THE PRESIDENT'S U.N. CLIMATE PLEDGE: SCIENTIFICALLY JUSTIFIED OR A NEW TAX ON AMERICANS?

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

APRIL 15, 2015

Serial No. 114–14

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

THE PRESIDENT'S U.N. CLIMATE PLEDGE: SCIENTIFICALLY JUSTIFIED OR A NEW TAX ON AMERICANS?

THE PRESIDENT'S U.N. CLIMATE PLEDGE: SCIENTIFICALLY JUSTIFIED OR A NEW TAX ON AMERICANS?

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

APRIL 15, 2015

Serial No. 114–14

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 PUBLISHING OFFICE

95–219PDF WASHINGTON : 2015

For sale by the Superintendent of Documents, U.S. Government Publishing 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*

FRANK D. LUCAS, Oklahoma
F. JAMES SENSENBRENNER, JR., Wisconsin
DANA ROHRABACHER, California
RANDY NEUGEBAUER, Texas
MICHAEL T. McCAUL, Texas
STEVEN M. PALAZZO, Mississippi
MO BROOKS, Alabama
RANDY HULTGREN, Illinois
BILL POSEY, Florida
THOMAS MASSIE, Kentucky
JIM BRIDENSTINE, Oklahoma
RANDY K. WEBER, Texas
BILL JOHNSON, Ohio
JOHN R. MOOLENAAR, Michigan
STEVE KNIGHT, California
BRIAN BABIN, Texas
BRUCE WESTERMAN, Arkansas
BARBARA COMSTOCK, Virginia
DAN NEWHOUSE, Washington
GARY PALMER, Alabama
BARRY LOUDERMILK, Georgia

EDDIE BERNICE JOHNSON, Texas
ZOE LOFGREN, California
DANIEL LIPINSKI, Illinois
DONNA F. EDWARDS, Maryland
SUZANNE BONAMICI, Oregon
ERIC SWALWELL, California
ALAN GRAYSON, Florida
AMI BERA, California
ELIZABETH H. ESTY, Connecticut
MARC A. VEASEY, TEXAS
KATHERINE M. CLARK, Massachusetts
DON S. BEYER, JR., Virginia
ED PERLMUTTER, Colorado
PAUL TONKO, New York
MARK TAKANO, California
BILL FOSTER, Illinois

CONTENTS

April 15, 2015

THE PRESIDENT'S U.N. CLIMATE PLEDGE: SCIENTIFICALLY JUSTIFIED OR A NEW TAX ON AMERICANS?

WEDNESDAY, APRIL 15, 2015

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

The Committee met, pursuant to call, at 10:06 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Lamar Smith [Chairman of the Committee] presiding.

Chairman SMITH. The Committee on Science, Space, and Technology will come to order.

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

Full Committee

The President's UN Climate Pledge: Scientifically Justified or a New Tax on Americans?

Wednesday, April 15, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Dr. Judith Curry, Professor, School of Earth and Atmospheric Sciences, Georgia Institute of Technology

The Honorable Karen Harbert, President and CEO, Institute for 21st Century Energy, U.S. Chamber of Commerce

Mr. Jake Schmidt, Director, International Program, Natural Resources Defense Council

Dr. Margo Thorning, Senior Vice President and Chief Economist, American Council for Capital Formation

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

HEARING CHARTER

The President's UN Climate Pledge: Scientifically Justified or a New Tax on Americans?

Wednesday, April 15, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

PURPOSE

The Committee on Science, Space, and Technology will hold a hearing entitled *The President's UN Climate Pledge: Scientifically Justified or a New Tax on Americans?* on Wednesday, April 15, 2015 in Room 2318 of the Rayburn House Office Building. The hearing will examine the scientific justification and economic impact of the United States' submission to the United Nations Framework Convention on Climate Change (UNFCCC) issued on March 31, 2015.[1]

The Obama Administration's Intended Nationally Determined Contribution (INDC) commits the United States to reducing greenhouse gas emissions 26-28% by 2025, based on the 2005 level, with "deep, economy-wide emission reductions of 80% or more by 2050."[2] The hearing will review the scientific understanding and uncertainties of this proposal; examine the technologies and authorities required to meet the Administration's commitment; and evaluate the environmental impact and economic cost of this proposal. With several interim meetings during the course of the year in Germany, the UNFCC is planning to hold its Conference of Parties with many heads of state in Paris in late November-early December with plans to ratify a treaty-level agreement on climate change among member nations.

WITNESS LIST

- **Dr. Judith Curry,** Professor, School of Earth and Atmospheric Sciences, Georgia Institute of Technology
- **The Honorable Karen Harbert**, President and CEO, Institute for 21st Century Energy U.S. Chamber of Commerce (former Assistant Secretary for Policy and International Affairs, U.S. Department of Energy)
- **Mr. Jake Schmidt,** Director, International Program, Natural Resources Defense Council
- **Dr. Margo Thorning,** Senior Vice President and Chief Economist, American Council for Capital Formation

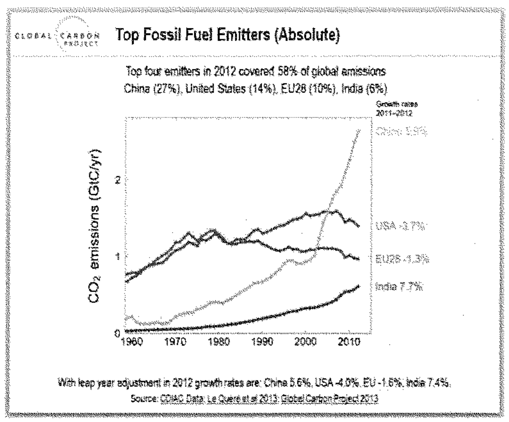
---

[1] UNFCCC, United States' Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change. March 31, 2015. Available at: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx.
[2] *Id.*

BACKGROUND

The international body overseeing the subject of the Earth's changing atmosphere is the United Nation's Framework Convention on Climate Change (UNFCCC). The Framework Convention on Climate Change was negotiated and subsequently adopted by the United Nations in May 1992.[3] Countries that signed the treaty, including the United States, are known as "parties." According to the Congressional Research Service:

