in high school for parties, and we were—and it has been decades, decades, since we have talked to each other, and we were laughing at each out about how serendipitous it is that we would now be talking about ITER in detail, when a week ago I would never even heard of ITER, and—anyway, it was very informative, and it was also delightful to sort of re-acquaint with an old high school buddy.

So, at this time, I would like to introduce our witnesses. If I mispronounce your name, would you please correct me? Our first witness today is Dr. Frank Rusco. Is it Rusco?

Dr. RUSCO. Yes.

Chairwoman LUMMIS. What is—how do you pronounce it?

Dr. RUSCO. Half my friends call me Rusco, and—but I say Rusco.

Chairwoman LUMMIS. Rusco, excellent. Well, I want to do what you do. Okay. Dr. Frank Rusco, thank you. Dr. Rusco is the Director of the Natural Resources and Environment Team at the Government Accountability Office. Dr. Rusco really leads a broad spectrum of energy issues government-wide. Dr. Rusco received both his Master's and Doctorate in Economics from the University of Washington. Thank you for being here.

Now, Dr. Dehmer——

Dr. DEHMER. Dehmer.

Chairwoman LUMMIS. Dehmer, thank you. Our second witness is Dr. Patricia Dehmer, Deputy Director for Science Programs at the Department of Energy. Dr. Dehmer provides scientific and management oversight for a number of DOE science programs, including fusion energy sciences.

Our third witness is Dr. Iotti. Did I get——

Mr. IOTTI. Iotti, Iotti, either way.

Chairwoman LUMMIS. Okay. How do you pronounce it?

Mr. IOTTI. —Americans—Iotti——

Chairwoman LUMMIS. Iotti? Okay. Well, I am going to Americanize it, and I—our third witness is Dr. Robert Iotti, Chair of the ITER Council. Dr. Iotti became involved in fusion nearly 40 years ago, working at the Princeton Plasma Physics lab. Dr. Iotti received his Ph.D. in Nuclear Engineering.

And our final witness today is Dr. Ned Sauthoff. Did I get that right?

Mr. SAUTHOFF. Perfect.

Chairwoman LUMMIS. Thank you. Director of the U.S. ITER project at Oak Ridge National Laboratory. Previously Dr. Sauthoff was a physics researcher, and head of the Off-Site Research Department at the Princeton Plasma Physics Lab. Dr. Sauthoff received his Ph.D. in Astrophysical Sciences from Princeton.

Welcome one and all. As you know, our spoken testimony is limited to five minutes, and Members then will have five minutes each to ask you questions. So, again, welcome, and thank you. I now recognize Dr. Rusco for five minutes to present his testimony.

TESTIMONY OF DR. FRANK RUSCO, DIRECTOR, NATURAL RESOURCES AND ENVIRONMENT, GAO

Dr. RUSCO. Thank you. Chairman Lummis, Ranking Member Swalwell, Chairman Smith, and Ranking Member Johnson, Members of the Subcommittee, thank you for the opportunity to discuss our recent report on DOE's cost and schedule estimates for the U.S. ITER project. The ITER project is an important scientific endeavor, and one that has large potential implications for basic science, and for the future of energy production. As you know, the U.S. has committed to providing about nine percent of ITER's construction costs through contributions of hardware, personnel, and cash. In addition, the U.S. has agreed to contribute to ITER's operational and decommissioning costs.

However, since the ITER agreement was signed in 2006, the project has experienced significant cost increases and schedule delays. GAO has reviewed the U.S. ITER project twice, in 2007 and 2014. Both reports identified similar concerns about the reliability of cost and schedule estimates for ITER. Specifically, in 2007, we reported on the importance of DOE assessing the full costs of U.S. participation in ITER, and setting a definitive cost estimate for the project.

We reported that the U.S. had committed to contributing to ITER without definitive estimates, or a complete project design, and that the preliminary estimate of about $1.1 billion could change significantly as a result. We also noted that the international ITER organization faced a number of management challenges that might significantly affect U.S. costs.

In our most recent report, published in June 2014, we found that DOE's current estimate of about $4 billion for the U.S. ITER project basically did a good job of incorporating the important characteristics of reliable cost estimates. However, factors outside of DOE's control continue to prevent it from setting a reliable cost baseline more than seven years after the project began. Most importantly, the overall international project schedule that DOE uses as the basis for the U.S. schedule is not reliable. This is in part because of long running management deficiencies within the international ITER organization that continue today.

For example, an external assessment of the ITER organization in 2013 found that significant management issues hindered international project performance. The ITER council has committed to addressing these issues, and, as part of that effort, the ITER organization is currently reassessing the international project schedule, and will report its results to the council in June 2015. The purpose of the reassessment is to create a realistic schedule for ITER that will provide all members, including the U.S., a credible overall project schedule to which they can link their individual efforts and cost estimates.

Given the importance of a reliable project schedule for completion of the ITER project, this next year will be critical to ITER's long term success. In line with that, we recommended in our report that DOE continue to formally advocate for timely implementation of the necessary actions laid out in the management assessment that are needed to set a reliable international project schedule, and improve ITER organization project management.

We urge DOE to be vigilant in its efforts to influence to the maximum extent possible the ITER organization's development of this schedule so that, at this time next year, the U.S. will be in a position to endorse the revised international schedule and use that to set a definitive cost baseline for the U.S. project.

In conclusion, the ITER project is at a crossroads. In the absence of a reliable schedule and improved international project management, ITER will remain subject to a significant amount of uncertainty, and may continue to face significant cost overruns or schedule delays. DOE should do as much as it can over the next year to push the ITER organization toward a realistic schedule and improved project management. Only if this is achieved will DOE be able to provide a firm and reliable estimate to Congress of the expected U.S. contribution to the ITER project.

Alternatively, if DOE cannot, upon evaluating the ITER organization's revised schedule, determine that this schedule is indeed reliable, it is imperative that DOE provide a transparent and complete accounting of the schedule's deficiencies to Congress, so that lawmakers can have the information to make reasoned budget and other decisions.

Chairman Lummis, Ranking Member Swalwell, and Members of the Subcommittee, this concludes my prepared statement. I will be pleased to answer any questions you may have.

[The prepared statement of Dr. Rusco follows:]

United States Government Accountability Office

Testimony
Before the Subcommittee on Energy, Committee on Science, Space, and Technology, House of Representatives

For Release on Delivery
Expected at 9:00 a.m. ET
Friday, July 11, 2014

FUSION ENERGY

Observations on DOE's Cost and Schedule Estimates for U.S. Contributions to an International Experimental Reactor

Statement of Frank Rusco, Director,
Natural Resources and Environment

Chairman Lummis, Ranking Member Swalwell, and Members of the Subcommittee:

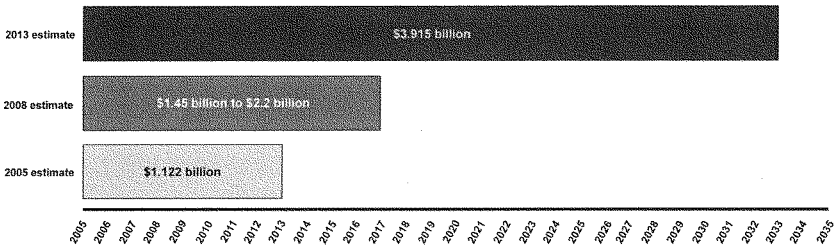
I am pleased to be here today to discuss our recent report on the Department of Energy's (DOE) cost and schedule estimates for U.S. contributions to the International Thermonuclear Experimental Reactor, now known as ITER.[1] As you know, ITER is an international research facility being built in France to demonstrate the feasibility of fusion energy. Fusion occurs when the nuclei of two light atoms collide and fuse together at high temperatures, which results in the release of large amounts of energy. The United States has committed to providing about 9 percent of ITER's construction costs through contributions of hardware, personnel, and cash, and DOE is responsible for managing these contributions, as well as the overall U.S. fusion program. Agreeing to share the cost of building ITER allows the United States to benefit from the scientific and technological expertise of the other six ITER members and have full access to ITER's research results.[2] However, since the ITER Agreement was signed in 2006, ITER's expected construction cost has grown by billions of dollars, and its construction schedule has slipped by years, as have the cost and schedule estimates for U.S. contributions to the project's construction (see fig. 1).

---

[1] GAO, *Fusion Energy: Actions Needed to Finalize Cost and Schedule Estimates for U.S. Contributions to an International Experimental Reactor*, GAO-14-499 (Washington, D.C.: June 5, 2014).

[2] The other six ITER members are the European Union, India, Japan, the People's Republic of China, the Republic of Korea, and the Russian Federation.

Figure 1: Total Estimated Cost and Completion Date for U.S. Contributions to ITER's Construction



Source: GAO analysis of DOE data. | GAO-14-750T

The ITER Agreement established a management framework under which the international ITER Organization manages the overall project and is governed by a council, known as the ITER Council, which is composed of high-level government officials from each of the seven ITER members. During ITER's construction, each individual ITER member is responsible for managing the cost and schedule of its assigned contributions within the overall goals set in the international schedule. DOE manages U.S. contributions through the U.S. ITER Project Office at the Oak Ridge National Laboratory in Tennessee. In fiscal year 2014, the U.S. ITER Project received $199.5 million, which is about 40 percent of that year's overall U.S. fusion program budget. The ITER Agreement includes a provision that allows any ITER member except the European Union to withdraw from the project after the agreement has been in force for 10 years, which would be in October 2017. However, withdrawing members still have the responsibility of providing the entire cost of their assigned hardware components and cash contributions to the construction phase, and they could be responsible for other costs as well if they withdraw during ITER's operation phase.

In 2007, when the United States was just beginning to participate in ITER, we reported on the importance of DOE assessing the full costs of U.S.

participation in ITER and setting a definitive cost estimate for the project.[3] Specifically, we reported that DOE had made a commitment to provide hardware components to ITER without a definitive cost and schedule estimate or a complete project design. We reported that, as a result, DOE's preliminary cost estimate of $1.122 billion for U.S. contributions to ITER's construction might be subject to significant change. We also reported that the management challenges facing the ITER Organization could result in ITER construction delays and further increase costs for the United States. Today, significant questions remain about how much the U.S. ITER Project will cost, when it will be completed, and how DOE plans to manage the impact of U.S. ITER Project costs on the overall U.S. fusion program in a constrained federal budget environment.

In this context, my testimony today discusses the findings from our recent June 2014 report on DOE's cost and schedule estimates for the U.S. ITER Project. Accordingly, this testimony addresses (1) how and why the estimated cost and schedule for the U.S. ITER Project have changed since 2006; (2) the reliability of DOE's current cost and schedule estimates for the U.S. ITER Project and the factors, if any, that have affected their reliability; and (3) the actions DOE has taken, if any, to reduce U.S. ITER Project costs and plan for their potential impact on the overall U.S. fusion program. In addition, I will highlight several key actions that we recommended in our report that DOE can take to help reduce uncertainty about the U.S. ITER Project's cost and schedule.

To conduct this work, among other things, we reviewed the ITER Agreement, relevant laws, and DOE guidance, DOE's most recent cost and schedule estimates for the U.S. ITER Project—as developed by the U.S. ITER Project Office in August 2013—and DOE's internal peer review of those estimates, and we interviewed DOE officials and U.S. ITER Project Office representatives. Our June 2014 report includes a detailed explanation of the methods used to conduct our work. We conducted the work on which this testimony is based in accordance with generally accepted government auditing standards.

---

[3] GAO, *Fusion Energy: Definitive Cost Estimates for U.S. Contributions to an International Experimental Reactor and Better Coordinated DOE Research Are Needed*, GAO-08-30 (Washington, D.C.: Oct. 26, 2007).

The Estimated Cost and Schedule of the U.S. ITER Project Has Grown Substantially Since 2006 for Several Reasons

DOE's estimated cost for the U.S. ITER Project has grown by almost $3 billion since the ITER Agreement was signed in 2006, and the agency's expected schedule for completing the project has slipped by 20 years.

DOE identified several reasons for the growth in its cost and schedule estimates, including

- higher estimates for U.S. hardware components as designs and requirements have been more fully developed over time;
- higher contingency amounts added to address risks from the project's significantly longer schedule;
- U.S. schedule delays due to international project schedule delays and U.S. funding constraints; and
- higher cash contributions to the ITER Organization due to growth in ITER construction costs.

Nonetheless, DOE's current estimates remain preliminary because DOE has not approved a performance baseline for the U.S. ITER Project. A performance baseline captures a project's key performance, scope, cost, and schedule parameters, and it represents a commitment from DOE to Congress to deliver a project within those parameters.

Despite Reflecting Most Characteristics of Reliable Cost and Schedule Estimates, DOE's Estimates Cannot Be Used to Set a Baseline

DOE's current cost and schedule estimates for the U.S. ITER Project reflect most characteristics of reliable estimates.[4] However, DOE's estimates cannot be used to set a performance baseline that would represent a commitment from DOE to Congress to deliver the project at a specific cost and date. DOE's target date for setting such a performance baseline has slipped from fiscal year 2007 to late in fiscal year 2015. DOE's current estimates cannot be used to set a performance baseline because of three factors, two of which DOE can only partially influence. First, the overall international project schedule that DOE uses as a basis for the U.S. schedule is not reliable, in part, because of management deficiencies within the ITER Organization. Second, DOE has not proposed a final, stable funding plan for the U.S. ITER Project. DOE's most recent plan was to provide a flat $225 million per year for the project, but that plan could change depending on the outcome of the

---

[4] GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: Mar. 2, 2009) and *GAO Schedule Assessment Guide: Best Practices for Project Schedules—Exposure Draft*, GAO-12-120G (Washington, D.C.: May 30, 2012).

ITER Organization's reassessment of the international project schedule. The third factor that has kept DOE from setting a performance baseline is within the agency's direct control. Specifically, an August 2013 DOE internal peer review found that the methodologies used to develop the agency's current cost estimate of $3.915 billion and its schedule estimate were appropriate, but the estimates do not sufficiently consider all the project's risks and uncertainties. This review found that when these risks and uncertainties are accounted for, the U.S. ITER Project was more likely to cost from $4 billion to $6.5 billion.

DOE has taken several actions to try to get the ITER Organization to address international project management and scheduling deficiencies including: (1) participating in early ITER Agreement negotiations leading to the adoption of biennial management assessments; (2) advancing project management principles such as competitive procurement actions in ITER Council Management Advisory Committee meetings; and (3) providing position papers to other ITER members on DOE's concerns about ITER Organization management. To address the uncertainty of the funding plan for the U.S. ITER Project, DOE has evaluated a range of funding scenarios for executing the project. To ensure that all risks and uncertainties are sufficiently incorporated into its estimates, DOE officials told us the U.S. ITER Project Office held a series of risk workshops. These efforts may have helped improve ITER Organization project management and helped jump-start efforts to develop a reliable international project schedule, but such a schedule is not expected until June 2015 when the ITER Organization hopes to complete its schedule reassessment. Further, project management and schedule deficiencies in the ITER Organization and uncertainty in the U.S. ITER Project funding plan continue to delay the agency's efforts to set a performance baseline.

DOE Has Taken Several Actions to Reduce U.S. ITER Project Costs but Has Not Adequately Planned for Their Impact on the U.S. Fusion Program

According to DOE documents and officials, DOE has taken several actions that have reduced the cost of the U.S. ITER Project by about $388 million as of February 2014. However, DOE has not adequately planned for the potential impacts of U.S. ITER Project costs on the overall U.S. fusion program. In fiscal year 2014, the U.S. fusion program budget was approximately $505 million, of which $199.5 million, or about 40 percent, went toward the U.S. ITER Project. We have previously reported that strategic planning is a leading practice that can help clarify priorities,[5] and the House and Senate Appropriations Committees have directed DOE to complete a strategic plan for the U.S. fusion program. DOE has begun work on such a plan but has not committed to a specific completion date. Without a strategic plan for the U.S. fusion program, DOE does not have information to create an understanding among stakeholders about its plans for balancing the competing demands the program faces with the limited available resources or to help Congress weigh the trade-offs of different funding decisions for the U.S. ITER Project and overall U.S. fusion program.

DOE Can Take Action to Reduce Uncertainty about the U.S. ITER Project's Cost and Schedule

To reduce uncertainty about the expected cost and schedule of the U.S. ITER Project and its potential impact on the U.S. fusion program, we made several recommendations to DOE in our June 2014 report. These included the following:

- direct the U.S. ITER Project Office to revise and update the project's cost estimate by including a comprehensive sensitivity analysis and conducting an independent cost estimate to meet all characteristics of high quality, reliable cost estimates;
- develop and present at the next ITER Council meeting a formal proposal describing the actions DOE believes need to be taken to set a reliable international project schedule and improve ITER Organization project management, and continue to formally advocate for the timely implementation of those actions at future ITER Council meetings;
- once the ITER Organization completes its reassessment of the international project schedule, use that schedule, if reliable, to

---

[5] For example, see GAO, *Environmental Protection: EPA Should Develop a Strategic Plan for Its New Compliance Initiative*, GAO-13-115 (Washington, D.C.: Dec. 10, 2012) and *Environmental Justice: EPA Needs to Take Additional Actions to Help Ensure Effective Implementation*, GAO-12-77 (Washington, D.C.: Oct. 6, 2011).

propose a final, stable funding plan for the U.S. ITER Project, approve a performance baseline, and communicate this information to Congress; and

- set a specific date for completing, in a timely manner, a strategic plan for the U.S. fusion program that addresses DOE's priorities for the overall U.S. fusion program in light of U.S. ITER Project costs, and involve the Fusion Energy Sciences Advisory Committee in the development of the plan.

DOE agreed with all of our June 2014 report's recommendations and said it has taken steps or plans to take additional steps to fully implement them.

In conclusion, in 2007 and now again in 2014, we have found that the U.S. ITER Project is subject to a significant amount of uncertainty and may continue to face significant changes or delays in the future. In addition, the cost of U.S. contributions to ITER could continue to grow. ITER provides an opportunity to develop a clean, abundant source of energy, but it should be considered in terms of its likelihood of success, broader impacts on the U.S. fusion program, and federal budget constraints.

Chairman Lummis, Ranking Member Swalwell, and Members of the Subcommittee, this concludes my prepared statement. I would be pleased to answer any questions that you may have at this time.

GAO Contact and Staff Acknowledgments

If you or your staff members have any questions concerning this testimony, please contact me at (202) 512-3841 or ruscof@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. Other individuals who made key contributions to this testimony include Dan Haas, Assistant Director; David Marroni, and Andrew Moore.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's website (http://www.gao.gov). Each weekday afternoon, GAO posts on its website newly released reports, testimony, and correspondence. To have GAO e-mail you a list of newly posted products, go to http://www.gao.gov and select "E-mail Updates."

Order by Phone

The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's website, http://www.gao.gov/ordering.htm.

Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537.

Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.

Connect with GAO

Connect with GAO on Facebook, Flickr, Twitter, and YouTube. Subscribe to our RSS Feeds or E-mail Updates. Listen to our Podcasts. Visit GAO on the web at www.gao.gov.

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Website: http://www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Katherine Siggerud, Managing Director, siggerudk@gao.gov, (202) 512-4400, U.S. Government Accountability Office, 441 G Street NW, Room 7125, Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548

BIO for Frank Rusco

Frank Rusco is a Director in GAO's Natural Resources and Environment team, leading work on a broad spectrum of energy issues, including federal oil and gas management; DOE's energy, R&D and loan programs; Nuclear Regulatory Commission oversight; and government-wide energy programs and activities. Mr. Rusco holds both a master's degree and doctorate in economics from the University of Washington in Seattle.

Chairwoman LUMMIS. Thank you, Dr. Rusco.

I now recognize Dr. Dehmer to present her testimony.

TESTIMONY OF DR. PATRICIA DEHMER, DEPUTY DIRECTOR FOR SCIENCE PROGRAMS, DOE

Dr. DEHMER. Chairman Lummis, Ranking Member Swalwell, Chairman Smith, Members of the Committee, I am pleased to come before you today to discuss the Department's Fusion Energy Sciences program, which supports work to understand matter at very high temperatures and densities, and to build the scientific foundation needed to develop a fusion energy source. The ITER project is the only planned burning plasma experiment in the world, and it is an important component of the Fusion Energy Sciences program. Indeed, our program is configured to support ITER activities, both now and in the future.

The idea to build a burning plasma device through an international agreement originated from a Geneva superpower summit in November 1985, at which time Premier Gorbachev proposed to President Reagan that an international project be established to develop fusion energy for peaceful purposes. Many years, and may project changes later, including a congressionally directed withdrawal when project costs were escalating, the U.S. re-entered ITER in 2007.

At that time, the expected U.S. cost for ITER was $1.1 billion, which was a tractable amount in an era of projected strong budget growth. Indeed, in 2007, President Bush signed the America Competes Act, which authorized a doubling of funding for the Office of Science, and other Federal basic science programs over a period of a decade.

However, since that time, as you well know, the estimated cost of U.S. ITER contributions has grown to more than $4 billion. The growth arises from several factors, which are summarized in the GAO report. The project has also seen a multi-year schedule slip from the original projected completion date. In contrast to the increased estimate for the cost of U.S. obligations to ITER, funding for the Office of Science has grown more slowly.

This makes annual budgeting a challenge. It is made significantly more challenging each year, owing to stunning new scientific discoveries and new technologies that have created imperatives in every program of the Office of Science. For example, we are in worldwide competitions for the most capable scientific computers, and for revolutionary X-ray light—laser light sources that probe matter at the atomic level. Neither was envisioned a decade ago. Increased urgency has been placed on research to develop new materials, new chemistries, and new biological processes for clean and efficient energy.

In addition to cost growth and schedule slip, other issues have emerged that affect ITER. In late 2013 to third biennial management assessment of the ITER organization identified significant management issues that threatened the success of the project. Eleven recommendations resulted. The U.S. agreed with all of the recommendations put forward. Key among them is that leadership, management, and culture within the ITER project must be improved if it is to succeed.

The U.S. has spent significant time and energy to help ITER succeed. We have sent our best personnel in the United States to work at the ITER organization. We have recommended that Dr. Bob Iotti be the council chair, and he accepted, and we are very pleased. And we have insisted that all of the management assessment recommendations be adopted and implemented. The administration maintains its commitment to our responsibilities under the joint implementing agreement for ITER, but we insist on the reforms articulated in the management assessment report.

I would like to close by remarking on the GAO report. As always, we thank the GAO for its findings and its recommendations. This was a particularly difficult report, and the GAO did an excellent job. The Department of Energy agrees with the four recommendations for executive action. We have already implemented those recommendations that we can address more, and we plan to take action on the recommendations that first require the international organization to baseline the project.

Finally, I want to thank this Committee for holding the hearing on ITER, and providing the Department with the opportunity to testify. We look forward to continuing to work with you on the complex domestic and international challenges that we face in fusion research. Thank you.

[The prepared statement of Dr. Dehmer follows:]

Statement of Dr. Patricia Dehmer
Acting Director of the Office of Science
U.S. Department of Energy
before the
House Committee on Science, Space, and Technology
Subcommittee on Energy
Fusion Energy: The World's Most Complex Energy Project
July 11, 2014

Thank you Chairman Lummis, Ranking Member Swalwell, and distinguished members of the Committee. I am pleased to come before you today to discuss the status of the Department of Energy's (DOE) Fusion Energy Sciences (FES) program within the Office of Science.

The Fusion Energy Sciences Program and ITER in the Office of Science

The Fusion Energy Sciences (FES) program is one of six science program areas in DOE's Office of Science. Among the goals of the FES program are to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished through the study of plasma, the fourth state of matter, and how it interacts with its surroundings. Understanding the scientific character of the burning plasma state, as well as establishing the science for maintaining this state for long durations, is a major objective of FES research. To achieve these research goals, FES invests in U.S. experimental facilities of various scales, international partnerships that leverage U.S. expertise, large-scale numerical simulations based on experimentally validated theoretical models, the development of advanced fusion-relevant materials, and the invention of new measurement techniques.

The knowledge established through FES research supports U.S. goals for future scientific exploration on ITER, an international partnership, under an agreement among the U.S, China, India, Japan, Russia, South Korea, and the European Union, to produce net fusion energy. . If successful, ITER will be the world's first magnetic-confinement burning plasma experiment to demonstrate the scientific and technical feasibility of fusion as a future energy source.

The idea to cooperatively design and build a burning plasma device through an international agreement originated from a Geneva superpower summit in November 1985, at which Premier Gorbachev proposed to President Reagan that an international project be established to develop fusion energy for peaceful purposes. The ITER Agreement thus began as a four-party collaboration among the former Soviet Union, the U.S, the European Community (which has since become the European Union, or EU), and Japan. As a technical basis for the ITER project, the four parties agreed that the tokamak configuration would be the logical choice, given its superior performance (both then and now) in plasma energy confinement. The ITER Conceptual Design Activities began in 1988. This was followed in 1992 by the Engineering Design Activities (EDA), which involved a great deal of research and development and concluded in 1998. At that point, Congress directed DOE not to participate in a 3-year extension of the EDA primarily because of concerns over the size of ITER's construction cost estimate. The remaining three Parties continued to work on the ITER design, with an emphasis on de-scoping to cut its construction cost by roughly half. The result was the 2001 ITER Final Design Report (FDR).

As the result of an initiative by President Bush in 2003, the U.S. initiated negotiations to rejoin the ITER project through entering into an international agreement with the countries involved, including the EU. Later in 2003, South Korea and China joined, followed by India in 2005. In addition to determining a construction site, the negotiations produced the *Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project (JIA),* which was signed by the seven Members in November 2006. It entered into force on October 24, 2007, for a period of 35 years, consisting nominally of 10 years for construction, 20 years for operation, and 5 years for deactivation.

U.S. participation in ITER, and its execution of the ITER international agreement, was specifically authorized by the Energy Policy Act of 2005 (EPAct 2005), Section 972(c)(5)(C). The EPAct 2005 also required that any final ITER agreement be submitted to Congress for its review prior to its execution by the U.S. To comply with EPAct 2005, DOE provided Congress with the following reports: (1) a document entitled *Plan for U.S. Scientific Participation in ITER*; (2) a report describing the management structure of the ITER and an estimate of the cost of U.S. participation (although the ITER Agreement requires principally in-kind contributions, rather than fixed, dollar contributions); and (3) a report describing how U.S. participation in the ITER would be funded without a funding reduction in other Office of Science programs. In 2008, the National Research Council (NRC) reviewed and endorsed the *Plan for U.S. Scientific Participation in ITER*; such a review was another requirement of EPAct 2005. Currently, the ITER project is the only planned burning plasma experiment in the world, and it is therefore an important component of the FES program. The U.S. domestic fusion program and facilities are currently aligned to support research relevant towards a burning plasma experiment at ITER. For our agreed 9% share of the ITER project under the ITER Agreement, the U.S. would have access to all the science. Given the projected costs it is unlikely that any single country would build the ITER machine on its own.

ITER is an extremely large and complex construction project, with additional challenges coming from its international governance and distributed workload. As mentioned, each ITER partner is obligated to build and deliver specified components or systems for the ITER machine and complex. These completed components are shipped to the ITER site in France and are to be assembled and integrated by the ITER Organization.

An important aspect of the FES program is the completion of a strategic plan for the entire domestic program. In April of this year, I charged the Fusion Energy Sciences Advisory Committee with providing advice on priorities among continuing and potential new Fusion Energy Sciences program investments. The charge requests advice and priorities in areas relevant to burning plasmas and discovery plasma science, and the charge explicitly assumes continued U.S. participation in ITER. The Office of Science will use this input to develop a congressionally directed strategic plan for fusion by the end of this calendar year.

FES and ITER in Context: The Office of Science and its Broad Mandate

The Office of Science is the nation's largest Federal sponsor of basic research in the physical sciences and the lead Federal agency supporting fundamental scientific research for energy, supporting discovery science in high energy, nuclear, and plasma physics; materials and chemistry; biological systems and earth system components; and mathematics, computer, and computational sciences. Much of this research underpins advances in clean energy. The Office of Science supports about 22,000 investigators at over 300 U.S. academic institutions and at all of the DOE laboratories. The Office of Science user facilities – the finest collection of such facilities anywhere in the world – support about 28,000 users annually. Our research investments are vital to advancing U.S. leadership in science and strengthening our national competiveness.

Within the Office of Science, a priority is the pursuit of leadership in areas judged to be critical for the U.S. and for DOE's missions, especially the energy mission in the midterm time frame. Examples include high performance computing with the development of a capable exascale machine over the next decade; the characterization of materials—including biomaterials—to enable predictive design using facilities such as the upgraded Linac Coherent Light Source and the upgraded Advanced Photon Source; and research to address some of the most important fundamental research problems facing DOE, including solar energy conversion, bio-energy, catalysis, and energy transduction and storage.

Investments in FES and ITER are part of this balanced portfolio within the Office of Science, a balance made increasingly more difficult each year by a host of new scientific discoveries and new technology developments that have created scientific imperatives in virtually every sector of science supported by the Office of Science. We now are in world-wide competitions for the most capable scientific computers and for revolutionary x-ray laser light sources that probe matter at the atomic level and thus help us create designer materials. Increased urgency has been placed on research to develop new materials, new chemistries, and new biological processes for clean and efficient energy. Furthermore, within the past two years, discoveries in subatomic physics—such as the characterization of the neutrino and the discovery of the Higgs Boson—have redefined and clarified the future of high energy physics, which we steward, and have made progress toward that future more urgent.

Considerations of the Future for the Office of Science Programs and FES Activities in a Constrained Budget Environment

At the time of U.S. re-entry into ITER, the U.S. planned contribution to ITER was estimated at $1.1 billion, a tractable amount in an era of projected strong budget growth. Indeed, in 2007, President Bush signed the America COMPETES Act, which authorized appropriations initiating a trajectory for the doubling of funding for the Office of Science—and other federal basic science programs—over a period of a decade. However, since that time, the estimated cost of U.S. contributions to ITER has grown to more than $4 billion. While the actual components the U.S. is obligated to contribute under the ITER Agreement have remained unchanged, the growth in the dollar cost of U.S. contributions to ITER from the initial 2005 estimate arise from several factors, captured in the recent GAO report on ITER. The initial estimates for the cost of U.S. hardware components were low due to incomplete design and requirements for the project. Changes to the U.S. hardware component requirements and the international project schedule also added additional cost. In contrast to the sharply increased estimate for the cost of the U.S. obligations under the ITER Agreement, funding for the Office of Science has grown slowly, particularly in the past few years.

In addition to costs, other factors impacting ITER have recently emerged. In late 2013, the third biennial Management Assessment (MA) of the ITER Organization identified significant management issues, which threaten the success of the project; the Management Assessment produced eleven recommendations for the ITER Organization and the ITER Council. The Administration agreed with the MA's findings that the management of the international ITER Project must be improved for ITER to succeed. Subsequently, U.S. delegations to ITER Council meetings have consistently and strongly argued that the recommendations be adopted and implemented. These management problems do not relieve the U.S. of any of its obligations under the ITER Agreement.

In the FY 2014 President's Budget request to Congress, the Administration made the decision to support an annual funding level [for ITER] of no more than $225,000,000 per year, while also maintaining funding for an impactful domestic fusion program. In FY 2015, the Administration requested $150M for ITER, as the U.S. believed the project could not meet the most recent schedule put forward by the ITER Organization. Our best estimate of the international schedule is that it is currently delayed approximately three years due to the delay in the civil construction of the tokamak building that will house the ITER machine. Through FY 2014, Congress has appropriated $667.2 million for hardware and $130.7 million for cash contributions for a total of $797.9 million for support of ITER.

Success of the global ITER project requires changes and improvements that go beyond the required U.S. contributions. In order to improve the operations of the ITER Organization and the Council, and in accordance with the procedures of the ITER Council, chairmanship of the Council has changed; it was assumed by Dr. Robert Iotti (recommended for the post by the U.S.), who has the broad respect of the partners and of the ITER Organization and who is working tirelessly to improve the project.

We believe that, at present, the success of ITER will require that all Members support the necessary changes in the ITER Organization and the ITER Council; acknowledge the true global schedule of the ITER project and plan to that schedule; improve performance and cooperation by the ITER Organization and the EU domestic agency, which is a 45% partner of the project; and execute the storage, assembly, and integration of the components of ITER by the ITER Organization.

The U.S. obligation under the ITER Agreement is only 9% of the total obligations—unlike most Office of Science construction projects—and therefore many aspects of ITER are outside U.S. control. This includes, for example, the current delay in the civil construction of the Tokamak Building. At the most recent ITER Council meeting, it was determined that this is the critical path item currently limiting the ITER schedule.

It will not be possible to baseline the U.S. contributions to ITER until a realistic schedule is developed by the ITER Organization. This updated schedule is to be completed by the ITER Organization by June 2015. The best U.S. estimate is that the ITER first-plasma milestone would be achieved no earlier than late 2023 and that full fusion operations would begin in the 2030s. We continue to apply the principles of DOE's Project Management Order 413.3 to the U.S. contributions, reassessing annually.

The U.S. has spent significant time and energy to help ITER succeed: we have sent U.S. personnel to work at the ITER Organization; we have recommended Dr. Robert Iotti as ITER Council Chair; and we have insisted that all the Management Assessment recommendations be adopted and implemented. At

ITER council meetings and in bilateral meeting with our partners, we have emphasized the need for improved project management and leadership, and we have repeatedly noted the urgency of righting the project.

If the U.S. were to abandon the ITER project, the U.S. could be liable for significant fiscal obligations, because the ITER Agreement allows for withdrawal from the project only after 10 years and requires the withdrawing party to fully perform its obligations, even after withdrawal. Modification of this requirement, or withdrawal from ITER earlier than 10 years from entry into force of the ITER Agreement would require negotiation with and consent of the other ITER members. An unconsented withdrawal might trigger responses from our international partners.

Finally, the Department agrees with the four recommendations for Executive Action that the GAO identified in its recent report on ITER. We have already taken action to advocate for a credible international project schedule; once completed in June of 2015, we will use that schedule to establish a baseline and funding plan for the U.S. contributions. We have set a date for completing a strategic plan for U.S. fusion, using FESAC in the development of the plan.

Thank you for providing me with the opportunity to testify before your Committee today. I look forward to continuing to work with the Committee on the complex domestic and international challenges in fusion research.

Dr. Patricia M. Dehmer

Acting Director, Office of Science
U.S. Department of Energy

Patricia M. Dehmer has been the Acting Director for the Office of Science since April 2013. She is the Deputy Director for Science Programs in the Office of Science at the U.S. Department of Energy (DOE). In this capacity, Dr. Dehmer is the senior career science official in the Office of Science, which is third largest Federal sponsor of basic research in the United States, the primary supporter of the physical sciences in the U.S., and one of the premier science organizations in the world.

As Deputy Director for Science Programs, Dr. Dehmer provides scientific and management oversight for the six science programs of the Office of Science (basic energy sciences, biological and environmental research, fusion energy sciences, advanced scientific computing research, high energy physics, and nuclear physics), for workforce development for teachers and scientists, and for construction project assessment. The Office of Science supports research at 300 colleges and universities nationwide, at DOE laboratories, and at other private institutions.

From 1995 to 2007, Dr. Dehmer served as the Director of the Office of Basic Energy Sciences (BES) in the Office of Science. Under her leadership, the BES budget more than doubled in size to $1.2B annually. She built a world-leading portfolio of work in condensed matter and materials physics, chemistry, and biosciences. A five-year effort to relate fundamental research in these disciplines to real-world problems in energy – including problems in fossil energy and carbon dioxide sequestration, nuclear energy, renewable energy, energy efficiency, energy transmission and storage, and the mitigation of environmental impacts of energy use – facilitated greater integration of basic and applied research across DOE.