> *The United States, as a Party to the UNFCCC, has qualitative obligations to report national GHG emissions; cooperate on science and technology development; enact programs to abate emissions; and provide agreed new and additional financial resources to assist low-income countries to mitigate and adapt to climate change. When the UNFCCC was drafted, the then-industrialized countries emitted two-thirds of annual GHG emissions (excluding emissions from deforestation). These Annex I countries correspondingly accepted a lead role in abating GHG emissions, though all countries agreed to "common but differentiated responsibilities."*[4]



Notably absent from the original Annex I countries are China and India, who today make substantial greenhouse gas emissions compared to other countries.[5] A total of 196 countries (including China and India) eventually signed on to the treaty, giving it near universal membership. Countries meet annually at a "Conference of the Parties" (COP) to negotiate and discuss responses to climate change.[6]

Kyoto Protocol & Beyond

In 1995, at the first COP in Berlin, German representatives put forth the Berlin Mandate, which established a process to revise and strengthen commitments for developed countries.[7] The Mandate laid the groundwork for the Kyoto Protocol, which was adopted by the UNFCCC in1997 at the third COP.[8] The Kyoto Protocol established the world's first international greenhouse gas emissions reductions

[3] UNFCCC, 20 Years of Effort and Achievement. 2015. Available at: http://unfccc.int/timeline/.
[4] Congressional Research Service, A U.S.-Centric Chronology of the United Nations Framework Convention on Climate Change. November 8, 2013. Available at: http://www.crs.gov/pdfloader/R40001.
[5] *See* , Global Carbon Project, Carbon Dioxide Analysis Center, U.S. Department of Energy. 2014. Available at: http://cdiac.ornl.gov/GCP/carbonbudget/2013.
[6] Congressional Research Service, A U.S.-Centric Chronology of the United Nations Framework Convention on Climate Change. November 8, 2013. Available at: http://www.crs.gov/pdfloader/R40001.
[7] *Id.* See also: UNFCCC, Report of the Conference of the Parties. June 6, 1995. Available at: http://unfccc.int/resource/docs/cop1/07a01.pdf.
[8] *Id.* See also: UNFCCC, Kyoto Protocol. 2015. Available at: http://unfccc.int/kyoto_protocol/items/2830.php

treaty. In 2001, at the seventh COP, the Marrakesh Accords were put forth, outlining agreements and detailed operational guidelines for implementation of the Kyoto Protocol.[9] In 2005, the Kyoto Protocol entered into force, with a commitment period starting in 2008 and ending in 2012.[10]

In 2011, at the seventeenth COP, signatories committed to agreeing to a new climate change protocol by 2015 for future greenhouse-gas emissions reductions beyond the Kyoto Protocol.[11] Recent COPs have largely focused on working toward a new agreement for the upcoming meeting in Paris November 30-December 11, 2015.

However, forging an agreement that incorporates enforceable accountability without infringing upon the independence of sovereign nations is a major challenge. From the outset, the UNFCCC has grappled with the question of real-world implementation. According to the Congressional Research Service, "[t]he question of how to share any effort to address climate change has been a core challenge for international cooperation. Because emissions come from all countries, only concerted reductions by all major emitters can stabilize the rising GHG concentrations in the atmosphere."[12]

Beyond the task of quantifying global emissions reductions and allocating contributions, cost is a fundamental challenge. "The wealthiest Parties (including the United States) pledged "fast start" financing approaching $30 billion during 2010-2012, and a goal of mobilizing financing of $100 billion annually by 2020." [13] However, financing and "loss and damage" payments remain a core area of disagreement between parties.[14]

Intended Nationally Determined Contributions

In advance of the Paris COP, participating countries were asked to submit a domestic plan to address the objectives of the Convention, called an Intended Nationally Determined Contribution (INDC).[15] These plans are expected to include:

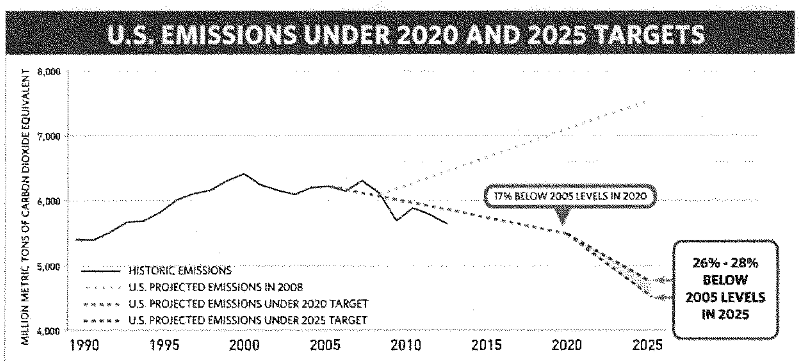
> "quantifiable information on the reference point (including, as appropriate, a base year), time frames and/or periods for implementation, scope and coverage, planning processes, assumptions and methodological approaches including those for estimating and accounting for anthropogenic greenhouse gas emissions and, as appropriate, removals, and how the Party considers that its intended nationally determined contribution is fair and ambitious, in light of its national

---

[9] UNFCCC, 20 Years of Effort and Achievement. 2015. Available at: http://unfccc.int/timeline/.
[10] UNFCCC, Kyoto Protocol. 2015. Available at: http://unfccc.int/kyoto_protocol/items/2830.php
[11] UNFCCC, 20 Years of Effort and Achievement. 2015 Available at: http://unfccc.int/timeline/.
[12] Congressional Research Service, A U.S.-Centric Chronology of the United Nations Framework Convention on Climate Change. November 8, 2013. Available at: http://www.crs.gov/pdfloader/R40001.
[13] Congressional Research Service, International Climate Change Financing: The Green Climate Fund, February 2, 2015. http://www.crs.gov/pdfloader/R41889.
[14] *See* Submission on Elements of the 2015 Agreed Outcome, Like Minded Developing Countries, March 8, 2014. Available at http://www.crs.gov/pdfloader/R41889.
[15] UNFCCC, Intended Nationally Determined Contributions. 2015. Available at: http://unfccc.int/focus/indc_portal/items/8766.php

circumstances, and how it contributes towards achieving the objective of the Convention as set out in its Article 2."[16]

On March 31st, the United States submitted their INDC to the United Nations. The United States' INDC "intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26-28 per cent below its 2005 level in 2025," and "deep, economy-wide emission reductions of 80% or more by 2050."[17] The document notes that the United States has undertaken policy actions to reduce greenhouse-gas emissions, but also notes that "additional action to achieve the 2025 target represents a substantial acceleration of the current pace of greenhouse gas emission reductions."[18] Below is a graph from the official U.S. INDC submission.