During this period, Dr. Dehmer also was responsible for the planning, design, and construction phases of more than a dozen major construction projects totaling $3 billion. Notable among these were the $1.4 B Spallation Neutron Source at Oak Ridge National Laboratory, five Nanoscale Science Research Centers totaling more than $300M, the total reconstruction of the Stanford Synchrotron Radiation Lightsource at the SLAC National Accelerator Laboratory (SLAC), and the start of two new facilities for x-ray scattering – the Linac Coherent Light Source at SLAC, which is the world's first hard x-ray free electron laser, and the National Synchrotron Light Source II at Brookhaven National Laboratory, which will provide the highest spatial resolution of any synchrotron light source in the world.

Dr. Dehmer began her scientific career as a postdoctoral fellow at Argonne National Laboratory in 1972. She joined the staff of the Laboratory as an Assistant Scientist in 1975 and became a Senior Scientist in 1985. In 1992, the Laboratory established a new scientific rank that recognizes sustained outstanding scientific and engineering research, and Dr. Dehmer was among the 1% of the Laboratory's technical staff promoted to that rank, now called Argonne Distinguished Fellow, in that first year.

Dr. Dehmer's research in atomic, molecular, optical, and chemical physics resulted in more than 125 peer-reviewed scientific articles. Her studies of the interactions of electronic and atomic motion in molecules provided fundamental understanding of energy transfer, molecular rearrangement, and chemical reactivity.

Dr. Dehmer is a fellow of the American Physical Society and the American Association for the Advancement of Science. For the 15 years prior to assuming her position as Director of BES, she served in dozens of elected and appointed positions in scientific and professional societies and on review boards. Dr. Dehmer was awarded the Meritorious Presidential Rank Award in 2000 and 2008 and the Distinguished Presidential Rank Award in 2003.

Dr. Dehmer received the Bachelor of Science degree in Chemistry from the University of Illinois in 1967 and the Ph.D. degree in Chemical Physics from the University of Chicago in 1972.

Chairwoman LUMMIS. Thank you, Dr. Dehmer.

And now I recognize Dr. Iotti to present his testimony.

TESTIMONY OF DR. ROBERT IOTTI, ITER COUNCIL CHAIR

Mr. IOTTI. Thank you, Madam Chairman, Ranking Member Swalwell, Chairman Smith, Members of the Subcommittee. I thank you very much for the opportunity of appearing before you. I am presently the chair of the council, but I want to make sure that you understand I don't represent the view of the council, but my own as a person who has been involved for over 45 years in defense and nuclear—commercial nuclear facilities, as well as fusion facilities.

I could not be as eloquent as the members themselves on the promise of fusion, or why ITER is so important, so let me just get to the status of ITER. This is a nuclear facility which is licensed in France. It is being constructed in Cadarache, and work is progressing on site. At 6:00 a.m. yesterday morning the project began pouring the major slab on which the tokamak itself will sit, and the design, the fabrication, and the construction of the various component structures, buildings, and systems that comprise ITER are progressing, both on site, as well as in the domestic agencies, of the various parties that contribute to ITER. I brought a booklet to the Committee that I ask the Committee to be part of this record because, pictorially, it will show progress, and it will take me thousands of words to explain what pictures will tell you.

Unquestionably, ITER has had management problems. The schedule is uncertain, as is its final cost. What is known is that the schedule is going to be longer, and the cost higher than had originally been anticipated. And, as mentioned, the project is preparing an updated schedule, which should be ready by the middle of 2015. The reasons for the cost and schedule overruns are varied, but unique to ITER is the ITER international agreement itself, which causes some of these problems.

The Director General of the ITER organization is responsible for the overall design, the licensing, the construction, the commissioning, and the operation, but the various buildings, components, systems are provided by—as contribution in kind by the domestic agencies, and the domestic agencies have all of the funds. The operations are funded from those funds, and the funds are subject to budgets that are allocated to ITER by the various parties. So the Director General and the ITER organization have really no direct control on the funds, or on the domestic agencies, so that when there is any misalignment between the ITER organization and domestic agencies on any particular topic, decisions would typically require unanimity, or at the very least consensus cannot be readily made, leading to delays and cost increases.

Now, funding shortfalls can contribute to those schedule delays and consequent cost increases. Given the delays and increases experienced to date, many parties have budget problems, and the U.S. is not alone. However, the U.S. strategy to minimize yearly funding until the schedule is known with high degree of confidence, and ITER performance is improved, will increase the ITER cost for the U.S., and could delay the ITER schedule. You know, when the new schedule becomes known, whether the U.S. will be a critical—

or not is uncertain at this point. But if they are, lest they cause international delays, they may have to adjust the budget afterwards. The same failure of any member can affect any of the members.

Now, with regard to the management assessor, the council has immediately improved its effectiveness and efficiencies. We used to take up days without concluding anything, and take up a large fraction on trivial matters. Now they are disposed instantly by approving a consent package that contains all the non-controversial, and then the council concentrates on the big issues. The IO has prepared a detailed action plan, and the detailed action plan has been acted upon on all actions, so we are responding to every recommendation of the management assessors.

Now, some actions pay immediate dividend. We see now we are meeting milestones on the schedules that before we used to meet only 50 percent of the time. That is a good sign. On the other hand, changing culture takes time, so all of the action related to culture will be work in progress for a bit of time.

Perhaps the most important action taken is on the action of changing the management of ITER. A formation of a search committee has already occurred. This committee meets Tuesday in Paris to elect their own chair, and then start evaluating the recommendation of—members, potential candidates for Director General, and other important positions on the project.

So I would like to leave the Committee that, in summary, we are not just making progress in constructions. We are also making progress in fixing the management project. Will ITER be successful? Well, you know, it is an experimental reactor, but it is based on the knowledge acquired throughout the world, and all of the fusion devices, so the likelihood of not meeting performance is low. There are no showstoppers, and the technological challenges can be met and overcome. So let me stop right now, and ask the Members—again, thanking them. If there are any question, I will be happy to answer them.

[The prepared statement of Dr. Iotti follows:]

Testimony (Written Statement) of Robert C. Iotti

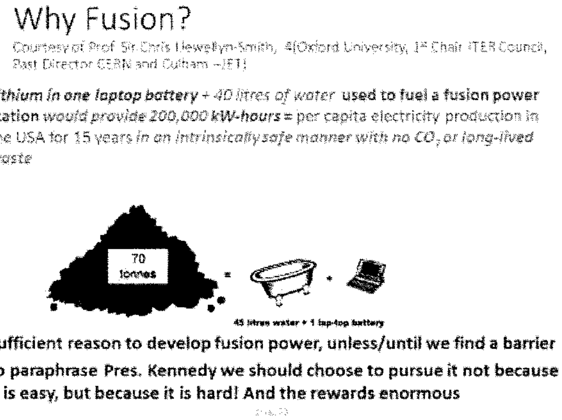
Submitted to the Committee on Science, Space and Technology, Subcommittee on Energy, July 11, 2014

Madame Chair, Ranking Member Swalwell, and Members of the Committee: Thank you for this opportunity to appear before you today.

My name is Bob Iotti. I am the present Chair of the ITER Council. It is an honor to provide this testimony on progress of the ITER international fusion project and the challenges that we are facing. While being the Chair of the Council provides me with a unique perspective on the project, I am not representing the views of the Council, but simply providing information that is known to me in as its Chair, as well as offering some personal views.

Since one of the purposes of the Hearing is to assess the status of the International Thermonuclear Experimental Reactor (ITER) it is appropriate that I begin with my view of the worldwide importance of this project.

Nuclear Fusion is what powers the Sun and the stars, and, in principle, could provide an almost unlimited, environmentally benign power on Earth: unlimited because the fuel is essentially unlimited, and environmentally benign because it is inherently safe and produces no long lived radioactive isotopes. To put it in perspective, the lithium from one laptop battery plus 40 liters of water can provide the per capita consumption of electricity in the US for 15 years. Harnessing fusion, however, has proven to be a much greater scientific and technical challenge than originally hoped, and ITER is indispensable and pivotal to such achievement



Why Fusion?

Courtesy of Prof Sir Chris Llewellyn-Smith, 4(Oxford University, 1st Chair ITER Council, Past Director CERN and Culham –JET)

Lithium in one laptop battery + 40 litres of water **used to fuel a fusion power station** *would provide 200,000 kW-hours* = per capita electricity production in the USA for 15 years *in an intrinsically safe manner with no CO_2 or long-lived waste*

Sufficient reason to develop fusion power, unless/until we find a barrier

To paraphrase Pres. Kennedy we should choose to pursue it not because it is easy, but because it is hard! And the rewards enormous

We do know that the fusion process produces energy. Aside from powering the Sun and stars, a controlled magnetic confinement fusion experiment at the Join European Torus (JET in the UK) has produced 16 MW of fusion power, and the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory produced 10MW; both experiments sustained the fusion power for about a second and required somewhat more heating power than the power produced. Based on these successful experiments and many other experiments worldwide, ITER has been designed to produce 500 MW of power for about 450 sec or more, with a power gain, which is the ratio of fusion power to external heating power, of 10 which is 8 times larger than the current world record made by JT-60 in Japan (equivalent to 1.25 with D-T fuel). In ITER, unlike JET and TFTR, the plasma will be mainly self-heated by the fusion reactions, which is why it is called a burning plasma since it burns the fuel and fusion power dominates the dynamics of the plasma. This is the only planned magnetic fusion facility that will enable us to study both the physics and technological issues of a burning plasma. The achievement of high power gain, large fusion power and long pulse operation are key scientific and technological challenges that need to be addressed for the development of a fusion power plant.

While I was involved in the construction of TFTR nearly 40 years ago and worked on ITER for two years in the 90's, my career has been mainly in the design and construction of defense nuclear facilities and commercial nuclear power plants in the U.S and Internationally, in large infrastructure projects and in successful waste management projects at INL, Hanford and Savannah River. Thus, I have developed an appreciation for the complex nature of large projects and the additional complexity associated with international projects. I was nominated by the U.S. to become the Chair of the ITER Council beginning on January 1st of this year, and elected unanimously by the other Members. I had previously been the Chair of the Council's Management Advisory Committee (MAC) and had attended Council meetings from mid- 2007 through the end of 2009. I had remained as U.S member of the MAC for the next four years, and hence followed the deliberations and decision of the Council during that period.

ITER has recently been the subject of several articles in the press. Unfortunately most of the articles have chosen to highlight the challenges that ITER face. Not as well publicized is the progress that ITER has made. Construction of the facility is proceeding in Cadarache, France, after receiving regulatory approval. Nearly 90% of the Procurement Arrangements (PAs) have been signed (specifically 99 PAs out of a total 140. The 99 PAs account for 2600 kIUA of the possible 2901 kIUA credit. The kIUA is a unit of account establishing the credit that a party is given for a particular contribution in kind). The PAs are the contractual documents between central organization (called the ITER Organization or IO for short) and the Domestic Agencies (DAs) of the parties who are signatories to the Joint ITER Joint Implementation Agreement (JIA) These PAs enable design, fabrication, and installation of the various required buildings, structures, systems and components of the facility. Buildings are under construction and the components are being fabricated in the diverse Domestic Agencies. Progress has been and is being made.

Unquestionably ITER as a project has had management problems. At present, the schedule for achieving first plasma and DT operations is uncertain, as is its final cost. What is known is that the schedule is longer and its costs greater than originally anticipated. There are a number of reasons for the overrun in schedule and cost. Some are not within the control of the project, such as the explosion in commodity prices in the 2005-2010 period. Some are due to the first of a kind nature of the ITER project and are almost invariably present in first of a kind facilities worldwide. We have seen them in the U.S first of a kind projects, like NIF and MOX for example. Some are indeed failures of management and also of multiple stakeholders in their decision making process. The latter encompass lack of sufficiently completed design for some systems and components, and delays caused by advisable changes in the design.

One of the difficult, if not the most difficult, problems causing delays and overruns are those that stem from the (JIA) itself. The IO and the Director General (DG) of the project are held responsible for the overall design, licensing, construction, commissioning, and then operation of the facility. The various buildings, structures, components and systems are provided as contributions in-kind to the IO by the DAs. The Domestic Agencies have all of the funds, which in turn are subject to the budgets allocated to ITER by the various parties. The IO operations are funded by cash contributed from those funds by the various parties on a yearly basis. The DG and the IO have no direct control over the Domestic Agencies, so that when, as is often the case, there is misalignment of incentives between the IO and any particular DA, decisions cannot be readily made, leading to delay and cost increases. An example of divergence of incentives, which occurs very frequently, is proceeding with a change in design, which the IO considers essential, but for which the particular DA or DAs involved have insufficient funds. The JIA specifies that anything that involves cost or schedule decisions requires unanimity or at least Members' best efforts to achieve consensus. All it takes is for the Member that has a problem with a particular decision, to not agree and that decision cannot be made. While the issue is difficult, it does not mean it is without a solution, and we are working on it, and are making reasonable progress.

Funding shortfalls can directly contribute to schedule delays and consequent cost increases. Given the schedule delays and cost increases experienced to date, it is normal for the parties to have budget problems. The U.S is not alone in experiencing these cost increases and delays. However, the US's strategy that yearly funding should be minimized until the schedule is known with a high degree of confidence and international ITER performance improves can further increase US costs and could well delay the ITER schedule. It creates a funding profile that is clearly insufficient for the US to deliver all of its in-kind contributions on the Council's presently approved schedule (1st plasma in Nov 2020, DT in 2027), necessitating delaying the delivery of some of the in-kind systems/components to much later dates. That presently approved schedule, however, is being updated. Whether the updated schedule, when completed in mid-2015, will show the US to be on the critical path remains to be seen. To avoid being the cause of international delay, the US may have to adjust the US budget accordingly. How much adjustment will be required will be determined by schedule dates. Similarly, failure of other Members to deliver on appropriate dates, whether because of budget shortfalls or other reasons, can cause cost increases for some or all Members, including the US.

A recent Management Assessment, conducted in 2013, pointed out issues in the IO management as well as the overall governance by the ITER Council. It also pointed out that action would be required on all, not just a few, of the recommendations in order to turn the project around.

So what steps has the Council taken to address the management challenges in ITER?

Prior to the 2013 Management Assessment, the Council had already been active in intervening in ways that would spur progress, such as would be expected from the equivalent of a Board of Directors. However, due in part because the people who prepared for the meeting did not bring forward the tough issues, and in part because the meeting agenda contained a large number of topics with no assigned priority or importance, the Council effectiveness was not optimal. In response to the MA recommendations, the Council has taken action to improve its effectiveness and efficiency. In the just completed Council meeting, the issues which used to consume a great part of the meeting, but were not controversial, were disposed instantly by approving a Consent Package containing the material on those issues, thereby enabling the Council to concentrate solely on the difficult and controversial issues. Of course, any member can raise issues regarding the Consent Package but this has streamlined the meeting making it more substantive.

Specifically in regard to the management of the project, the DG accepted all of the recommendations of the MA, and immediately after the IO started corrective action. The Council requested that the IO and the Council Preparatory Working Group prepare a detailed plan of action to respond to each and every recommendation that the Management Assessment had. The plan was then reviewed and some actions were approved and some sent back for further improvement. I was charged to provide the guidance to the DG to improve the response, which I did. For some recommendations many different actions are necessary, while for others a single action suffices. Every one of the actions is being implemented. Some are paying immediate dividends, and some will require more time to complete implementation and for us to see the results.

One example of tangible progress being already seen is the development of an updated realistic schedule. Because of the past experience of clearly being unable to do so, the approach to develop an updated schedule is to first develop an annual work plan for 2014, and use the experience in how well that plan can be met, to inform the subsequent development of the overall schedule. Until very recently, we were developing schedules replete with milestones, but were only meeting about 50% of them, and when a milestone was not met, it would simply be rescheduled. That has changed! In the first five months of this year, virtually all milestones have been met, and a few more, not yet scheduled, have been achieved. Milestones that are in jeopardy are immediately acted upon to prevent or minimize slippage. Of course five months of progress do not necessarily make a trend, but compared to the past, this is very gratifying. Not only is this a good sign, but we are learning from the annual work plan effort how to develop a more realistic updated schedule, and this bodes well for the ability of meeting our target date to have an updated, high confidence schedule by the middle of 2015.

With regard to the recommendation to reduce the number of senior managers in the IO and move more authority to delegate to the lowest technically competent level, the IO has proposed and begun implementing a revised organization which already reduces the senior managers by about 25% and flows down the decisions to the appropriate competent technical levels. The Council is still reviewing the IO proposed organization with a view to reduce the senior managers further to about 50%

As part of the same organizational changes, the IO is adding a considerable number of systems engineers, which will strengthen the systems engineering and integration capability, not only of the IO, but that of the DAs, by facilitating the handling of the interfaces with the DAs. This has contributed to the schedule delays and is being addressed.

Steps have been taken to reduce the IO bureaucracy and in particular to increase the IO effectiveness and efficiency. This will remain work in progress for some time, but as an example, the Council has approved the centralization of CAD services and its performance by IO staff as opposed to the previously used outside contractors. This saves money and time.

The actions to establish a project and a safety culture will also be work in progress for some time. Although all of the numerous actions proposed to accomplish this are being implemented, changes in culture take time. However I am encouraged with the different attitude I see in both the IO and the DAs. There is a new "can-do" spirit and increased cooperation, not quite at the optimal level, and not universal to all persons, but clearly much improved over what used to be there.

For those recommendations that affect not only the IO, but the relation between the IO and the DAs, and hence depend on their cooperation, the Council established a working group, under the chairmanship of an IO senior representative, and including the most senior personnel from each of the domestic agencies, to study ways in which the interaction between the IO and the DAs could be significantly improved without requiring a change in the JIA. A change of the JIA is considered impractical and virtually impossible.

This working group is addressing what is perhaps the most difficult task of any of those resulting from the MA recommendations. It has made very good progress is establishing means whereby decision are made jointly by the IO and DAs without jeopardizing compliance with the JIA, which holds the DG as the leader and nuclear operator. In this approach issues will be studied, with different options for decision presented to an executive group, comprising the IO and all DAs, that works with the DG and jointly arrives at a decision, which is then announced by the DG, but has already been agreed by the DAs. This approach will not solve all problems, and some decision may still have to go to the Council. The Council itself, however, will have the same problem of being blocked by any Member, hence to aid the Council in arriving at a decision, the various options with pros and cons will be presented to them.

I need to add that in establishing the action plans, in helping implementing them, and in the various working groups, the US is a very active contributor to the solutions. I am not referring to myself, because I am not a member of the US team, but as Chair I represent all Parties in the Council. Here, I refer to US representatives from the Domestic Agency and directly from the DOE. The US influence on ITER transcends its financial contribution, with many Members looking to the US to lead in solutions. This is true even despite the U.S present budget situation, although I must admit that it is sometime difficult to have the U.S opinion prevail, when the U.S is having budget difficulties, which are perceived as a lack of U.S commitment to the ITER Project.

Finally the Council, with the highest priority, has acted on the recommendation to accelerate the Director General transition, by forming a working group chaired by me. The assignment of this working group was to detail all of the steps necessary for an appropriate succession planning. This working group has completed its work, which has been accepted by the Council. The next step, already approved, is the formation of a Search Committee, who will meet in Paris on July 15th, elect its own chair, and start reviewing potential candidates and establish a ranked short list as soon as practical. While this effort is being conducted on a schedule which is as accelerated as possible, the priority is on identifying and successfully recruiting the next DG. Until that is done, it makes little sense to discuss if the present DG term of office should end before the end of his contract.

In summary, progress is being made. In the IO and some of the DAs, progress in fixing the management issues is not as rapid as one would like, but that is not surprising given the international nature of ITER, the difficulties of making decisions, due to the underlying structure of the project which to date has often resulted in stalemated IO and DAs. A new and better spirit of cooperation between the IO and the DAs is nascent, but not yet fully at the level it must be. Communication within the project is improving, but still has a way to go.

Nevertheless, despite the management problems, it is important that this Committee recognize that progress is being made in the licensing of the facility and the fabrication of the ITER various components and in the buildings. Attached to this testimony, I have provided a booklet of pictures that show the progress made in this regard in the various Domestic Agencies and at the site. The project has received approval for construction from the French regulator, and the first components will start arriving on site at the end of this year.

Obviously that progress is impeded every time any Member has difficulties with their budget, and given the past schedule slippages and cost increases, budget difficulties should be expected. At the very least, they should be expected to continue until such time that the project can develop reliable schedule and cost estimates so that they become known with high confidence, and the various Members can use that information to make concrete plans based on predictable data.

I believe that the project will produce a predictable schedule by mid-2015. Having a predictable schedule will also enable knowledge of the costs.

Let me close my testimony by answering two questions: will ITER be successful and what is in it for the U.S?

Success may be in the eye of the beholder, and given the history to date, some may consider ITER to be an unsuccessful project regardless of the ultimate outcome. I choose to judge its success based on whether it will deliver or exceed the performance that is expected. Like all "experimental" facilities, there is always a risk that the facility will fall short of the objective. That is why it is called "experimental". Nevertheless the design of ITER has been based on, -and takes advantage of decades of-, progress made in all of the fusion facilities worldwide, and as such the risk of falling short in performance is low. There are no showstoppers, and what technological challenges exist can be met and overcome.

Why does it benefit the U.S?

- In the shorter term, 80 per cent of the US contribution to the ITER Project is in the form of components, systems and structures produced by the US – which has a direct, positive impact on U.S. jobs, and U.S. industry.
- As I have pointed out, the biggest challenge to the project is the JIA where systems, components, buildings etc. are provided as contributions-in-kind. However, it is this same in-kind contribution approach which provides the US (and other members) the opportunity to develop its industry and people in cutting-edge areas of technology. We are not just building a tokamak. The technological spin-offs from the US experience in fabricating the ITER tokamak components can be potentially immense.
- The US cannot afford to be left behind in this technology. By contributing just 9 per cent of the cost of the project, the US obtains full and equal access to the Intellectual Property to be generated during the course of constructing and operating this facility. This intellectual property is likely to go well beyond just component-specific fabrication technologies and methods.
- Once built, this immense facility is going to be available for a considerable period of time for researchers and scientists from the member countries as a matter of right. JET was commissioned in 1983-84 and is still continuing in operation.

In conclusion, I firmly believe that ITER will be a great success, not only as an experimental facility, but as a model of international cooperation, and the U.S must be part of this grand challenge.

Thank you, Madame Chair and Members of the Committee. I will be happy to answer any questions you may have.

Short Narrative Biography

Robert C. Iotti

Dr. Iotti holds a PhD Nuclear Engineering. He is currently the Chair of the ITER Council. He became involved with fusion nearly 40 years ago, with the design and construction of the TFTR at the Princeton Plasma Physics Laboratory. Since then, he continued work on fusion facilities planned for PPPL, and for about two years in the early 90's worked on the ITER Engineering Design Phase (EDA) as the Administrative Officer, responsible for the project management plans, systems and their implementation, the application of systems engineering to the overall design, as well as the preparation of the initial cost and schedule for the facility. He left ITER when the U.S pulled out of this initial phase. In 2007 he was appointed as the coordinator of the Management Advisory Committee to the ITER Council, when ITER was officially restarted, and became the first Chair of that committee. He remained as a Member of the MAC until his appointment as Chair of the ITER Council in January 2014.

His career has been mainly in the design and construction, both in U.S and internationally, of defense-oriented nuclear facilities and commercial nuclear power plants, including firsts of a kind, very large nuclear waste management projects, and large infrastructure projects, as well as building organizations virtually from scratch. As such he has a deep appreciation of the complex nature of large projects and of the difficulties encountered in their execution, particularly with initially inexperienced organizations.

Chairwoman LUMMIS. Thank you, Dr. Iotti. It is an amazing scientific experiment, but it is also an amazing experiment in international management of a very complex project. We recognize the challenges that you face.

I now recognize Dr. Sauthoff to present his testimony.

TESTIMONY OF DR. NED SAUTHOFF, DIRECTOR, U.S. ITER PROJECT, OAK RIDGE NATIONAL LABORATORY

Mr. SAUTHOFF. Well, thank you very much, Chairman Lummis, Ranking Member Swalwell, Chairman Smith, other Members of the Committee, and other distinguished Members of Congress. As Chairman Lummis said, my name is Ned Sauthoff, and my role is the director of the U.S. ITER Project Office, which has been charged by DOE with executing the U.S. part of the ITER project. And—so I am the "evil" domestic agency, as Bob would call it.

In any case, I would like to deviate from my prepared text by responding to Mr. Smith's question about ITER/ITER, okay? Turns out that ITER is called ITER because it is a Latin Third Declension noun meaning the journey or the way, and it is the origin of the word itinerary.

Chairman SMITH. Correct.

Mr. SAUTHOFF. Okay? So I could see why it could be ITER, if it is in Latin, or ITER, if it is itinerary. So you were right.

Chairman SMITH. If the gentleman would yield, and I don't want to eat up into your 5 minutes, but having taken more years of Latin than I want to confess, we always pronounced it ITER. As you say, it means the way, the road, the journey. It is where we get the word itinerary. So it seems counter-intuitive to pronounce a word with a long E that starts with an I. And I know that is more than we want to hear today, so——

Mr. WEBER. ITER way, you are both correct.

Mr. SAUTHOFF. Okay. Well, building on Mr. Smith's comment, I would like to characterize ITER by a sentence from Virgil's Aeneid, "Forsan et haec olim meminisse juvabit." Perhaps someday it will be a pleasure to remember even this.

Chairman SMITH. Very good.

Mr. SAUTHOFF. Okay. So let me move on from that. If I could have the first slide brought up? Okay. What we will see is the ITER site. And as Dr. Iotti described, there are buildings popping up out of the ground. In the foreground you see a headquarters building. In the middle you see where the tokamak will be built. In the background you see a building built by the Indians for building the cryostat, which is too big to ship. And behind—and beside that you see a poloidal field coil building, where the Europeans will build magnets that are also too big to ship, okay?

And then if we focus in on the tokamak building, this is the basement for the tokamak, on which the tokamak will sit. And, as Dr. Iotti said, yesterday they started pouring the concrete of a 1–1/2 meter thick slab on which the tokamak will be built. That slab is actually not on the ground. It is on 493 seismic isolator pillars because you have to avoid earthquakes, okay? So it is a rather complex building within a building, and so what we are in the process of doing now is pouring the basement floor of the inner building, okay? And that is what you see there.

If we look at what is going on around the world, you would see that there are many pieces of hardware being built around the world. And now let me focus on the U.S. hardware, because I know you are interested in the U.S. part particularly. These are pieces of hardware, which we are fabricating, and have either delivered, or are delivering this year.

If you look in the upper left, that is an 800 meter long spool of conductor. It is four meters wide, four meters tall, you know, a meter is, like, a yard, so it is really big. This is our prototype winding, where we validated all of our fabrication processes. That conductor has been shipped to Italy, to ASG in La Spezia, Italy, where the Europeans will turn it into a coil, a trial coil. We have also shipped 100 meter superconducting coil, a spool, which was built out of conductors that came from Oxford Superconductor in Carteret, New Jersey, and Luvata, in Waterbury, Connecticut. And it was then cabled in New Hampshire, and then it was integrated and jacketed in Tallahassee, at a small business called High Performance Magnetics.

So we actually have put money into 40 different states. And so what we are trying to do is to build up the technological capability. And let me just elaborate on that. Oxford Superconductor and Luvata have gotten contracts from other ITER parties because our investment in those companies has made them the world leader. There was more than $50 million went to one of them to provide superconductor to Europe, okay? So here it is, a case where our investment in ITER enabled U.S. industry to be world class competitive, and win contracts from another member.

Below, you see some components which we are providing to provide site power. And to the right you see one of five drain tanks of about 60,000 gallons, which have to be put into the basement before they pour the next floor up. That is why our schedule is not totally within our control. We have to fit into the schedule of the building.

And then the last slide here are components that we are putting into a new building at General Atomics in Poway, California for us to fabricate the world's highest stored energy superconducting pulsed magnet in the world, okay? So this is a case where the U.S. is going to have a capability which no one else has, and we will have built a magnet that has more energy in it in a pulsed way than anyone else. So at the left is a heat treatment furnace, where we can cook it for 100 hours at 650 degrees Centigrade to turn Niobium and Tin into Niobium-3 Tin. And at the right, you see the first of 11 stations for doing the winding.

So—I am done with the slides now, so you can return to the camera. So, as others have said, what we are building on here is an attempt to create a burning plasma. This is a plasma which emulates the sun, and the key part is that the fusion reactions themselves keep it hot. And so, within the U.S., we have done the systems engineering such that we know what we have to build. We know the system performance requirements for all the components for first plasma. We know the interfaces so that we can reliably proceed to fabricate those components with acceptable risk. Those that are needed post-first plasma need more design work, so we are not ready to run with those.

But let me just report to you that our team is ready to run. The funding that we are now getting allows us to walk. We would prefer to run. It would be cheaper for us to run, and I am sure some of the questions will relate to that. And I also wanted to comment that ITER alone does not constitute a U.S. fusion program. What we have to do is to support ITER design, and position the U.S. for leadership in ITER research. And that means we have to be studying the topics that ITER will be studying on our domestic facilities in such a way that the U.S. has world leadership capability so that we are part of the teams that do experiments on ITER. And lastly, let me say that we also have to move on, before we have a fusion reactor, to study materials, components, and the like, and that is part of the strategic planning exercise which is now being conducted.

So I conclude by saying our fusion community is confident, we are excited about the opportunities before us, and we look forward to working with you and the Department of Energy in developing, and planning, and implementing a vibrant U.S. fusion program.

[The prepared statement of Dr. Sauthoff follows:]

Main Points of Ned Sauthoff's Statement
Before the Subcommittee on Energy of the Committee on Science, Space and Technology of the U.S. House of Representatives
July 11, 2014

"Burning plasma" in ITER is recognized worldwide as being a major next step for fusion energy sciences, aimed at producing a safe and nearly-inexhaustible energy source.

- Study of self-heated "burning" plasmas will provide scientific understanding of the core of a magnetically-confined fusion reactor, reducing risk for future development.
- ITER is the joint approach being followed by the 7 ITER Members.
- The U.S. participates in ITER project governance through the Council, and it designs and fabricates U.S.-assigned hardware.
- The U.S. accesses 100% of the ITER results while contributing 9% of the funds.

Progress has been made at the ITER Site, although it is not as quick as planned.

- Concrete is being poured for the central ITER-site buildings.
- The French regulator authorized pouring for the Tokamak Building basement this week.

The 7 Members are making good progress on their in-kind hardware contributions.

- Most ITER components are fabricated in the Member nations, enabling Members to develop their domestic technological and manufacturing capabilities and create domestic jobs.
- The 7 members are fabricating core components in their countries: magnets, vacuum vessel, the cryostat, heating and current drive systems, instrumentation, and supporting systems.
- This year, the U.S. Domestic Agency is shipping several finished components:
  - large drain tanks that must be installed prior to pouring the basement ceiling
  - electrical components to provide construction site power
  - toroidal field conductor needed by the EU to wind their share of the coils
- U.S. high-tech fabrication facilities are being set up for systems such as the Central Solenoid at General Atomics in California.
- Roughly 80% of the U.S. funds stay in the U.S. to design and fabricate U.S.-assigned hardware that is then shipped to France for installation and operation.
  - U.S. ITER project funds have been distributed to U.S. industry, universities, and laboratories in 40 states.
- U.S. and ITER Organization systems engineering of U.S. First Plasma components has resolved requirements and interfaces, enabling fabrication at acceptable U.S. risk.
- The GAO report says that "DOE's current cost estimate for the U.S. ITER Project reflects most of the characteristics of a reliable cost estimate, and its schedule estimates reflect all characteristics of a reliable schedule".

The international ITER schedule has slipped, and development of a realistic schedule is underway

- To address the performance impediments, the ITER Council has adopted all the recommendations of the 2013 ITER Management Assessor and has approved actions plans to implement the recommendations, but the actions are not yet complete.
  - The US ITER Project Office is strongly engaged in the improvement of the ITER design and project management systems and of the ITER Organization/Domestic Agency interactions.
- The IO and Domestic Agencies are developing a realistic schedule, emphasizing inter-system integration and assembly/installation as well as Member funding constraints.

Testimony of Ned Sauthoff
Director, U.S. ITER Project Office
Oak Ridge National Laboratory

Before the
Subcommittee on Energy
Committee on Science, Space and Technology
U.S. House of Representatives
July 11, 2014

Fusion Energy: The World's Most Complex Energy Project

Chairwoman Lummis, Ranking Member Swalwell, and Members of the Committee: Thank you for this opportunity to appear before you today.

My name is Ned Sauthoff. I am the Director of the U.S. ITER Project Office at the U.S. Department of Energy's Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. It is an honor to provide this testimony on progress of the ITER international fusion project, challenges we are facing, and the vision for hydrogen fusion to become an attractive source of future U.S. energy.

INTRODUCTION

The goal of ITER is to create and study a reactor-scale "burning plasma," the core of a magnetically-confined fusion power reactor. In such a system, the energy from fusion reactions "self-heats" the plasma. Fusion combines light elements such as hydrogen; in contrast, fission splits heavy elements such as uranium, exploiting Einstein's famous mass-energy equivalence principle $E = mc^2$. Both fusion and fission nuclear reactions produce about a million times more energy per pound of fuel than chemical reactions, such as the burning of fossil fuel. ITER seeks to study the behavior of a reactor-scale system based on fusion of hydrogen into helium at the level of 500 Megawatts of fusion power.

A reactor based on fusion has attractive characteristics:

1. ***Fusion would be a virtually inexhaustible energy source.*** Hydrogen fusion is fueled principally by common elements found in the Earth's oceans and crust: deuterium (a stable isotope of hydrogen) and lithium[1].
2. ***Fusion would produce neither greenhouse gases nor long-lived high-level radioactive waste.*** Fusion of the most-reactive hydrogen isotopes, deuterium and tritium, produces the inert gas helium and a neutron that in turn reacts with lithium to breed the tritium fuel; with proper selection of materials for reactor components, the neutron bombardment can produce waste with a lifetime comparable to that of a human.
3. ***Fusion has inherent safety advantages.*** The amount of fuel in the reaction chamber is small and the fusion reaction itself shuts down if control is lost.

These desirable characteristics have made fusion energy a long-standing quest. The scientific proof-of-principle for controlled fusion power using magnetic confinement was first demonstrated in the U.S. at Princeton's Tokamak Fusion Test Reactor in 1994, and then in Europe in 1997 at the Joint European Torus located near Oxford. Laboratories focused on the tokamak concept have grown

---

[1] Transmutation of lithium into tritium by a fusion-produced neutron is an integral aspect of the hydrogen-fusion closed fuel cycle.

worldwide, including major facilities in China, Europe, India, Japan, Korea, Russia and the U.S. and smaller facilities in many industrialized countries.

In the Summer of 2002, over 200 fusion scientists and engineers from around the world met to conclude an extensive investigation of options for the next major step in the U.S. and world magnetic-confinement fusion programs: the creation and study of a self-heated burning plasma. Burning plasma, much like that found in the Sun, remains hot because enough of the energy from the fusion reactions self-heats the plasma to overcome energy losses. Such a plasma would form the core of a fusion reactor that could burn forms of hydrogen plentiful enough to power civilization for thousands of years. A burning plasma facility using magnetic confinement fusion must be large like ITER so that the surface-like energy losses are less than the volume-heating, enabling the plasma to stay sufficiently hot.

One key challenge for fusion energy is confining the plasma so that fusion reactions can take place. While the Sun utilizes strong gravity to confine the plasma, gravity cannot be used as the confinement force on Earth; as a measure, the mass of the Sun is roughly 300,000 times that of the Earth. Further, we seek to produce an energy source that uses little land area. To meet this containment challenge, fusion scientists utilize a magnetic bottle configured in the shape of a toroid (doughnut), called a tokamak, to confine the hot ionized gas. The 2002-study's scientific and engineering teams assessed the research benefits of burning plasma studies, the scientific and technological feasibility, and the advantages and disadvantages of multiple approaches using the tokamak configuration. The tokamak formed the basis for the multiple magnetic confinement approaches because it offers the greatest opportunity to advance understanding of the dynamics associated with burning plasma in the near term, based on a consistent demonstrated performance history by tokamaks. While the tokamak may not be the optimum long-term fusion reactor configuration, the advances from such a tokamak-based burning plasma study would be applicable to virtually any future toroidal-confinement approach to fusion, due to the similarities of the toroidal physics.