ADDITIONAL READING

- United Nations, Framework Convention on Climate Change, Intended Nationally Determined Contributions Submissions: United States. March 31, 2015. http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
- Congressional Research Service, A U.S.-Centric Chronology of the United Nations Framework Convention on Climate Change. November 8, 2013. http://www.crs.gov/pdfloader/R40001
- Congressional Research Service, International Climate Change Financing: The Green Climate Fund, February 2, 2015. http://www.crs.gov/pdfloader/R41889

[16] *Id.* See also: http://unfccc.int/files/meetings/lima_dec_2014/application/pdf/auv_cop20_lima_call_for_climate_action.pdf

[17] UNFCCC, United States' Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change. March 31, 2015. Available at: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx.

[18] UNFCCC, United States' Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change. March 31, 2015. Available at: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx.

Chairman SMITH. Without objection, the Chair is authorized to declare recesses of the Committee at any time, and welcome to today's hearing titled "The President's U.N. Climate Pledge: Scientifically Justified or a New Tax on Americans?"

Let me recognize myself for an opening statement, then I will recognize the Ranking Member, then I will introduce the witnesses, and let me say that because I was late I didn't have an opportunity to say hello to each of you individually but we very much appreciate your expertise and your presence as well.

Last June, the Obama Administration proposed sweeping new electricity regulations. Now, despite heavy and growing opposition to the proposal, the Administration seeks to commit America to costly new requirements that won't improve the environment. The President has promised the United Nations that the United States will cut its greenhouse gas emissions by as much as 28 percent over the next decade and by 80 percent or more by 2050. He is attempting to write large checks we simply cannot cash.

The pledge was made in preparation for a U.N. summit in Paris this December aimed at producing an international agreement that would impose legally binding requirements on the United States for the next decades. But all of this activity, at home and abroad, disregards the concerns of the majority in Congress and many states. The President's attempt to justify his actions with an alarmist, one-sided focus on worst-case scenarios establishes a poor foundation for sound policymaking.

When President Obama took office, he had an opportunity to work with a Democrat-controlled House and Senate to create climate legislation. But that effort failed because opposition to costly climate regulation crosses party lines. Congress has repeatedly rejected the President's extreme climate agenda. So the Administration instead has taken the unprecedented step of attempting to create laws on his own and twist environmental regulations in ways Congress never intended. Now the Administration has packaged up all these regulations and promised their implementation to the United Nations, but the President's Power Plan is nothing more than a power grab.

Environmental laws can't trump the Constitution. They can't give the federal government the right to regulate the daily lives of citizens within their homes. Regardless of what the President may try to claim, Congress has not given him or the Environmental Protection Agency the authority to rewrite laws.

Opposition to the President's agenda is widespread and continues to grow. At least 32 different states are openly opposed to the plan and many now consider the possibility of refusing to enact his edicts at all. The majority of the members of the U.S. House of Representatives and the Senate are opposed, and numerous organizations that are concerned about the cost and reliability of America's electric grid have issued dire warnings about the likely impacts of the President's plan. And the EPA's models show there will be no real climate benefits.

Whether that plan can stand up to legal scrutiny will take years to sort out. The legality of President Obama's unilateral action certainly will not be known when climate negotiators set out to create binding international rules in Paris later this year. The President's far-reaching proposals and international promises will do lasting damage to our Nation, all for little to no environmental benefit. In fact, the pledge to the U.N. is estimated to prevent only a .03 percent Centigrade temperature rise, and in testimony before this Committee, former Assistant Secretary for Energy, the Honorable Charles McConnell, noted that the President's Clean Power Plan would reduce sea-level rise by less than half the thickness of a dime. Meanwhile, middle and lower income American families will be hit hardest as energy costs inevitably rise.

The President's pledge to the U.N. hinges on a questionable and unclear plan. The commitment submitted two weeks ago lacks details about how we will achieve such goals without burdening our economy and it fails to quantify the specific climate benefits tied to the promise.

Today is April 15th, Tax Day. It is a day that many Americans dread. As more Americans feel squeezed by rising costs, flat wages, and rising taxes, we should ask ourselves: can we really afford another extreme and expensive mandate? We will never reach the President's arbitrary targets, which would increase electricity costs, ration energy, and slow economic growth. Such severe measures will have no discernable impact on global temperatures. They will make the government bigger and Americans poorer.

I expect today's hearing will demonstrate that the President's U.N. climate pledge is destructive to the American economy and would produce no substantive environmental benefits.

[The prepared statement of Chairman Smith follows:]

PREPARED STATEMENT OF CHAIRMAN LAMAR S. SMITH

Last June, the Obama Administration proposed sweeping new electricity regulations. Now, despite heavy and growing opposition to the proposal, the administration seeks to commit America to costly new requirements that won't improve the environment.

The president has promised the United Nations that the United States will cut its greenhouse gas emissions by as much as 28 percent over the next decade and by 80 percent or more by 2050. He is attempting to write large checks we simply cannot cash.

The pledge was made in preparation for a U.N. summit in Paris this December aimed at producing an international agreement that would impose legally binding requirements on the United States for the next decades.

But all of this activity—at home and abroad—disregards the concerns of the majority in Congress and many states. The president's attempt to justify his actions with an alarmist, one-sided focus on worstcase scenarios establishes a poor foundation for sound policy-making.

When President Obama took office, he had an opportunity to work with a Democrat controlled House and Senate to create climate legislation. But that effort failed because opposition to costly climate regulation crosses party lines.

Congress has repeatedly rejected the president's extreme climate agenda. So the administration instead has taken the unprecedented step of attempting to create laws on his own—and twist environmental regulations in ways Congress never intended.

Now the administration has packaged up all these regulations and promised their implementation to the U.N. But the president's "Power Plan" is nothing more than a power grab. Environmental laws can't trump the Constitution. They can't give the federal government the right to regulate the daily lives of citizens within their homes.

Regardless of what the president may try to claim, Congress has not given him or the Environmental Protection Agency the authority to re-write laws. Opposition to the president's agenda is widespread and continues to grow. At least 32 different states are openly opposed to the plan and many now consider the possibility of refusing to enact his edicts at all.