The DOE's Fusion Energy Sciences Advisory Committee (FESAC) built upon these studies and technical assessments, and recommended creation and study of burning plasma as a next major step toward fusion energy.[2] Subsequently, the DOE commissioned the National Academies' National Research Council to conduct "an assessment of a program of burning plasma experiments and its role in magnetic fusion research." This assessment resulted in a report that recommended that the U.S. enter negotiations on the construction and operation of ITER.[3]

Similar studies were being conducted by fusion communities and governments worldwide, and negotiations on moving the ITER activity to construction began in 2003. The international consensus was, and remains, that the creation and study of self-heated "burning" plasma is a next major step in fusion energy research, and that ITER is the best path for that research. In 2006 and 2007, nations representing over half the world's population agreed to partner on design, construction, operation and decommissioning of an approximately 500 Megawatt, industrial-scale fusion experimental system termed "ITER" (Latin for "the way").

---

[2] U.S. Department of Energy, Fusion Energy Sciences Advisory Committee, *A Plan for the Development of Fusion Energy*, DOE/SC-0074, Washington, D.C., 2003.

[3] U.S. National Academy of Sciences, Burning Plasma Assessment Committee, *Burning Plasma: Bringing a Star to Earth*, National Academies Press, ISBN 0-309-52766-X, Washington, D.C., 2004.

The international mission of ITER is to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes. Associated burning plasma studies are to:

(1) Produce and study the dynamics of a self-heated plasma wherein power released in the fusion reaction keeps the plasma hot;
(2) Advance knowledge on the effects of high-energy particles on the stability and confinement of hot plasma; and
(3) Advance understanding of a reactor-scale plasma.

Fusion research over the past decade has reinforced confidence that ITER can meet its mission and produce approximately 500 Megawatts of fusion thermal power with only about 50 Megawatts of external heating power absorbed by the plasma—a factor-of-10 "gain". The ITER project represents the frontier in magnetic-confinement fusion power generation, and will deliver an international scientific laboratory to study burning plasmas and supporting technologies. It will advance scientific understanding of fusion plasmas, a key part of the foundational knowledge base for an attractive fusion power system in the 21st century.

The ITER international partnership enables the U.S. to gain access to 100 percent of the ITER results, to propose and execute experiments, and to share in the governance of the project while paying 9 percent of the cost (an advantage of 11 to 1).

Today's tokamak fusion research, underway on existing fusion facilities worldwide using international teams, is both answering key questions relevant to ITER and establishing the foundational teams and tools that will enable exploitation of ITER during its research phase. A strong U.S. fusion research program is essential because it increases scientific understanding and establishes the U.S. as a leader on ITER-related research topics, positioning the U.S. for strong participation in exploiting ITER for research.

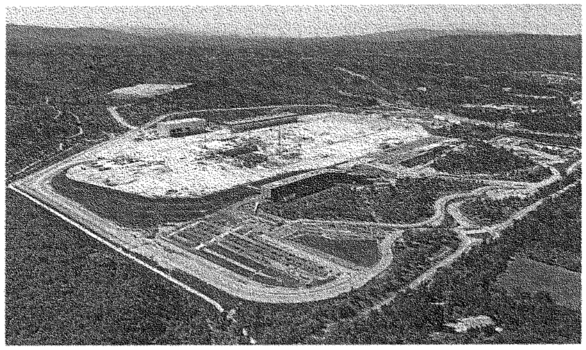
GLOBAL PROGRESS ON THE ITER PROJECT

The ITER project has made substantial progress with

- Construction of buildings and infrastructure at the ITER site in southern France, mostly by the host Member, Europe, and
- Fabrication of hardware components and subsystems, mostly by the ITER national teams. (For example, the U.S. budget supports the U.S. team designing and procuring assigned hardware from the U.S., contributing to the advancement of U.S. industrial capabilities, and providing high-tech U.S. jobs.)

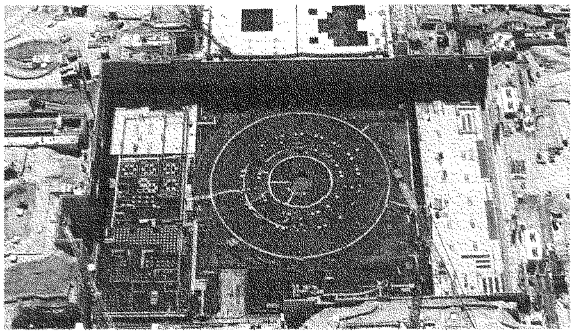
In addition, the ITER team is now engaged in management reforms to improve the effectiveness of the integrated project team, which consists of the ITER Organization and teams from seven countries,, referred to as Domestic Agencies. The U.S. DOE and the U.S. ITER Project Office are both actively engaged in these management reforms.

Preparation of the ITER site began in 2008 in St. Paul-lez-Durance, France, adjacent to the French Alternative Energies and Atomic Energy Commission (CEA) Cadarache site. On November 12, 2012, following two years of investigation and analysis performed in strict accordance with regulatory review procedures, the French Ministry of Environment issued a decree authorizing ITER to begin construction. The decree also established a binding contract between France and the ITER Organization as nuclear operator.



ITER site, April 2014 [Photo: ITER Organization]

- The **European Domestic Agency** is responsible for site construction and has made substantial progress on buildings and site infrastructure. Prime contracts have been placed and work is under way at the ITER site. Construction is proceeding on the tokamak complex, including the assembly, diagnostics, tritium and tokamak buildings, plus 12 support buildings that are beginning construction in 2014. Concrete pouring for the basement slab under the diagnostics building and the tritium building is nearly complete. Construction is expected to begin in the second half of 2014 on the assembly hall, site services building, electrical buildings, and walls of the tokamak complex. Also under construction is storage space for large near-term deliverables, including large drain tanks ready for shipment from the U.S. in 2014 as part of the U.S. contribution of the tokamak cooling water system. The EU Domestic Agency is also making progress on the manufacture of magnet systems; radial plates for the toroidal field magnets are in fabrication and winding of the first production conductor is complete.



The tokamak complex at the ITER site, April 2014 [Photo: ITER Organization]

- The **Chinese Domestic Agency** has completed two toroidal field conductors and five poloidal field conductors. Manufacturing equipment has already been commissioned for the correction coils and several prototypes have been produced for the feeder conductor.
- The **Indian Domestic Agency** is progressing on in-wall shielding components that will be captive inside the two walls of the vacuum vessel. Manufacturing of the cryostat base section has started and the cryostat fabrication workshop at the ITER site is complete.
- The **Japanese Domestic Agency** has work well under way on their toroidal field magnets plus toroidal field support structures, gyrotrons for heating systems, and conductor for the central solenoid. The Japanese conductor will be used by the U.S. to manufacture the central solenoid.
- The **Korean Domestic Agency** is also producing conductor for toroidal field magnets and fabricating two vacuum vessel sectors.
- The **Russian Domestic Agency** is fabricating multiple types of conductor for magnet systems, and has begun deliveries for both toroidal field coil conductor and poloidal field coil conductor.
- The **U.S. Domestic Agency** contributions are discussed in the next section.

In summary, progress is being made across the global partners, albeit in some cases slower than originally planned. Events ranging from earthquakes and heavy snow in Japan to technical challenges to budget constraints for several Member countries have had a ripple effect across the project, impacting some production schedules. The partners continue to work together and with the ITER Organization to identify the best approaches for coordinating interdependent manufacturing activities and accelerating the pace of work. Further information on the international aspects of the project is available at the ITER website: www.iter.org.

U.S. PROGRESS ON THE ITER PROJECT

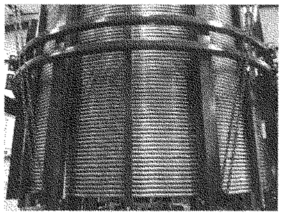
The **U.S. Domestic Agency** is responsible for delivering multiple hardware subsystems essential for ITER:

- Magnet Systems: Superconducting Toroidal Field Coil Conductor and fabrication of the Central Solenoid, to confine, shape and control the plasma inside the vacuum vessel
- Cooling Water System, to absorb and convect away the power output from operation of the tokamak
- Steady State Electrical Network, to supply the electricity needed for construction activities and operation of the non-pulsed parts of the entire plant
- Heating and Current Drive Systems (Electron Cyclotron and Ion Cyclotron Heating Transmission Lines), to deliver heating power to the plasma
- Pellet Injection, to fuel the plasma by injection of deuterium-tritium ice pellets
- Disruption Mitigation System, to reduce the impacts of plasma disruptions on the tokamak vacuum vessel, blankets, and other components
- Diagnostics, to provide the measurements necessary to control, evaluate and optimize plasma performance and to further the understanding of plasma physics
- Vacuum Auxiliary Systems and Roughing Pumps, to remove gases from the vacuum vessel, cryostat, and auxiliary vacuum chambers prior to and during operations
- Exhaust Processing System, to separate hydrogen isotopes from tokamak exhaust for isotope separation (by a European-supplied system) and re-injection of the hydrogen isotopes into the plasma.

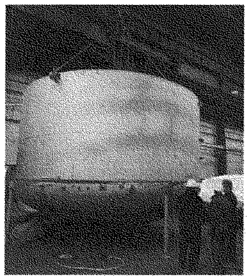
The U.S. continues to be a strong and demanding partner in the ITER project, with contributions in fabrication, technical innovation, and management practices. The benefits of U.S. contributions to ITER extend across the country, contributing to manufacturing and high technology industries, leading-edge research at universities and national laboratories, and U.S. readiness for fusion energy development.

More than 80 percent of the project's total funding will be spent in the U.S. Through March 31, 2014, over $616 million in purchase orders and commitments have been placed with U.S. industry and universities, and Department of Energy National Laboratories, in 40 states and the District of Columbia.

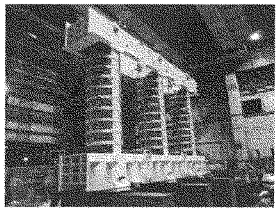
The R&D portion of the U.S. fabrication project effort is nearly complete (87 percent) and >70 percent (by value) of the U.S. hardware is in final design or beyond. Fabrication and delivery of hardware is underway. The U.S. schedule for these deliverables is driven by the international schedule, wherein the U.S. provides components that must be installed in the buildings as they are constructed, are needed to support construction activity such as site electrical power, or are needed by other Members for incorporation into their hardware.



An 800-meter sample toroidal field conductor was delivered to the EU in June 2014. Photo: U.S. ITER



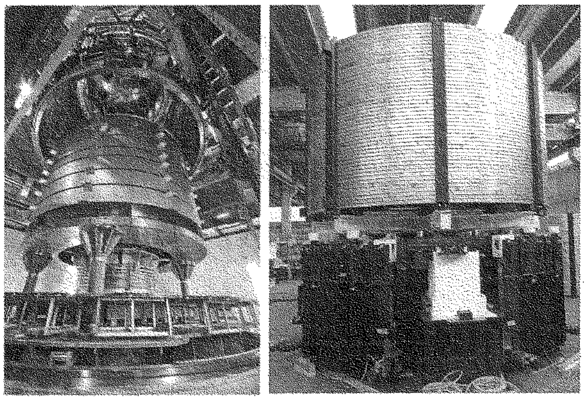
Joseph Oat Corporation in Camden, NJ is completing fabrication of drain tanks. Photo: U.S. ITER



Laminated core of a high voltage substation transformer in fabrication for the steady state electrical network. Photo: Hyundai Heavy Industries

- The U.S. completed fabrication of all 40 tons — over 4,000 miles — of superconducting strand, for the entire U.S. contribution of toroidal field coil conductor. The toroidal field conductor manufacturing process involves multiple vendors in four states: Superconducting strand was produced by Oxford Superconducting Technologies in Carteret, NJ and Luvata Waterbury, Inc. in Waterbury, CT; cabling of the strands is performed by New England Wire Technologies in Lisbon, NH; integration and jacketing of the cable into stainless steel conduit is performed by High Performance Magnetics in Tallahassee, FL. All of the manufacturing processes have been successfully developed by the U.S. project team and its contractors. An 800-meter sample conductor with copper, non-superconducting strands was fabricated and delivered to the EU winding facility in Italy in June 2014. A 100-meter superconducting conductor, using Oxford Superconducting Technologies strand, was shipped to the EU in June 2014.

- Other U.S. deliveries scheduled for 2014 include parts of the tokamak cooling water system and the steady state electrical network needed soon for the construction activities at the ITER site. Large-scale (up to ~61,000 gallon) drain tanks for the cooling water system are completing fabrication at the Joseph Oat Corporation in Camden, NJ, and will be ready for shipment to the ITER site by the end of 2014 for installation in the basement of the tokamak building. Components of the steady state electrical network will be delivered in 2014 to provide essential construction-site power; manufacturing is underway for high-voltage (HV) current transformers, HV potential transformers, and HV substation transformers and factory acceptance testing has been completed for HV surge arrestors.



A heat treatment furnace (left) and de-spooler for the winding station (right) are part of the 11 workstations that are being installed at General Atomics' central solenoid module fabrication building in Poway, CA. Photos: General Atomics

- The central solenoid is *the heart of ITER*—because its "beating" pulses the magnetic flux needed to initiate and sustain the plasma current. Weighing in at approximately 1,000 metric tons with a 5.5 Gigajoule stored energy capacity, the U.S.-supplied central solenoid will be the highest-stored-energy pulsed superconducting electromagnet ever produced.

  The U.S. is now preparing for central solenoid module fabrication, using superconductor supplied by Japan. A manufacturing building has been completed by General Atomics (GA) in Poway, CA and factory acceptance testing has been completed for the winding station, heat treatment furnace, insulation taping heads and air-bearing transfer cart. Ultimately, 11 tooling stations will be installed and utilized at GA for the fabrication of 7 modules. Winding of the mock-up module coil will begin this summer.

- The U.S. continues to advance design and prototype fabrication and testing for longer-term subsystems. For heating and current drive systems, the U.S. has already demonstrated operation of major ion cyclotron transmission line components at full power (6

> Megawatts/line), and has developed prototype designs for 12 of the 14 required ion cyclotron transmission line components and 14 of the 16 electron cyclotron transmission line components. For fueling and disruption mitigation systems, the U.S. is developing the injectors required to provide continuous frozen pellets of gases that penetrate into the ITER plasma. These pellet injectors will also be used to reduce divertor-wall erosion from edge plasma- and power- flux to acceptable levels. The design and prototyping of early-delivery diagnostics — the residual gas analyzer and low field-side reflectometer — are on schedule. For vacuum and pumping systems, the U.S. has completed prototype fabrication of tritium-compatible screw pumps and roots pumps and is now testing these components. The tokamak exhaust processing is a late delivery item, but design is under way to solidify interfaces and support the ITER safety basis.

The U.S. is committed to delivering its commitments in the most cost effective manner and has achieved more than $225 million in cost avoidance by applying value engineering across its subsystems, including an innovative procurement arrangement with the ITER Organization for cooling water design and piping.

The engagement of U.S. industry with ITER has resulted in an expansion of technology-readiness across a number of sectors, including:

- Enhanced industrial capacity for production of high-performance superconducting cable;
- Advanced plasma diagnostic systems and high-power microwave transmission lines; and
- Industrial experience in complying with French nuclear pressure equipment regulations.

More information is available at the U.S. ITER website: www.usiter.org

SCIENTIFIC, TECHNOLOGICAL AND MANAGEMENT CHALLENGES

As with any grand challenge in science and engineering, progress is paced by the magnitude of the scientific, technological, and management hurdles to be overcome and the technical, budgetary and management assets brought to bear on the challenges.

Scientific Challenges

While ITER will be a large scientific endeavor that will enable understanding of the burning plasma state, science is no longer the constraining factor for ITER's design, fabrication and construction. The scientific basis for ITER is well established. As pointed out previously, scientific proof-of-principle for fusion power was demonstrated during the 1990s in both the U.S. and Europe. More recently, confinement and stability studies on tokamaks worldwide have increased confidence in ITER's performance. Significant progress has been achieved in tokamaks around the world, most notably DOE's DIII-D facility managed by General Atomics in San Diego, CA, on the mitigation of edge-localized modes and other forms of major disruption that cause plasma instabilities. This understanding has increased confidence that ITER can both meet the desired objectives and will further advance knowledge on how to control burning reactor-scale plasma dynamics.

The basic fusion sciences research program sponsored by the DOE and implemented at leading U.S. universities, industry and national laboratories is of strategic importance since it is key to addressing the scientific challenges that ITER will address. The basic research program is pivotal because it:

(a) Advances burning plasma science and technology, contributing to the science and technology basis of ITER and acquiring accessible burning plasma knowledge in advance of ITER to enhance the research effectiveness of ITER, and

(b) Positions the U.S. to be a leader in burning plasma research topics, thus enabling the U.S. to exploit its investment in ITER.

The scientific challenges that ITER will resolve include burning plasma dynamics, effects of energetic particles and size-scaling of physical processes. These challenges are already key research areas on today's tokamaks. The U.S. is a founding member of the International Tokamak Physics Activity, which enhances the coordination of joint tokamak research on the world's toroidal facilities under the auspices of ITER.

Technological Challenges of ITER and beyond ITER

Technology hurdles have existed throughout the history of fusion research. However, through a combination of innovation and opportunity capture, these hurdles have consistently been vaulted. ITER's technology challenges in magnets, heating and current drive, instrumentation, vacuum, plasma-facing components, among other things, have been resolved such that no prohibitive technological barriers are foreseen.

For an attractive electricity-producing fusion reactor, research beyond ITER will be required. ITER's pulsed operation is sufficient to meet the primary objective to achieve and study burning plasma, but does not represent a complete prototype of a commercial reactor which would operate for longer durations and at a higher duty factor possibly at higher power density. As such, further scientific and technological advances beyond ITER will be necessary to ultimately enable an attractive fusion power system. Promising materials have already been identified[4], but development of these materials and components is not within the mission of ITER and will require other test facilities in the future. Innovations and refinements of the confinement configuration will enhance the attractiveness of fusion reactor concepts and should be an essential element of worldwide fusion research in addition to research on ITER.

Progress in magnetic confined fusion has also relied heavily on theoretical modeling and empirical validation through experimental tests. Because of the complexity of plasma turbulence, magnetohydrodynamics (MHD), and other advanced physics phenomena and systems integration, state-of-the-art computational power and advanced diagnostic instruments will be continue to be keys to understanding. Leadership-class supercomputers and superior diagnostics will enable enhanced understanding of ITER plasma behavior. Existing niobium-titanium (NbTi) and niobium-tin (Nb_3Sn) superconductors are sufficient for ITER; more attractive fusion magnet systems may be enabled by development of more advanced superconducting magnets. Such disruptive technologies will continue to contribute to the advancement of fusion systems.

---

[4] For example, the FESAC report on "Opportunities for Fusion Materials Science and Technology Research Now and During the ITER Era" (February 2012), http://science.energy.gov/~/media/fes/pdf/workshop-reports/20120309/FESAC-Materials-Science-final-report.pdf

Management Challenges

As the current ITER governance framework was being formulated in 2003-06, three characteristics were determined to be paramount to mission success:

1. Engagement of the top fusion physics and engineering talent available worldwide,
2. Equitable sharing of the cost and risk such that no single sovereign nation bore the entire cost, or burden of risk, and
3. Opportunity for development of industrial capabilities in ITER-related areas.

Achievement of these attributes was considered essential to forge the global team needed to meet the grand challenge of fusion. The equitable sharing was negotiated to be 1/11 (approximately 9%) for the 6 non-host partners, including the U.S., and a 5/11 (approximately 45%) share for the European Union host. For an approximately 9 percent share of the construction cost, the U.S. receives access to 100 percent of the project benefits. While the international partnership adds complexity and uncertainty to the project management and planning, the cost sharing affords sufficient national cost savings to overcome the cost increase related to the international aspects.

The ITER Project represents a grand management challenge comparable in magnitude to the Manhattan and Apollo Projects, or the more recent International Space Station Program. Meeting grand challenges such as these required the unwavering commitment of highly skilled and dedicated teams. The ITER team is engaged in continuous improvement as a path to mission achievement. In November 2013, an external ITER Management Assessment report identified 11 specific recommendations for improvements. These recommendations have since been adopted by the ITER Council and translated into action plans that were approved by the Council and are now being implemented. The U.S. DOE and the U.S. ITER Project Office are actively engaged in the implementation of the action plans.

CLOSING REMARKS

The ITER Project is making significant and measurable progress around the world. In the U.S., the ITER project is making good progress, constrained by funding. The U.S. project team has been aggressively proactive in performance of systems engineering with the ITER Organization to define the requirements and interfaces for U.S. systems, sufficiently to enable the U.S. to proceed with acceptable risk to fabrication of the systems needed for the integrated systems test of the core tokamak and First Plasma. The U.S. First Plasma systems constitute about 2/3 of the U.S. hardware contributions, with the remaining 1/3 being that balance of systems needed to produce and handle the large fusion power and enable detailed measurements of plasma behavior. First Plasma subsystem designs are sufficiently mature and the cost basis sufficiently sound to proceed to fabrication, with the greatest uncertainties related to the extended schedule. To address these uncertainties, a 47% contingency is included in the cost basis. According to a recent GAO report, "DOE's current cost estimate for the U.S. ITER Project reflects most of the characteristics of a reliable cost estimate, and its schedule estimates reflect all characteristics of a reliable schedule"; the GAO assessment concluded that the cost estimate developed by the U.S. ITER Project Office for DOE "substantially met best practices for comprehensive, well-documented, and accurate estimates."[5]

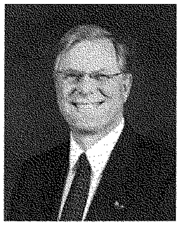
---

[5] *Actions Needed to Finalize Cost and Schedule Estimates for U.S. Contributions to an International Experimental Reactor*. GAO-14-499: Jun 5, 2014, pp. 25, 22.

The U.S. ITER schedule is driven by the international schedule for building construction and component assembly and installation. The present realistic U.S. schedule does not meet the currently agreed ITER international schedule (first plasma in 2020, not later than 2021), but could meet a realistic ITER international schedule if the associated U.S. funding profile is appropriated. The development a U.S. funding profile should be part of the international project planning effort wherein the Member countries and the ITER Organization refine individual schedules for component fabrication and overall installation and commissioning to achieve an acceptable integrated international master schedule, with supporting Member funding profiles. The U.S. ITER Project looks forward to the completion of that activity in the next year.

ITER will address the challenge of producing and controlling a self-heated burning plasma, the core of a magnetically-confined fusion reactor and an essential achievement for fusion energy development. Next steps beyond ITER will build on ITER science and technology, and address issues of fusion materials and components, power-conversion systems including breeding of the tritium fuel, and concept improvement. We see a realistic schedule for ITER that achieves both First Plasma and demonstration of self-heated, burning plasma within the next 20 years.

Thank you, Madame Chair and Members of the Committee. I will be happy to answer any questions you may have.



Ned R. Sauthoff, Ph.D.
Director, U.S. ITER Project Office
Tel: 865-574-5947
sauthoffnr@ornl.gov

Dr. Ned Sauthoff is a plasma physicist and project manager of the U.S. Contributions to ITER Project, the U.S. portion of an international partnership aimed at demonstrating the scientific and technological feasibility of fusion energy using magnetic confinement of plasmas. ITER is a large toroidal magnetic confinement device of the tokamak configuration that is being built by China, the European Union, India, Japan, South Korea, the Russian Federation, and the United States to enable study of a self-heated "burning" plasma, the core of a fusion reactor. It is sited in St. Paul-lez-Durance, France.

Prior to the establishment of the U.S. ITER Project Office, Ned was a physics researcher and head of the Off-Site Research Department at the Princeton Plasma Physics Laboratory (PPPL), where he managed experimental and theoretical work on leading facilities around the United States and the world to address key fusion physics and technology questions.

Early in his PPPL career, Ned developed x-ray instrumentation and performed research on tokamak plasmas. He managed design and operation of the control and data system for the Tokamak Fusion Test Reactor until 1985, and headed the PPPL Computer Division until 1988, the Princeton Beta Experiment until 1990, the Experimental Projects Department until 1992, the Physics Department until 1994, and the Plasma Science and Technology Department until 1997.

He is a fellow of the American Physical Society, the American Association for the Advancement of Science, and the Institute of Electrical and Electronics Engineers. Ned received his Bachelor of Science degree in physics and Master of Science degree in nuclear engineering from MIT and his Ph.D. in astrophysical sciences from Princeton University.

Chairwoman LUMMIS. Thank you again, all of you, for being available for questioning today. We will now begin member questions, reminding Members that Committee rules limit questions to five minutes. And the Chair will, at this point, begin. And in order to get us all an opportunity to ask some questions before anticipated 10:15 votes, I would ask all the Members to err on the side of brevity.

First of all, Dr. Rusco, thank you again for being here. Recognizing the complexity of this project, the reliance of 11 nations on each other to do their part to keep this thing on schedule, and, to the extent we can, as close to a reasonable budget as could possibly be attained, given the difficulties of managing all these languages, all these countries, all this science, it is almost mind boggling.

Your report provides a historic account of the U.S. ITER project's increasing costs and schedule. What can our government do to establish a reliable budget and schedule, so DOE and U.S. ITER have a clear plan to fulfill the U.S. hardware obligations, and lower overall costs?

Dr. RUSCO. Very briefly, the U.S. project is dependent on the success of the management improvements of the international organization. That—those must occur, and there must be a reliable and definitive schedule put out before they can use the tools, which they are using very well, of cost estimation to give a reliable cost estimate to Congress. So it is really—it is—the first step is the international organization has to improve its management practices in very important ways, and then it has to come up with a full schedule in consultation with all the members. And then the U.S., I think, has the tools to make a reliable cost estimate for our own share of that.

Chairwoman LUMMIS. Hence I will skip now to Dr. Iotti, and ask, is that an attainable goal within a reasonable timeframe, to have just the international scope of work, budget, and timeline?

Mr. IOTTI. The brief answer is yes. Sorry. The brief answer is yes, and I could elaborate, but I will be even more confident come this September, where I am going there to review the progress on coming up with the schedule, the resource—and where the project will be in the middle of 2015.

Chairwoman LUMMIS. Who will be responsible between now and September in preparing the schedule that you will be reviewing?

Mr. IOTTI. There is the—a group within the ITER organization that is preparing the schedule as we speak. And they already have prepared the front end of that schedule, which is the 2014 annual work plan, and that is the one that I was referring to. In the past, when we made this annual work plan, the project would miss about half the milestones. Now they are meeting them all. In fact, sometimes they are beating them. And those that are in jeopardy, they are acted upon right away to mitigate possible delays, or retreatment entirely. So there is a whole new spirit of can-do attitude that did not—was not present in the past.

Chairwoman LUMMIS. Okay. So there is scope of work, there is timeline——

Mr. IOTTI. Correct. They are all——

Chairwoman LUMMIS. —and there is——

Mr. IOTTI. —together.

Chairwoman LUMMIS. —budget. Okay.

Mr. IOTTI. Correct.

Chairwoman LUMMIS. All three of those elements are being handled by the same——

Mr. IOTTI. With the cooperation of the domestic agencies. It is not, you know, that has to be a complete cooperation between the ITER organization that prepares the overall schedule and the domestic agencies, because each of the domestic agencies prepare its own schedule for their own scope, when then has to be integrated overall. And then the whole thing has to make sense——

Chairwoman LUMMIS. Um-hum.

Mr. IOTTI. —which is one of the reasons I am going there also in September, to make sure that everything is right. And when that has happened, then you can have a high confidence both in the ITER organization, as well as the domestic agencies. That is what Mr. Rusco is referring to. Until we have that, it is very difficult for the U.S. to prepare anything, okay?

Chairwoman LUMMIS. Who is preparing the budget for each country's scope of work within the timeframe?

Mr. IOTTI. That you would have to address—for instance, for the U.S., you would have address Dr. Sauthoff. The domestic agencies prepare the basic information, which then goes to the government to request certain budget to enable them to do the work. That is within the domestic agencies. It is not within the purview of the overall ITER organization. They just have to integrate all of those and alert members when they see a problem.

Chairwoman LUMMIS. Okay. Dr. Sauthoff, given that, can you give me the 25 second version of your answer?

Mr. SAUTHOFF. Yes. My answer is that we have a very good process for developing schedule and cost estimate. As Dr. Rusco said, GAO reviewed us, and they said that we have all the characteristics of a reliable schedule system, and we have most of the characteristics of a reliable cost system. The only things they cited as missing had to do with an independent cost estimate, and a more extensive sensitivity analysis, which is something we do before baselining. So we have a good system, and I am proud of our cost estimate of 3.9 billion.

Chairwoman LUMMIS. Thank you, panel. I now recognize Mr. Swalwell for 5 minutes.

Mr. SWALWELL. Thank you, Chairman Lummis, and I was also delighted to hear from Chairman Smith that—his remarks about how ITER, and investments in fusion research can get us to an energy source that is carbon neutral. And that, you know, Chairman Smith, could really change the debate in this town, and make moot a lot of the back and forth about fossil fuels versus other sources of energy. I mean, I am a big believer in the renewables, but an investment in something like this, I think, could render many of these debates moot, and I think we would both embrace that, if we could get to that point.

And—so my question first, for Dr. Sauthoff, is—I have been told that a significant portion of the U.S. contribution to ITER can be decoupled from the international schedule almost entirely, and that we have the opportunity to reduce the total cost to our taxpayers if we simply focus more attention and resources on those components in the near term. So I guess, first, is this true?

Mr. SAUTHOFF. Yes, it is true. Roughly 2/3 of our scope is aimed at coming up with the first configuration of the machine, which is the core tokamak, and that is what is sometimes called the first plasma configuration. It is what you need to demonstrate that the tokamak itself works. It is roughly 2/3 of our scope. We know what we have to build well enough that we can proceed to fabricate at acceptable risk. And if we were to proceed on an optimal profile, we think we could probably reduce that cost from 3.9 billion to about 3.4, saving about half a billion dollars.

Mr. SWALWELL. And also, Dr. Iotti, any thoughts on whether an accelerated contribution could work?

Mr. IOTTI. Well, clearly—will lower the cost. I think what Dr. Sauthoff said is absolutely right. The other thing that, though, he did not add is I happen to know that in his own estimate he has a large amount of contingency, something on the order of—I think it is close to 900 million.

If you accelerate, you retire some of that contingency. My experience in large project is the sooner you finish, the less risk you incur of changes, and that also saves some of that money that would otherwise go to pay for that risk. So the overall saving, in my opinion, would be larger than the half a billion, and may be close to 3/4 of it.

Mr. SWALWELL. Thank you, Dr. Iotti. And, Dr. Dehmer, speaking of contributions, I did mention in my opening statement the $225 million U.S. cap. And was I correct in describing this as an arbitrary level that the administration decided what would be politically palatable, or is this something that was arrived at from a bottom up project estimate that minimizes the total cost for U.S. taxpayers, and our contribution to ITER?

Dr. DEHMER. It was not a bottoms up, as you say, but it was also not arbitrary. Let me give you the context that we were living in when we made that decision. At the time, the Department, and as now, the Department leadership was very supportive of the joint implementing agreement for ITER. But we were having requests from the project upwards of $350 million a year. The project had no international baseline, it had no U.S. baseline, no cost and schedule profiles.

There were rumors of very significant cost growth and schedule delay, and deliberately many of these rumors were not put in the open, or kept silent. We have heard about the management weaknesses, and we heard that very significant improvements were needed. And all of this came against a background of sequestration, and many other projects that we were trying to support at the time.

Therefore, we made a decision that, with no cost and schedule baselines, with significant management weaknesses, we could not provide this project with everything that it was requesting. We had to make a balance across the opposite sides, and we chose $225 million. We believed that amount would allow us to go forward, and deliver what we needed to deliver, so as not to delay the project, but would allow us to do other things that we needed to do in the Office of Science.

Mr. SWALWELL. Thank you, Dr. Dehmer. And knowing what we know now, listening to the testimony of the witnesses, and that by and large much of sequestration has been rolled back, do you anticipate that the next recommendation for funding will increase beyond today?

Dr. DEHMER. We are in negotiations on that now, and so I can't talk about that. What I definitely want to say is we are looking forward to the June 2015 baseline exercise from the international organization.

Mr. SWALWELL. Thank you, Dr. Dehmer. Thank you, Chair, and yield back the balance of my time.

Chairwoman LUMMIS. The Chair now recognizes the full Committee Chairman, Mr. Smith of Texas.

Chairman SMITH. Thank you, Madam Chair. Let me direct my first question to Dr. Dehmer, Dr. Iotti—I am tempted to say Dr. Iotti, but I won't—Dr. Iotti, and Dr. Sauthoff. And, Dr. Rusco, I don't mean to slight you, but the question really is not for the GAO, and you will see why.

And it is this. I think we have to acknowledge that the practical delivery of fusion energy is dollars away and years away, but nevertheless it has incredible potential, and that is the point of my question. If we are successful in developing future sources of fusion energy, wouldn't that largely solve the problem of carbon emissions? And this is something that the Ranking Member alluded to as well. So, Dr. Dehmer?

Dr. DEHMER. It would help mitigate the problem of carbon emissions, and the if is a long way off, and——

Chairman SMITH. I acknowledge that.

Dr. DEHMER. Yeah. Okay. And——

Chairman SMITH. I am talking about the potential.

Dr. DEHMER. Yes, I think everyone agrees that the potential is very great.

Chairman SMITH. Okay. And, Dr. Iotti?

Mr. IOTTI. Well, I use an example that I borrow from Dr. Llewellyn Smith in Oxford. The potential of fusion, in terms of the issues that you are referring to can be translated in 40 liters of water, and the lithium from one laptop battery——

Chairman SMITH. Oh boy.

Mr. IOTTI. —can provide the per capita consumption in the United States for 15 years, and do away with 70 tons of coal. That is——

Chairman SMITH. I have never heard it put that way. That is a very descriptive and very persuasive answer. I thank you for that. Dr. Sauthoff, going back to our pronunciation, we may have to split the difference between ITER and ITER, because we checked the dictionary, and the correct pronunciation is in between, as it ITER, I–T. So ITER, or ITER.

Mr. SAUTHOFF. It depends whether you are going classical, church, or colloquial.

Chairman SMITH. Yes, I was always in the colloquial, and——

Mr. SAUTHOFF. Yes.

Chairman SMITH. —that is why we got the ITER.

Mr. SAUTHOFF. But do you do you veni, vidi, vici or veni, vidi, vici?

Chairman SMITH. Veni, vidi, vici, though, doesn't involve the I. By the way—from Caesar. But anyway, enough digression, I guess. If you want to talk about the potential, that would be great.

Mr. SAUTHOFF. Okay. The potential is indeed quite great. The amount of energy that you get out of a nuclear reaction is more than a million times that of what you get out of a chemical reaction. And so, per pound of fuel, you get more than a million times out in either fission or fusion than you get out of chemistry.

And what we have is a system which will allow us to address the risk of a fusion system, big risk of the plasma, but we only know how to do it on a big scale. It will be a central station plant——

Chairman SMITH. Right.

Mr. SAUTHOFF. —so we won't have addressed portable electricity and the like, and that is going to take storage. We haven't yet figured out how to make the Mr. Fusion machine that Professor Emmett Brown put on the top of his DeLorean in Back to the Future, and we won't know how to make that power pack that——

Chairman SMITH. Yeah.

Mr. SAUTHOFF. —Tony Stark had in Iron Man. But we do know how to make the arc reactor that is in the bottom of the Stark Tower in Iron Man 2.

Chairman SMITH. Okay. These are great answers. Let me ask a second question of the same three individuals. We will go in reverse order. And that is, what are the impacts of the proposed cuts, either on the mission, or on our international partners? Dr. Sauthoff?