The majority of the members of the U.S. House of Representatives and the Senate are opposed. And numerous organizations that are concerned about the cost and reliability of America's electricity grid have issued dire warnings about the likely impacts of the president's plan. And the EPA's models show there will be no real climate benefits.

Whether that plan can stand up to legal scrutiny will take years to sort out. The legality of President Obama's unilateral action certainly will not be known when climate negotiators set out to create binding international rules in Paris later this year.

The president's far-reaching proposals and international promises will do lasting damage to our nation, all for little to no environmental benefit. In fact, the pledge to the U.N. is estimated to prevent only a 0.03 degrees C temperature rise. And in testimony before this Committee, former Assistant Secretary for Energy, The Honorable Charles McConnell, noted that the president's Clean Power Plan would reduce sea level rise by less than half the thickness of a dime.

Meanwhile, middle and lower income American families will be hit hardest as energy costs inevitably rise. The president's pledge to the U.N. hinges on a questionable and unclear plan. The commitment submitted two weeks ago lacks details about how we will achieve such goals without burdening our economy. And it fails to quantify the specific climate benefits tied to the promise.

Today is April 15th, Tax Day. It is a day that many Americans dread. As more Americans feel squeezed by rising costs, flat wages, and rising taxes, we should ask ourselves: can we really afford another extreme and expensive mandate?

We will never reach the president's arbitrary targets, which would increase electricity costs, ration energy and slow economic growth. Such severe measures will have no discernable impact on global temperatures. They will make the government bigger and Americans poorer.

I hope today's hearing will demonstrate that the president's U.N. climate pledge is destructive to the American economy and would produce no substantive environmental benefits.

Chairman SMITH. That concludes my opening statement, and the gentlewoman from Texas, the Ranking Member, Eddie Bernice Johnson, is recognized for hers.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and let me apologize early that at the completion of my opening statement, I will have to depart for another committee markup, but our subcommittee Ranking Member, Ms. Bonamici, will take over.

We are here this morning to discuss the carbon reduction target recently submitted by the Obama Administration to the United Nations. This target, which is known as the United States' Intended Nationally Determined Contribution, sets a goal of reducing carbon pollution across the nation by 26 to 28 percent below 2005 levels by the year 2025.

Before I get too far into my statement, I would like to point out the fact that my colleagues in the Majority failed to invite anyone from the Administration to testify at today's hearing. It seems to me that the Administration is likely the best source to fill in any details regarding the proposal or to address any questions or concerns that members of the Committee may have. Despite this omission, I am looking forward to hearing from today's witnesses, and I welcome you.

Some may say that the Administration's carbon reduction goal is unrealistic or unwarranted, that addressing climate change will cause irreparable harm to the Nation's economy or that it is based on unsettled science. I disagree with such sentiments. I think the target put forward by the President is justified. It appears to strike the right balance between ambition and achievability, and perhaps, most importantly, it a sends a strong and much-needed signal—I am so sorry; this is my allergy season—to the rest of the world about the seriousness of the United States in addressing the impacts of climate change. Such a position is critical to meaningful international engagement.

I have been clear in my position that the time to address climate change is now. The potential costs of inaction are too high for us to continue to drag our feet or put our heads in the sand. A sobering report from a nonpartisan and well-respected group of business and financial leaders, including Michael Bloomberg, Henry Paulson, and Tom Steyer, titled "Risky Business—The Economic Risks of Climate Change in the United States," highlights the significant costs climate change has exacted and will continue to exact on our economy. The report presents a long list of concerns, including rising seas, increased damage from storm surge, more frequent bouts of extreme heat, and shines a light on the cost of inaction to private businesses across the country.

However, the economic costs of inaction are not the whole story. There are also serious public health impacts associated with climate change. Greater risk of asthma attacks, heat stroke, food and waterborne as well as respiratory diseases are all consequences of a warming climate. I know that some still question whether climate change is happening or if humans have contributed significantly to the impacts currently being observed. I know such opinions will be expressed again today, but it seems to me that most of the world has moved beyond such debates and is instead focused on taking concrete steps to address the problem at hand.

We in Congress have to acknowledge that we are not the experts on the science, and that allowing partisan politics to distort the scientific understanding of climate change is cynical and shortsighted. We, as a nation, must act today to address climate change if we are to preserve our quality of life for our children and grandchildren, and some old people like me. The negative consequences of climate change are not abstract scientific predictions for the far-off future. We are facing some of these consequences now and they are affecting every American.

The President's Climate Change Action Plan and the goal submitted to the United Nations represent commonsense steps that will lead to a healthier environment, because acting on climate change is not only an environmental imperative, but a public health and economic one as well.

In closing, I would like to draw on a recent op-ed from Bob Inglis, a former member, a Republican member of this Committee with whom I served, and Jack Schlossberg, comparing the challenge of addressing climate change to the space race. They state: "Climate change is only scary if we chose to sit, wait, and do nothing about it. Climate change is a chance for all of us to add a chapter to the story of American triumph and human progress. Courage of this scale will come from a people who are told they can do great things by leaders who believe that their people are capable of great things. We believe America will see opportunity in the danger of climate change just like we saw benefits on Earth from travel in space."

I thank you, Mr. Chairman, and I yield back the balance of my time.

[The prepared statement of Ms. Johnson follows:]

STATEMENT SUBMITTED BY FULL COMMITTEE RANKING MEMBER
EDDIE BERNICE JOHNSON

Thank you, Mr. Chairman. We are here this morning to discuss the carbon reduction target recently submitted by the Obama Administration to the United Nations. This target, which is known as the United States' Intended Nationally Determined Contribution sets a goal of reducing carbon pollution across the nation by 26 to 28 percent below 2005 levels by the year 2025.

Before I get too far into my statement, I'd like to point out the fact that my colleagues in the Majority failed to invite anyone from the Administration to testify at today's hearing.

It seems to me that the Administration is likely the best source to fill in any details regarding the proposal or to address any questions or concerns Members of this Committee may have. Despite this omission, I'm looking forward to hearing from today's witnesses.

Some may say that the Administration's carbon reduction goal is unrealistic or unwarranted; that addressing climate change will cause irreparable harm to the nation's economy or that it is based on ″unsettled″ science. I disagree with such sentiments. I think the target put forward by the President is justified. It appears to strike the right balance between ambition and achievability.

And perhaps, most importantly, it a sends a strong and much needed signal to the rest of the world about the seriousness of the United States in addressing the impacts of climate change. Such a position is critical to meaningful international engagement.

I have been clear in my position that the time to address climate change is now. The potential costs of inaction are too high for us to continue to drag our feet or put our heads in the sand.A sobering report from a non-partisan and well-respected group of business and financial leaders, including Michael Bloomberg, Henry Paulson, and Tom Steyer, entitled, Risky Business—The Economic Risks of Climate Change in the United States, highlights the significant costs climate change has exacted and will continue to exact on our economy.

The report presents a long list of concerns, including rising seas, increased damage from storm surge, more frequent bouts of extreme heat, and shines a light on the cost of inaction to private businesses across the country.

However, the economic costs of inaction are not the whole story. There are also serious public health impacts associated with climate change. Greater risk of asthma attacks, heat stroke, food and waterborne as well as respiratory diseases are all consequences of a warming climate.

I know that some still question whether climate change is happening or if humans have contributed significantly to the impacts currently being observed.

I know such opinions will be expressed again today, but it seems to me that most of the world has moved beyond such debates and is instead focused on taking concrete steps to address the problem at hand.

We in Congress have to acknowledge that we are not the experts on the science, and that allowing partisan politics to distort the scientific understanding of climate change is cynical and short-sighted.

We, as a nation, must act today to address climate change if we are to preserve our quality of life for our children and grandchildren. The negative consequences of climate change are not abstract scientific predictions for the far-off future. We are facing some of these consequences now and they are affecting every American.

The President's Climate Action Plan and the goal submitted to the United Nations represent common-sense steps that will lead to a healthier environment, because acting on climate change is not only an environmental imperative, but a public health and economic one as well.

In closing, I'd like to draw on a recent op-ed from Bob Inglis, a former Republican Subcommittee Chairman of this Committee, and Jack Schlossberg comparing the challenge of addressing climate change to the space race. They state: "Climate change is only scary if we chose to sit, wait, and do nothing about it. Climate change is a chance for all of us to add a chapter to the story of American triumph and human progress. Courage of this scale will come from a people who are told they can do great things by leaders who believe that their people are capable of great things. We believe America will see opportunity in the danger of climate change just like we saw benefits on Earth from travel in space."

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

Chairman SMITH. Thank you, Ms. Johnson.

Our first witness is Dr. Judith Curry, Professor and former Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology, and President of Climate Forecast Applications Network. Dr. Curry performs extensive research that focuses on air and sea interactions, climate feedback processes associated with clouds and sea ice, and the climate dynamics of hurricanes. Dr. Curry also serves on the NASA Advisory Council Earth Science Subcommittee and the Department of Energy Biological and Environmental Research Advisory Committee. She recently served on the National Academy's Climate Research Committee, the Space Studies Board, and the NOAA Climate Working Group. Dr. Curry received her Ph.D. in atmospheric science from the University of Chicago.

Our next witness is Ms. Karen Harbert, President and CEO of the U.S. Chamber of Commerce's Institute for 21st Century Energy. Ms. Harbert leads efforts to build support for meaningful energy action through policy development, education and advocacy. Under her leadership, the Institute established the groundbreaking Index of Energy Security Risk and the International Index of Energy Security Risk, the first tools to quantify America's energy security on an annual basis. Before joining the Chamber, Ms. Harbert served as the Assistant Secretary for Policy and International Affairs at the Department of Energy. She was the Primary Policy Advisor to the Secretary of Energy and to the Department on domestic and international energy issues. She also served as Vice Chairman of the International Energy Agency, which advises its 28 member nations on energy policy issues and orchestrates international responses to energy supply disruptions. Ms. Harbert received her bachelor's degree in international policy studies and political science from Rice University.

Our third witness is Mr. Jake Schmidt, the Director of the International Program at the National Resources Defense Council. Mr. Schmidt has 14 years of experience in international climate policy with a focus on climate change, clean energy, biogems, and sustainable development in India, Latin America, Canada, and at the international level. He leads NRDC's policy development and advocacy on international climate change including through climate negotiations and direct work with key countries around the world. Mr. Schmidt holds a bachelor's degree in economics from Muhlenberg College and a master's degree in environmental policy with a certificate in ecological economics from the University of Maryland.

Our final witness is Dr. Margo Thorning, Senior Vice President and Chief Economist for the American Council for Capital Formation and Director of Research for its public policy think tank. She also serves as the Managing Director of the International Council for Capital Formation. Dr. Thorning is an internationally recognized expert on tax, environmental and competitiveness issues. Dr. Thorning has made presentations on the economic impact of climate change policy at forums in China, India, the European Union, and Russia. In addition, she recently made a presentation titled "Investing in Energy and Industrial Development: Challenges and Opportunities" at a U.N. Commission on Sustainable Development meeting. Prior to joining the American Council for Capital Formation, Dr. Thorning served at the Department of Energy, the Department of Commerce, and the Federal Trade Commission. Dr. Thorning received her bachelor's degree from Texas Christian University, her master's degree in economics from the University of Texas, and her Ph.D. in economics from the University of Georgia.

We welcome you all. You are clearly all experts, and it is just coincidental that two of you all have degrees from Texas universities, but that is nice to see.

Dr. Curry, we will begin with you.

TESTIMONY OF DR. JUDITH CURRY, PROFESSOR, SCHOOL OF EARTH AND ATMOSPHERIC SCIENCES, GEORGIA INSTITUTE OF TECHNOLOGY

Dr. CURRY. I would like to thank the Committee for the opportunity to present testimony this morning.

I am concerned that both the climate change problem and its solution have been vastly oversimplified. The central issue in the scientific debate on climate change is the extent to which the recent and future warming is caused by human-caused greenhouse gas emission versus natural climate variability associated with variations from the sun, volcanic eruptions, and large-scale ocean circulations.

Recent data and research supports the importance of natural climate variability and calls into question the conclusion that humans are the dominant cause of recent climate change. This includes the substantial slow-down in global warming since 1998, reduced estimates of the sensitivity of climate to carbon dioxide, and climate models that are predicting much more warming than has been observed so far in the 21st century.