Mr. SAUTHOFF. Well, we are totally dependent on the other partners, and they are dependent on us. And what we have to do is to find a way where we work together such that all of us deliver all of our parts. And what we have to do there is to build up both a trust and a way to work together. And, as Dr. Iotti will—or Iotti, okay—will perhaps talk about, we have underway various approaches to achieving that interactivity, and that integration. And what we really need is to have an integrated team with strong leadership, and effective project systems that allows us to cooperate, and to achieve our mutual goals.

Chairman SMITH. Okay. Thank you. Dr. Iotti, the impact of the cuts? And I am afraid you are going to have to be the last one to answer, because of the time limitation.

Mr. IOTTI. There is—as Ned said, we have to work together. The moment that the other partner sees the U.S. is possibly wavering because of the budget cuts, it shows—it is much more difficult for us to influence the other ones, and working together. That is the bottom line. So we need to deliver just as much as we expect the other part to delivery. Budget cut can influence our ability to do.

Chairman SMITH. Okay. Thank you all. Thank you, Madam Chair.

Chairwoman LUMMIS. Thank you, Mr. Chairman. The Chair now recognizes the gentlewoman from California, Ms. Lofgren.

Ms. LOFGREN. Well, thank you very much. I was excited by the title of this hearing, "Fusion: The World's Most Complex Energy Project", and—but all we are talking about is ITER. And I learned, when I first was elected to Congress, that the competition and disagreement between scientists about whether you want to do inertial confinement fusion, or magnetic fusion, it is, like, almost a religious dispute, and people have very strong views.

But one question I have is how we might—or are we utilizing the information that we are obtaining out of the important work that is being done here in the United States, both at MIT, and at Lawrence Livermore that was mentioned earlier. How is that being integrated into the design of the science of this project, if at all? Anybody who could——

Mr. SAUTHOFF. Okay, let me start. First of all, the design of ITER has evolved to adapt to the best practices and best configurations known from the existing research, and the U.S., among others, has contributed a lot to that. We have adapted the ITER configuration recently by adding what are called in—vessel coils to address things that have been found on U.S. and other devices. We also have come up with ways of addressing how to increase confinement, and how to minimize the effects of instability.

And so these features have been put into the ITER design, such that the basic ITER has the systems in place, based on our knowledge to date, and there is a flexibility in all the peripheral systems to improve how you fuel it, how you heat it, and how you change the profiles. And so both past research has contributed, and future research will contribute not only to the peripheral systems, but how we operate ITER.

Ms. LOFGREN. I worry—I support funding for this project, I will just say that up front, but I worry about completion, given the terrible economic conditions in Europe, and whether people who have made commitments in the end are going to be able to follow through on those commitments. And I am also mindful that when you have a big construction project like this, by the time you finish, you know, the technology has moved forward, and it is dated. I mean, for example, NIF, by the time it was done, they would now have a facility probably a third the size. I mean, the lasers would be so different. Not that it isn't a useable facility, but I am sure the same will be true of ITER.

And so I guess—here is a question, looking at what—and I hope we—Madam Chair, we might be able to have a hearing on some of the other projects in the fusion arena, because it is very exciting, what is going on at Livermore. I just got a briefing yesterday from their scientific team, and with their high step efforts, I mean, they are generating alpha particles in a very interesting way.

You know, they are—I believe they have created fusion, although not ignition. And we don't know, it is a science experiment, whether they will. But let us just say what if they actually hit their ignition target before ITER is completed. Would that have an impact on ITER's development? Because they are making great progress in stability issues and the like. Would—how would that information be integrated into this project?

Mr. SAUTHOFF. Well, if I might be so bold as to start, I think, first of all, it would be a great accomplishment, and it will be a great accomplishment when NIF achieves ignition, and I believe that that will raise the recognition of the potential for fusion. And I personally believe that we should succeed in fusion in any way we can——

Ms. LOFGREN. I do as well.

Mr. SAUTHOFF. —and I also believe we should succeed in multiple ways. Because, in that redundancy, we get reliability, and we will be able to optimize the systems. And, quite frankly, I hope that inertial confinement succeeds, magnetic confinement succeeds, and some of these alternate concepts succeed.

You know, if we had set out to say we were only going to build one sort of a car, you know, we wouldn't have the variety——

Ms. LOFGREN. No, I absolutely agree, but the question is can you incorporate—I mean they have learned a lot on material science——

Mr. SAUTHOFF. Yes.

Ms. LOFGREN. —moving forward. That, I believe, would be instructive and useful for this alternate approach——

Mr. SAUTHOFF. Right.

Ms. LOFGREN. —and I agree. Once we get ignition, all that is left is engineering. And so, you know, that is a big challenge. But once we clear the science, I have a high level of confidence on implementation.

Mr. SAUTHOFF. Yes. I believe that there are areas that can be synergistic, and materials are among them. The systems are somewhat similar, but they are also quite different, and that means that we have multiple paths to success in fusion, and so we ought to celebrate the differences as well as we celebrate the similarities.

Ms. LOFGREN. Thank you.

Chairwoman LUMMIS. And the gentlewoman's time has expired. I now recognize the gentleman from Kentucky, Mr. Massie.

Mr. MASSIE. Ms. Lofgren asked most of my questions, and better than I could have, but I have the same sort of interest in this. And some of these research efforts that are global can almost be described as the analogy to 1,000 monkeys typing on keyboards, that eventually they will produce the works of Shakespeare, but this is not one of them. We have only a few bets to place on fusion, because the projects—the scale of the projects doesn't lend itself to having a lot of people working on different approaches. So I think it is very important, when we place our bets, what we place them on.

Dr. Sauthoff, you said that first plasma was an important milestone, or at least that is what it sounds like. What is the next milestone after that? And then, Dr. Iotti, in the event of 100 percent success of this project, what will this experiment produce? But Dr. Sauthoff, please.

Mr. SAUTHOFF. Okay. So the first event is a big integrated systems test that results in a plasma. We call that first plasma. That means the core tokamak is working.

Mr. MASSIE. Is that novel? Has that been achieved before?

Mr. SAUTHOFF. There has never been—it has never been achieved at this scale. You know, what we will be doing is to build a system that has more stored energy, and higher forces, and the like, than anywhere else. What we have to do after that is then build on top of the basic tokamak. We have to add the heating system, so that it gets up to thermonuclear temperatures. We have to add the instrumentation, so that we can study what is going on. We have—and we have to continue to optimize.

One of the key things is we have to start a tritium system, because the fuel is deuterium and tritium, and that is a system which is very complex, state of the art, beyond the current state of the art. It is not just like what you do in the weapons system. What you have to do is do this fast enough where you can separate different isotopes of hydrogen to separate out the deuterium, and the tritium, and the protium in time that you can cycle it back into the tokamak.

So this is a real development. We are doing our part at Savannah River. We are doing the separation. That then goes to Europe, that does the isotope separation. We are doing the exhaust processing, get hydrogen and separate it from other things. Europe is doing the isotope separation, and then it goes to China and Korea for injection.

Mr. MASSIE. Dr. Iotti, the ultimate outcome from this giant experiment will be what?

Mr. IOTTI. Well——

Mr. MASSIE. When I—I got excited when I saw the——

Mr. IOTTI. Two things——

Mr. MASSIE. —electrical substation. I thought, wow, they are going to send power out. But then I realized that is the power coming in——

Mr. IOTTI. That is the power coming in——

Mr. MASSIE. —to the magnets.

Mr. IOTTI. —right. It——

Mr. MASSIE. Okay.

Mr. IOTTI. The moment we can say that is the power out——

Mr. MASSIE. Yeah.

Mr. IOTTI. —we will have been successful. Well, first of all, this experiment is going to allow us to enter the regime where the plasma itself heat it. We have never been there for any substantial period of time. So that is the science, if you will. After you conquer the science, then it becomes an engineering problem.

So this device by itself will not enable us to immediately go to a demo plant. We can design a demo plant, but we will need information on materials. We will need other information that comes from other facilities that are being built around the world, by the way. But the fundamental output of ITER will be the knowledge of the science, and some of the engineering that is necessary to go to the next step, which will be the—not just the design, but the actual construction of a demonstration facility, which will produce power that will be put in the grid.

Mr. MASSIE. But not this facility?

Mr. IOTTI. Not—this facility will not put power in the grid——

Mr. MASSIE. Got you.

Mr. IOTTI. —no.

Mr. MASSIE. I want to use my remaining time to ask Dr. Rusco a few questions—or one question. I will leave it open ended. The design of the management of this project presents, I would imagine, some unique obstacles, and increases the overhead of completing these goals. What are some of those unique problems inherent in the management of this project?

Dr. RUSCO. Our review mostly focused on the U.S. project, but the management assessment which we were able to review laid out some really important challenges. And among the key ones were a top heavy management culture, and structure, and many managers from different——

Mr. MASSIE. Languages?

Dr. RUSCO. —and cultures. I don't think that the language and, you know, cultural aspects are as much of an issue as have too many managers, and too many layers of decision-making. Decision-making was not pushed down to the lowest reasonable level, and so it is a top heavy organization. Another is that they have an absence of a systems engineering culture, and they need that.

This is a huge, complex system, and it is a huge project. And another one is that they are lacking in things like a nuclear safety culture. And these are big changes, big cultural changes in an organization that is made up of people from all the member countries. And I think that that is just inherently a large challenge.

Mr. MASSIE. If—can I have just a little more time?

Mr. IOTTI. Could I add one more, if I may, because I think it responds to his question? There is an issue—imagine that you have a project, and you are the owner of the project. Normally the owner has the funds, and tell its contractors what to do. Not so in ITER. It is the reverse. The domestic agencies have the fund. They are the provider of the equipment to the owner, the ITER organization, which has no funds. So that is a big problem. It is not unsolvable.

And, as a matter of fact, one of the reaction to the recommendation of the management assessment said, improve the IO/DA interaction. It is a key of the group formed by the council, which is studying the problem, and is making good progress. That is something that is unique to ITER.

Mr. MASSIE. That occurred to me when Dr. Rusco talked about the problem with the decision process. Well, so many of the decisions have already been made. You know who you are going to buy it from, and what they are going to build, so why would it matter if you made a decision to do something else? You don't have the money to change the plan, seems like. I yield back. My time has expired.

Chairwoman LUMMIS. I thank the gentleman, and recognize the gentlelady from Massachusetts, Ms. Clark.

Ms. CLARK. Thank you, Chairman Lummis. I am very excited to be here, and very excited about the potential of fusion energy. And, with all apologies to George Gershwin, I say ITER, you say ITER, but let us not call the whole thing off. And I do have some particular questions. I have been very fortunate to be able to go out to the fusion lab at MIT and see the C–Mod there.

And I have some questions for Dr. Dehmer, because you have oversight of sort of what I see as two parallel management structures, one having to do with the Fusion Energy Advisory Committee, and one having to do with the High Energy Physics Advisory Board, and the P–5. And there seem to be similarities on these two, but some key differences, and I wondered if you could help me think through some of the differences.

In the P–5 panel, there is a feeling that there has been a better opportunity to incorporate community input, and there has also been some differences, in that membership in the strategic planning panel on the fusion side has barred membership from major

U.S. facilities to avoid conflicts of interest, but this has not been the case in the P–5 panel. And so that the feedback that I have been getting is that people feel the P–5 panel has been able to work through solutions in a better way. And I wondered if you could comment on that, and the difference in structures, and how we might reconcile these two parallel structures?

Dr. DEHMER. Yes. Let me talk about that. There are three committees that I would like to talk about. One is the P–5 HEPAP, one is the FESAC, and the third is the Basic Energy Sciences Advisory Committee, which went through a similar exercise about a year ago.

In prior committees under FESAC, there had been some concern expressed to me verbally, that the committee didn't appreciate conflict of interest as well as it should. So when we started this most recent study, I admonished them to be very, very careful about conflict of interest. Now, you can do that in a number of ways. You can have your sub-panel composed of people who have no obvious conflicts of interest, and that is what the chair of FESAC did. That was Mark Koepke. And that is also what BESAC did.

The BESAC and the FESAC committees were very, very similar. Neither one of the sub-panels had members from institutions that were directly affected. However, in both cases, there were very open community activities in which communities put white papers, and other kinds of documents, into the sub-panel, and had an opportunity to formally brief the sub-panel. That worked very well for BESAC, and FESAC Mark Koepke chose to adopt that for FESAC as well.

There is no intent whatsoever to inhibit input from these major facilities. And, in fact, if you look at the FESAC webpage for this activity, it is full of calls to the communities to provide input. And, in fact, they met just this week. Their meeting concluded yesterday, and they heard from all of the major facilities, national and international, that briefed the Subcommittee, and put in white papers for the Subcommittee. This worked very well for BESAC. I think Mark Koepke decided to adopt this for FESAC.

Ms. CLARK. Great. Thank you very much. I yield back my time.

Chairwoman LUMMIS. I thank the gentlelady, and yield to the gentleman from Illinois, Mr. Hultgren.

Mr. HULTGREN. Thank you, Madam Chair, and thank you to all of our witnesses. We most definitely have a very distinguished panel here today. I think this hearing is very important as we continue to assess ongoing viability of the ITER program. I think everyone on this Committee knows about my interest in our national labs, and I also recognize the need for international collaboration in some of these large science projects. Because of the sheer size of such of—as this, there is no way for the United States just to go it alone.

And it is not just a cost issue, it comes down to portfolio management. Doing this alone would require nearly all of the fusion budget, plus increases. We do have to ensure a balance of projects, because we don't always know where the next discovery or game changer will come from.

Dr. Dehmer, first of all, I want to thank you for the incredible work that you have done at the Office of Science. As I talk to my scientist back in Illinois, one word that keeps coming back to me is tough. And I don't think that is a bad thing, neither do they. They know that they have to have their plans well thought out and put together before they bring them to your desk. And I have faith that you have been a responsible steward of the taxpayers' dollars, and I thank you for that.

My first question comes down to our standing in the international community for these types of international programs. Our partners obviously get frustrated with the United States because of our yearly budgets, or sometimes monthly budgets, compared to the more long term planning in other nations. I wondered if you could talk briefly about if the United States pulls out of a program of this size, how do you believe the international community will react when we want to join in a host of other—or host other programs?

I wondered if you could also discuss the importance of domestic research and facilities programs in relation to ITER and other international partnerships. One last thing, also, how are these programs interrelated, and what would pitting one against the other mean for the ability to continue future work in fusion energy?

Dr. DEHMER. Let me answer the the Office of Science. And we heard today a lot about aggressively accelerating funding for fusion, but we simply can't do that, because there are so many other projects.

We have tried to assess how withdrawal from ITER, and we aren't proposing to do that, might affect other activities, both scientific and other, and we simply don't know the answer to that. I have to say that I have not heard from any part of the scientific community that they are nervous about the United States position on ITER. And you well know, with Fermilab in your district, that international projects are an increasingly important component of the science portfolio.

And you well know from the P–5 HEPAP report that encouraged Fermilab to reach out and internationalize the long baseline neutrino facility, and we are going forward in doing that. And that will be one of the first examples of a major international project on U.S. soil.

Mr. HULTGREN. I hope we can do it well. And, again, with our challenges budgeting here, where other nations, I think, have done a better job of long term planning, as far as science is concerned, I do think it is important for us to show that we can follow through if we have a hope of having future projects that we can work together on.

Dr. Iotti, I wonder—if I understand, that one of the key management challenges with ITER is the unanimity requirement for cost of schedule decisions, which allows one member to stall the decision-making process. Is there agreement on the council that this is a problem, and how do you plan to address this issue so that the organization can function?

Mr. IOTTI. Yes, the council has recognized the issues. They formed a working group that is called, surprisingly, IODA Interaction Group, and the group is making very good progress. They have defined a process whereby decisions are presented to a group which is chaired by a senior person in the ITER organization, but includes all of the most senior persons from each of the domestic agencies, and has formed kind of an executive group.

These decisions—the options for the various decisions, with the pros and cons, are presented to the group, and the decision then is made jointly by the ITER organization and the domestic agencies, and presented to the Director General, who can then still, if necessary. But generally they will come to an agreement. It will not solve all problems, but it will considerably ameliorate the issue.

Mr. HULTGREN. Real quickly in my last few seconds, Dr. Dehmer, if I can go back, what lessons has the United States learned about creating an international decision-making body for other projects domestically? As you mentioned, I am thinking about the P–5, the proposal of the international facility. But I think we have these questions about anything that we might ever want to host or join. While I do think ITER management problems can be rectified, is the current management a case study for how not to manage a program like this in the future?

Dr. DEHMER. I think we have examples of international projects that have worked, the Large Hadron Collider——

Mr. HULTGREN. Yes.

Dr. DEHMER. —and we have had examples, and ITER is one of them, where we would modify that agreement, if we had to do it all over——

Mr. HULTGREN. So lessons have been learned with——

Dr. DEHMER. Yes, indeed.

Mr. HULTGREN. Well, again, thank you so much. Madam Chair, thank you so much. Appreciate your generosity.

Chairwoman LUMMIS. Those were sweeping questions, and very succinct answers. Very impressive line of questioning. I want to recognize now the gentleman from Texas, Mr. Veasey.

Mr. VEASEY. Thank you, Madam Chair. I have a question for Dr. Sauthoff. We have three major magnetic fusion research facilities here in the U.S., at MIT, Princeton, and General Atomics in San Diego. And what I was curious about was if you would be able to explain how the smaller scale experimental facilities are contributing to ITER?

Mr. SAUTHOFF. Okay. Well, the smaller scale facilities in the U.S. are world class, even though they are not at ITER scale. There is not an ITER scale facility in the world. But the U.S. facilities are world class. They have produced results which have enabled ITER to optimize its design. I mentioned in-vessel coils, but there are other areas where that has been done. They have also identified ways where ITER can be operated more effectively, better modes of confinement, different modes of stability, better ways of protecting against loss of control and the like.

Furthermore, they provide a training base for—let us call it the workforce. We also want to establish a reputation where the U.S. has the stature to really be effective in international research, and be able to propose winning proposals, to win run time, to be members of international teams that do the research. And so, quite frankly, we have the ability to study the physics, which can then be extended to the ITER scale, based on understanding the basic physics, and then extrapolating it. And that extrapolation uses supercomputer simulations.