While there are substantial uncertainties in our understanding of climate change, it is clear that humans are influencing climate in the direction of warming. However, this simple truth is essentially meaningless in itself in terms of alarm and does not mandate a particular policy response.

We have made some questionable choices in defining the problem of climate change and its solution. First, the definition of dangerous climate change is ambiguous, and hypothesized catastrophic tipping points are regarded as very or extremely unlikely in the 21st century. Efforts to link dangerous impacts of extreme weather events to human-caused warming are unsupported by evidence. Climate change is a wicked problem and ill-suited to a command-and-control solution. And finally, it has been estimated that the U.S. national commitments to the U.N. to reduce emission by 28 percent will prevent three hundredths of a degree Centigrade in warming by 2100. The inadequacies of current policies based on emissions reductions are leaving the real societal consequences of climate change and extreme weather events largely unaddressed, whether caused by humans or natural variability.

The wickedness of the climate change problem provides much scope for disagreement amongst reasonable and intelligent people. Effectively responding to the possible threats from a warmer climate is made very difficult by the deep uncertainties surrounding the risk both from the problem and the proposed solutions.

The articulation of a preferred policy option in the early 1990s by the United Nations has marginalized research on broader issues surrounding climate variability and change and has stifled the development of a broader range of policy options. We need to push the reset button in our deliberations about how we should respond to climate change.

As an example of alternative options, pragmatic solutions have been proposed based on efforts to accelerate energy innovation, build resilience to extreme weather, and pursue no-regrets pollution-reduction measures. Each of these measures has justifications independent of their benefits for climate mitigation and adaptation.

Robust policy options that can be justified by associated policy reasons, whether or not human-caused climate change is dangerous, avoids the hubris of pretending to know what will happen with the 21st century climate.

This concludes my testimony.

[The prepared statement of Dr. Curry follows:]

STATEMENT TO THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY OF THE UNITED STATES HOUSE OF REPRESENTATIVES

Hearing on "The President's U.N. Climate Pledge"

15 April 2015

Judith A. Curry
Georgia Institute of Technology
curryja@eas.gatech.edu

Major points:

Recent data and research supports the importance of natural climate variability and calls into question the conclusion that humans are the dominant cause of recent climate change:

- The hiatus in global warming since 1998
- Reduced estimates of the sensitivity of climate to carbon dioxide
- Climate models predict much more warming than has been observed in the early 21st century

We have made some questionable choices in defining the problem of climate change and its solution:

- The definition of 'dangerous' climate change is ambiguous, and hypothesized catastrophic tipping points are regarded as very or extremely unlikely in the 21st century.
- Efforts to link dangerous impacts of extreme weather events to human-caused warming are misleading and unsupported by evidence.
- Climate change is a 'wicked problem' and ill-suited to a 'command and control' solution
- It has been estimated that the U.S. INDC of 28% emissions reduction will prevent 0.03°C in warming by 2100.

The inadequacies of current policies based on the Precautionary Principle are leaving the real societal consequences of climate change and extreme weather events (whether caused by humans or natural variability) largely unaddressed:

- We should expand the frameworks for thinking about climate policy and provide policy makers with a wider choice of options in addressing the risks from climate change.
- Pragmatic solutions based on efforts to accelerate energy innovation, build resilience to extreme weather, and pursue no regrets pollution reduction measures have justifications independent of their benefits for climate mitigation and adaptation.

STATEMENT TO THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY OF THE UNITED STATES HOUSE OF REPRESENTATIVES

Hearing on "The President's U.N. Climate Pledge"

15 April 2015

Judith A. Curry
Georgia Institute of Technology
curryja@eas.gatech.edu

I thank the Chairman and the Committee for the opportunity to offer testimony today on 'The President's U.N. Climate Pledge.' I am Professor and former Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. As a climate scientist, I have devoted 30 years to conducting research on a variety of topics including climate feedback processes in the Arctic, the role of clouds and aerosols in the climate system, and the impact of climate change on the characteristics of tropical cyclones. As president of Climate Forecast Applications Network LLC, I have been working with decision makers on climate impact assessments, assessing and developing climate adaptation strategies, and developing subseasonal climate forecasting strategies to support adaptive management and tactical adaptation.

I am increasingly concerned that both the climate change problem and its solution have been vastly oversimplified.[1] My research on understanding the dynamics of uncertainty at the climate science-policy interface has led me to question whether these dynamics are operating in a manner that is healthy for either the science or the policy process.[2] As a result, I am concerned that the U.S. Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) will do essentially nothing to change the climate, and the U.S. and other nations will remain vulnerable to climate surprises and extreme weather events.

My testimony focuses on the following issues of central relevance to the U.S. INDP:

- Weakening case for dangerous human-caused climate change
- The climate change response challenge
- Expanding the policy options for responding to climate change

A weakening case for dangerous anthropogenic climate change

Scientists agree that surface temperatures have increased since 1880, humans are adding carbon dioxide to the atmosphere, and carbon dioxide and other greenhouse gases have a warming effect on the planet. However there is considerable disagreement about the most consequential issues:

- Whether the warming since 1950 has been dominated by human causes
- How much the planet will warm in the 21st century
- Whether warming is 'dangerous'

The central issue in the climate change debate is the extent to which the recent (and future) warming is caused by human-caused greenhouse gas emissions versus natural climate variability – variations from

[1] Curry, JA and Webster PJ 2011: Climate science and the uncertainty monster. *Bull Amer Meteorol. Soc.*, 92, 1667-1682. http://journals.ametsoc.org/doi/pdf/10.1175/2011BAMS3139.1

[2] Judith Curry, Statement to the Subcommittee on Environment of the U.S. House of Representatives Hearing on Policy Relevant Climate Science in Context, 25 April 2013. https://curryja.files.wordpress.com/2013/04/curry-testimony-2013-il.pdf

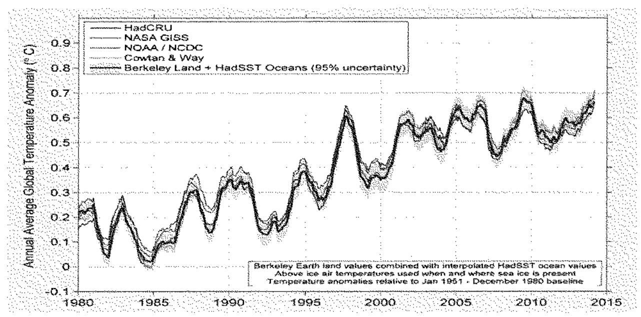
the sun, volcanic eruptions, and large-scale ocean circulations. My 2014 testimony before the Senate Environmental and Public Works Committee[3] argued that the 2013 report from the Intergovermental Panel on Climate Change (IPCC AR5 WG I)[4] weakened the case for dangerous anthropogenic climate change relative to the IPCC AR4 published in 2007. A summary is presented here of recent data and research that supports the importance of natural climate variability and calls into question the IPCC's conclusion that humans are the dominant cause of recent climate change. The policy relevance of this issue is that if humans are not the dominant cause of climate change, then attempts to modify the climate through reducing greenhouse gas emissions will have little impact on future climate change.

Hiatus in global warming

The IPCC AR5 notes a slowdown in surface warming since 1998:

> "[T]he rate of warming over the past 15 years (1998–2012) [is] 0.05 [–0.05 to +0.15] °C per decade which is smaller than the rate calculated since 1951 [of] 0.12 [0.08 to 0.14] °C per decade."

This figure shows the recent global temperatures through 2014 from several different global data sets[5]:



The media touted 2014 as the 'warmest year' in the historical record; however, given the uncertainties in the analyses, 2014 was in a statistical tie with 2010 and 2005. The UK dataset HadCRU, with perhaps a more realistic assessment of uncertainties, found 2014 to rank among the top 10 warmest years, all of which are since 1998. While the recent decade is the warmest in history, the ties for warmest year further reflect a plateau in the warming.

So we have no significant temperature increase since 1998, which has been a period with 25% of the total human CO_2 emissions. This hiatus in warming is at odds with the 2007 IPCC AR4 report, which expected warming to increase at a rate of 0.2 °C per decade in the early 21st century.

Numerous recent research papers have highlighted the importance of natural variability associated with circulations in the Atlantic and Pacific Oceans, which is now believed to be the dominant cause of the hiatus. If the recent warming hiatus is caused by natural variability, then this raises the question as to what extent the warming between 1975 and 1998 can also be explained by natural climate variability.

---

[3] Judith Curry, Statement to the Senate Committee on Environment and Public Works 25 April 2014 http://www.epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=07472bb4-3eeb-42da-a49d-964165860275

[4] IPCC reports can be obtained at http://www.ipcc.ch

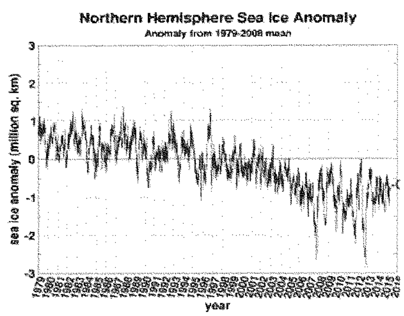
[5] Figure courtesy of Robert Rohde of the Berkeley Earth Surface Temperature team

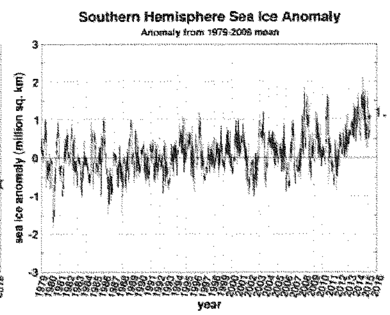
Sea ice

The IPCC AR5 acknowledges the strong role of natural variability in determining sea ice variability and change on multidecadal time scales. Nevertheless, the IPCC AR5 concluded:

- "[I]t is *very likely* that the Arctic sea ice cover will continue to shrink and thin all year round during the 21st century. It is also *likely* that the Arctic Ocean will become nearly ice-free in September before the middle of the century (*medium confidence*)."

Below are satellite observations of sea ice variability through 2014.[6]





In 2013 and 2014, Arctic sea ice recovered from its summertime minima during the period 2007-2012. Notably, Arctic sea ice volume (a metric that combines both horizontal extent and ice thickness) shows a continuing increase since 2012[7]. During 2014, Antarctic sea ice set a wintertime maximum record.

A recent paper by Swart et al.[8] emphasized that internal climate variability can mask or enhance human-induced sea-ice loss on timescales ranging from years to decades or even a century. A new paper by Zhang[9] clarifies the natural fluctuations that influence Arctic sea ice loss – heat transported by the Atlantic and Pacific, and wind patterns over the Arctic that drive sea ice out from the central Arctic, where it melts in the North Atlantic. In particular, the recent cooling in the high latitudes of the North Atlantic is associated with the current recovery of the sea ice in the Atlantic sector.

Clearly, there is a lot going on with respect to variability in Arctic and Antarctic sea ice that cannot be explained directly or even indirectly by warming from human-caused greenhouse gases. Climate models do not simulate correctly the ocean heat transport and its variations. Scientists do not agree on the explanation for the increasing Antarctic sea ice extent, and the key issue as to whether human-caused warming is the dominant cause of the recent Arctic sea ice loss remains unresolved.

---

[6] http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/seaice.anomaly.arctic.png
http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/seaice.anomaly.antarctic.png

[7] http://psc.apl.washington.edu/wordpress/wpcontent/uploads/schweiger/ice_volume/BPIOMASIceVolumeAnomalyCurrentV2.1.png

[8] Swart et al 2015 Influence of internal variability on Arctic sea-ice trends, *Nature climate Change*, 5, Pages: 86–89 DOI: doi:10.1038/nclimate2483

[9] Zhang, R. 2015. Mechanisms for low-frequency variability of summer Arctic sea ice extent, *Proceedings of the National Academy of Sciences*, doi:10.1073/pnas.1422296112

Sensitivity

Human-caused warming depends not only on increases in greenhouse gases but also on how 'sensitive' the climate is to these increases. Climate sensitivity is defined as the global surface warming that occurs when the concentration of carbon dioxide in the atmosphere doubles. If climate sensitivity is high, then we can expect substantial warming in the coming century as emissions continue to increase. If climate sensitivity is low, then future warming will be substantially lower.