So, really, what I see is devices such as today's tokamaks giving better understanding, giving rise to better physics models that are then embodied in supercomputer codes, which allow us to then extrapolate to the ITER scale.

Mr. VEASEY. Would there—were you finished? I am sorry. Would there still be a strong justification for continuing to support the current set of U.S. based magnetic fusion facilities if there were no burning plasma experiment like ITER in the works?

Mr. SAUTHOFF. Well, first of all, I hope that situation doesn't arise. However, you know, if there were no burning plasma facility in the world, there would be a gaping hole, because one of the greatest risks has to do with not understanding the dynamics of a burning plasma, or the effects of the energetic particles, or the size scaling.

However, there would be many things to learn if there were not a burning plasma facility. However, the E in fusion energy would not be fulfilled. What we would be studying is plasma physics. And so what we really need to do is have a balance between plasma physics and putting the E into fusion energy.

Mr. VEASEY. Interesting. On the facilities again, I mean, are we sufficiently supporting these facilities, and the related research programs at universities throughout the country to ensure the success of ITER?

Mr. SAUTHOFF. Well, I will transfer it to Dr. Dehmer in a moment. Of course it would be better if there were more run time on these facilities. They are starved for run time. A very small fraction of the available time is used for operation. But it is a question of balance, and so that is where Dr. Dehmer comes in.

Mr. VEASEY. Dr. Dehmer?

Dr. DEHMER. We do try to balance the amount of run time, and we have deliberately been pushing to increase the run time, particularly on NSTX, which is just finishing its upgrade at Princeton Plasma Physics Laboratory, and we are trying to have a very, very good run the first year after that upgrade is finished.

Mr. VEASEY. Okay. Thank you. Thank you, Madam Chair.

Chairwoman LUMMIS. I thank the gentleman from Texas. Without objection, the Chair recognizes Mr. Rohrabacher for five minutes for his questions. Those bells were just the call for votes, but this first vote is a 15 minute vote, thereby allowing Mr. Rohrabacher his complete use of time, so——

Mr. ROHRABACHER. Okay.

Chairwoman LUMMIS. We are going to complete our hearing, and still make votes. Perfect.

Mr. ROHRABACHER. All right.

Chairwoman LUMMIS. Mr. Rohrabacher?

Mr. ROHRABACHER. Thank you very much, Madam Chairman. Sorry I was a bit in and out. As we speak, that sound in Israel is the sound of a rocket coming in and blowing innocent civilians up. We were just briefed by the ambassador, and by an Israeli military official.

About fusion, as compared to other alternatives—and I am sorry I missed—I will come back and read your testimony as the hearings go on, but I have been here during this whole decision-making process for the last 26 years, and it seems to me that already what we have got again is a description of management problems with a multi-billion dollar program, and this is very serious.

And—especially if we have very limited resources now in this country. We are borrowing money from China in order to, you know, in order to do anything, in order to actually meet our own budget. So these management problems need to be overcome, I just would like to put that one the record, or we need to, say, have a serious look at whether we will continue pouring money into the project.

Madam Chairman, I would suggest that over these years there have been many spin-offs from the Fusion Energy Research Program that are very valuable. And I know that, for example, the railgun that has just been disclosed by our military would not have been possible without the material and development of the metals, and the things that were necessary for the fusion project to move forward. And it actually permitted us to develop a system that I think will enable us to build a defense system, so that if those alarms go off, we will actually have a missile defense system that will protect our people, and save thousands of lives.

So, in that degree, fusion energy research has been a benefit to the people of the United States. Perhaps, however, we should be looking now at whether or not the money we are going to be putting in to fusion, as compared to the money that would be putting in to small modular nuclear reactors that are fission reactors, we know we are going to get a benefit from that.

We know if we put several billion dollars into that, we will have a new system of fission reactors that will provide safe energy for our people, and we are assured of that. Can we be assured that the billions of dollars that we will need to pump in to the—to finish this project, this fusion project, can we be certain that it will result in an energy system for our country? We know it will if we put it into fusion. Do we know it—fission. Do we know it will happen if we put it into fusion? Whoever on the panel wants to go. Maybe each one of you could say, yes, we know, or no, we don't know. Maybe start at this end, and just run them down. Go ahead.

Mr. SAUTHOFF. Okay, I will start. No, we don't—do not have absolute certainty. But what I think we have to do is act somewhat as an investor. We have to look at what would be the return on investment if it were to succeed, and then——

Mr. ROHRABACHER. Yeah.

Mr. SAUTHOFF. —consider what are the probabilities——

Mr. ROHRABACHER. Versus risk, and——

Mr. SAUTHOFF. Yeah. It is—I think we ought to treat it as a portfolio management problem.

Mr. ROHRABACHER. Okay.

Mr. IOTTI. I agree with——

Mr. ROHRABACHER. Okay. So the idea is that no, we do not——

Mr. IOTTI. We do not know for certain.

Mr. ROHRABACHER. —we do not know for certain, but we feel there is a probability?

Mr. IOTTI. Very high probability.

Mr. ROHRABACHER. Okay.

Dr. DEHMER. Exactly the same. Long term, high risk project.

Mr. ROHRABACHER. All right. But we do know that there is an alternative, in terms of development of nuclear energy for the use of our people that is far less risky, in terms of—we know we can produce fission reactors that are small modular reactors.

Mr. SAUTHOFF. Yeah.

Mr. ROHRABACHER. I mean, I asked that of other witnesses, and they say absolutely we can, if we had the resources. So, for the same amount of money, we could have a certain return, versus—and, due to dealing with fusion, we don't have a certain return. However, we do have a probability. One last note our GAO, how does that all add up?

Dr. RUSCO. I can't add anything to what they said. It is a high risk, potentially high reward project.

Mr. ROHRABACHER. All right. Thank you very much.

Chairwoman LUMMIS. We have had a fascinating line of questions and answers today. We all thank you for your valuable testimony, and I thank the Members for their valuable questions, and thoughtful questions. Members of the Committee will have additional questions for you, and if they come to you, we will ask you to respond in writing. The record will remain open for two weeks for additional comments and written questions for Members.

Members, we have on the floor eight minutes remaining on a Motion to Recommit on H.R. 4718, so plenty of time. And, again, with gratitude towards our panel, this hearing is adjourned. The witnesses are excused. Thank you.

[Whereupon, at 10:30 a.m., the Subcommittee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

Answers to Post-Hearing Questions

Responses by Dr. Dehmer

QUESTION FROM REPRESENSTATIVE JOESEPTH KENNEDY

Q1. It is my understanding that the Fusion Energy Sciences Advisory Committee (FESAC) is scheduled to deliver a proposed strategic plan for the Office of Science's fusion energy research program to the Department of Energy (DOE) by October 1, 2014. This proposal is critical in order for DOE to submit a fully informed Fusion Energy Sciences Strategic Plan to Congress by January 2015.

I am strongly in favor of this process and believe a comprehensive strategic plan will be invaluable to the future of our U.S.-based fusion community and our international partnerships as well.

As specifically as possible, what is the extent to which the broader community of stakeholders will be able to provide input in the strategic planning process both before and after the October 1 deadline?

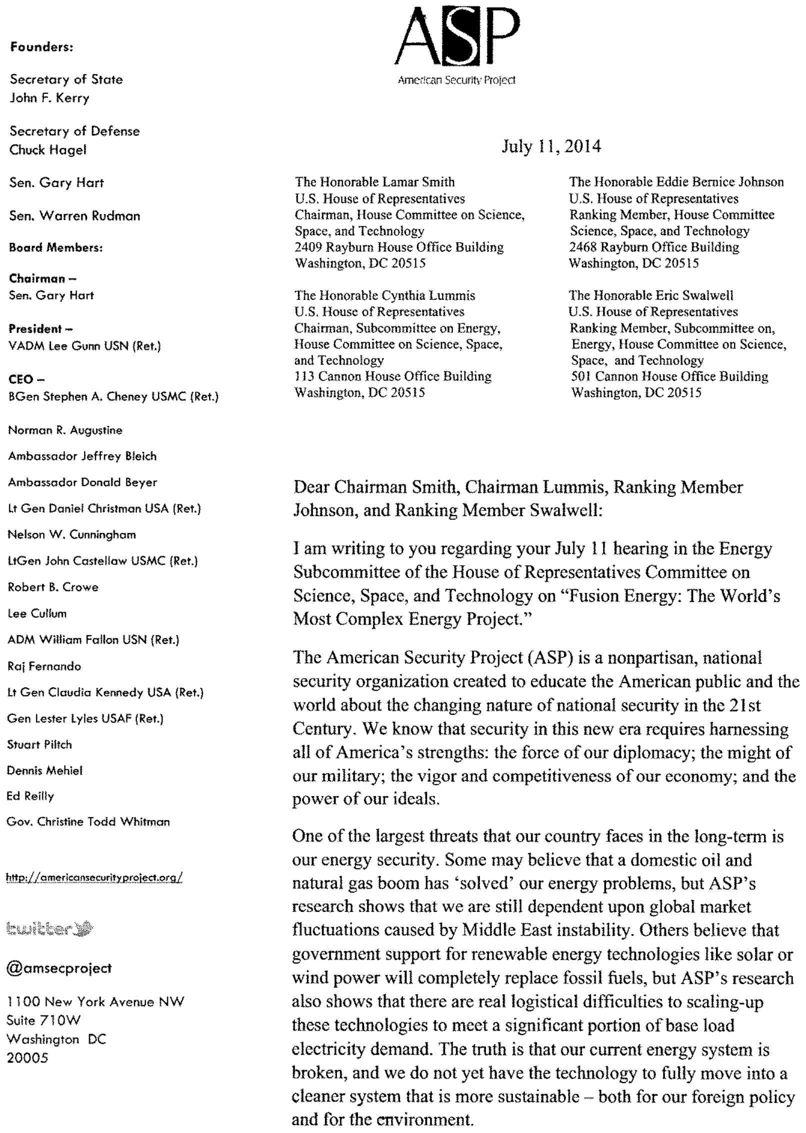
A1. In order to meet the Congressional request contained in the FY 2014 Omnibus Appropriations Act for a fusion strategic plan, earlier this year I issued a charge to FESAC directing the committee to prioritize among the elements of the domestic fusion energy sciences program under four distinct budget scenarios. The FESAC chartered a subcommittee to execute this charge, and the chair of FESAC, Professor Mark Koepke, is also chair of that subcommittee. Professor Koepke has designed and is leading a process to solicit broad community input prior to the October 1 submission deadline for the response to the charge. The subcommittee recently completed its second week-long information gathering meeting; over the course of these two meetings literally dozens of community leaders have briefed the subcommittee on a wide range of topics. In addition, the subcommittee has posted an open invitation to the fusion community to submit white papers.

After October 1, 2014, the Office of Science will undertake internal deliberations as we prepare the congressionally required FES strategic plan. Given the rigor of the current subcommittee activity, the FESAC report to the Office of Science is expected to have a major impact on those deliberations.

Appendix II

ADDITIONAL MATERIAL FOR THE RECORD

LETTER SUBMITTED BY CHAIRMAN LAMAR S. SMITH



ASP
American Security Project

http://americansecurityproject.org/

twitter

@amsecproject

1100 New York Avenue NW
Suite 710W
Washington DC
20005

July 11, 2014

The Honorable Lamar Smith
U.S. House of Representatives
Chairman, House Committee on Science, Space, and Technology
2409 Rayburn House Office Building
Washington, DC 20515

The Honorable Cynthia Lummis
U.S. House of Representatives
Chairman, Subcommittee on Energy, House Committee on Science, Space, and Technology
113 Cannon House Office Building
Washington, DC 20515

The Honorable Eddie Bernice Johnson
U.S. House of Representatives
Ranking Member, House Committee Science, Space, and Technology
2468 Rayburn Office Building
Washington, DC 20515

The Honorable Eric Swalwell
U.S. House of Representatives
Ranking Member, Subcommittee on, Energy, House Committee on Science, Space, and Technology
501 Cannon House Office Building
Washington, DC 20515

Dear Chairman Smith, Chairman Lummis, Ranking Member Johnson, and Ranking Member Swalwell:

I am writing to you regarding your July 11 hearing in the Energy Subcommittee of the House of Representatives Committee on Science, Space, and Technology on “Fusion Energy: The World’s Most Complex Energy Project.”

The American Security Project (ASP) is a nonpartisan, national security organization created to educate the American public and the world about the changing nature of national security in the 21st Century. We know that security in this new era requires harnessing all of America’s strengths: the force of our diplomacy; the might of our military; the vigor and competitiveness of our economy; and the power of our ideals.

One of the largest threats that our country faces in the long-term is our energy security. Some may believe that a domestic oil and natural gas boom has ‘solved’ our energy problems, but ASP’s research shows that we are still dependent upon global market fluctuations caused by Middle East instability. Others believe that government support for renewable energy technologies like solar or wind power will completely replace fossil fuels, but ASP’s research also shows that there are real logistical difficulties to scaling-up these technologies to meet a significant portion of base load electricity demand. The truth is that our current energy system is broken, and we do not yet have the technology to fully move into a cleaner system that is more sustainable – both for our foreign policy and for the environment.

We must develop energy technologies that will power America's economy for the next generation – technologies that are clean, safe, secure and abundant. One that holds great promise in meeting our needs is energy from fusion. The same process that powers the sun, it will completely revolutionize the world's energy system when commercialized.

Fusion emits zero greenhouse gases and is not variable like other renewable sources of energy. For the long-term energy and environmental security of future generations, developing fusion energy is critical. As fusion power will be affordable, plentiful, and 'always on,' base load energy provided by fusion power could be harnessed for many uses other than today's electricity; biofuels, desalinization, or fertilizer production could all be supported by fusion power.

It is not an exaggeration to say that fusion power would revolutionize America's economy.

That is why, on Thursday July 10, ASP updated its "Fusion White Paper 2014 – 10 Year Plan for American Energy Security" to provide a Ten Year plan for fusion development. This plan is available in full on ASP's website. This plan calls for a sustained national investment into fusion research of $30 billion over 10 years. While that sounds like a great deal in these times of tight budgets, columnist George Will, in his December 22 article "A Dazzling Bright Future Dawns in New Jersey" notes that it is less than what the U.S. spends on energy in one week.

If Congress chooses not to reach this level of investment, we must ensure that the U.S. maintains a strong fusion research program in both the international program (ITER) and our domestic program. The Administration's FY2015 Budget request of $405 million for Fusion Energy Sciences was inadequate to maintain this leadership, harming both the domestic program and the U.S. contribution to ITER. The House Appropriations Committee has recommended $540 million in their FY2015 Energy and Water Appropriations bill. This amount of funding would ensure that the U.S. continues to play a leading global role in developing fusion.

However, we cannot afford to sit back; the rest of the world is not waiting. The Chinese, South Koreans, Russians, Japanese, and Europeans are moving forward quickly with fusion research. Despite the impressive progress that fusion scientists are making in American laboratories, the U.S. is ceding leadership in fusion energy to other countries. Many of the magnetic fusion facilities in other countries have surpassed the technological capabilities of the best American labs. International plans for power-plant deployment are also substantially more advanced.

ITER

One of the main topics of this hearing will be management and budget issues with the ITER project. ASP strongly supports ITER, and understands that large, international projects often fall behind schedule and over-budget. However, that is not an excuse. The U.S. presence as a full-partner in ITER can help to bring their project-management ability up to the highest levels, while also working with other countries to bring costs down.

Being a part of ITER has great benefits to the United States. First, ITER is a great return on investment: The U.S. only contributes about 9% but reaps 100% of the research that ITER produces. Second, ITER provides business opportunities and creates jobs: About 80% of the funds for the ITER project are spent within the U.S. The ITER Organization predicts that between 2014 and 2017 there will be around 3,000-4,000 workers added to the existing 1,000 employees. In addition, the project anticipates an estimate of $1 Billion in future contracts for the United States. Already, ITER contracts extend over 38 states, with jobs created across the country.

ASP believes that America must lead in the pursuit of our common goals and shared security. We must confront international challenges with our partners and with all the tools at our disposal and address emerging problems before they become security crises. To do this we must forge a bipartisan consensus here at home. Our international commitment to ITER is a method of practicing diplomacy through science. During the Cold War, Mikhail Gorbachev and Ronald Reagan saw fusion energy as a solution to bridge the divide between the Soviet Union and the U.S. Today, this consortium brings together countries representing over half of the world's population. We cannot withdraw from such a project without a significant blow to our international credibility.

Conclusion

America faces a crisis in its declining support for Research and Development. The next generation of America is in danger of inheriting a country that is no longer the world's leader in science or engineering; the very skills we know will be the building blocks of 21st Century prosperity.

This crisis is paired with a coming crisis in energy: our economy depends on reliable sources of power, but over the next few decades, almost all of the power plants in the U.S. will need to be replaced, and America's dependence on fossil fuels presents serious national security concerns – they sap our economy, exacerbate climate change, and constrict our foreign policy.

America needs to produce energy that is clean, safe, secure and abundant. We see that energy from fusion has huge potential.

With direction from Congress, America's scientists could begin today to build the next-generation of facilities that will develop and prove the feasibility of fusion power. We know that our competitors in China and Russia have begun work on these facilities. Our superior scientific expertise means that we can beat them: but we first need to get to the starting line.

Achieving practical fusion power will cement American leadership in solving some of the world's critical problems, and drive American competitiveness in the coming decades.

Other countries (like China, Russia and South Korea) already have ambitious plans to develop fusion. The U.S. will be left behind if Congress and the President fail to make the smart investments we know are necessary. Fusion power is possible and America can do it. The payoff will prove to be a revolution in America's energy system.

ASP looks forward to working in a bipartisan fashion with Members of the House Science, Space, and Technology Committee to bring about a breakthrough in fusion energy research. ASP's staff and board stand-by as a resource for you on this and other issues of national security.

Yours sincerely

Stephen A. Cheney
BGen USMC(Ret)
Chief Executive Officer