The most relevant definition of climate sensitivity is the actual change of surface temperature in 70 years if carbon-dioxide concentrations double, called the 'transient climate response'. The IPCC AR4 (2007) concluded that the transient climate response is *very likely* larger than 1°C and *very unlikely* greater than 3°C. The IPCC AR5 (2013) concluded that the transient climate response is *likely* [17-83%] in the range of 1 to 2.5°C.

Last year, Nicholas Lewis and I published a paper[10] that found transient climate response to have a *likely* range of 1.05-1.80°C. Using an observation-based energy balance approach, our calculations used the same data for the effects on the Earth's energy balance of changes in greenhouse gases, aerosols and other drivers of climate change given by the IPCC AR5. Our range for the transient climate response is much narrower, with far lower upper limits, than reported by the IPCC AR5.

Recent research suggests even lower values of the transient climate response. The greatest uncertainty in these estimates is accounting for the effects of small aerosol particles in the atmosphere, which have a cooling effect on the climate (partially counteracting the greenhouse warming). A new paper by Stevens[11] constrains the impact of aerosols on climate to be significantly smaller than assumed in the AR5. Nicholas Lewis has re-run the calculations using aerosol impact estimates in line with this paper. The *likely* range for the transient climate response is 1.05 to 1.45°C. By contrast, most climate model estimates of transient climate response are higher than 1.8°C. Research continues to assess the methods used to estimate climate sensitivity. However, the reduced estimates of aerosol cooling lead inescapably to reductions in the estimated upper bound of climate sensitivity.

Are climate models running too 'hot'?

These new climate sensitivity estimates, combined with the slowdown or 'hiatus' in global warming since 1998, add to the growing evidence that climate models are running too 'hot.'

The near-term temperature projections of the climate models are shown below, compared with observations of global temperatures through 2014.[12] The observed global temperatures, particularly since 2011, are below or just at the bottom bound of the 5-95% envelope of the CMIP5 climate model simulations. Overall, the trend in the model simulations is substantially larger than the observed trend over the past 15 years.

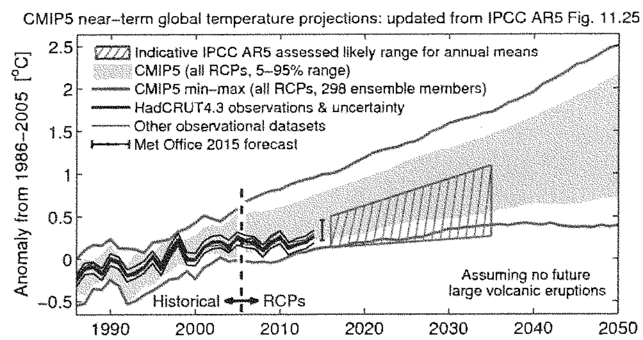
Note the hatched red area, this seems to be a concession to the hiatus. The IPCC cites 'expert judgment' as the rationale for lowering the projections (indicated by the red hatching), to account for the apparent oversensitivity of the models.

---

[10] Lewis, N. and J.A. Curry, (2014) The implications for climate sensitivity of AR5 forcing and heat uptake. *Climate Dynamics* http://link.springer.com/article/10.1007%2Fs00382-014-2342-y#page-1

[11] Stevens, B (2015) Rethinking the lower bound on aerosol forcing. *J. Climate*, http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-14-00656.1

[12] A revised version of Figure 11.25 from the AR5 WG1 Report is given by Ed Hawkins at http://www.climate-lab-book.ac.uk/comparing-cmip5-observations/



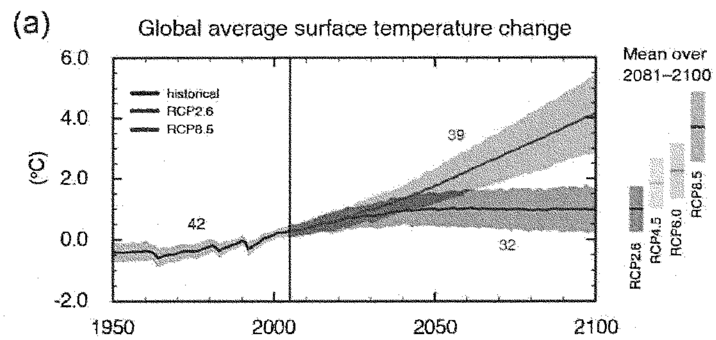
Based upon climate model projections, the probability of the hiatus extending beyond 20 years is vanishing small. The warming hiatus, combined with assessments that the climate-model sensitivities are too high, raises serious questions as to whether the climate-model projections of 21st century temperatures are fit for supporting public policy decisions:

- Are climate models too sensitive to greenhouse forcing?
- Is modeled treatment of natural climate variability inadequate?
- Are model projections of 21st century warming too high?

Whither the 21st century climate?

The issue of greatest concern is how the climate will evolve during the 21st century. There are two different views on this.

The first perspective is that of the IPCC, which projects continued warming through the 21st century, and is expected to surpass the 'dangerous' threshold of 2°C warming as early as 2040. The figure below, from the IPCC AR5 Summary for Policy Makers, shows climate model projections of 21st century warming, with RCP8.5 reflecting 'business as usual' emissions of greenhouse gases.



The other perspective emphasizes natural variability:

- Our understanding of circulation regimes in the Atlantic and Pacific Oceans (stadium wave hypothesis)[13] suggests that the 'hiatus' will continue at least another decade, perhaps into the 2030's. Arctic sea ice will recover over the next two decades.
- Climate models are too sensitive to human forcing; 21st century warming will be on the low end of IPCC projections (or even below).
- Solar variations and volcanic eruptions are a wild card. Russian scientists[14] argue that there was a Grand Solar Maximum that peaked in the late 20th century, and that we can expect a Grand Solar Minima (contributing to cooling) to peak around 2060.
- And finally, we can't rule out unforeseen surprises. The hiatus in warming in the early 21st century was an unforeseen surprise.

Time will tell which of these two perspectives is correct.

Summary

Anthropogenic climate change is a theory in which the basic mechanism is well understood, but the potential magnitude is highly uncertain. We know that the climate changes naturally on decadal to century time scales, but we do not have explanations for a number of observed historical and paleo- climate variations, including the warming from 1910-1940, the mid-20th century cooling and the 21st century hiatus in warming. Disagreement regarding climate change arises from our recognized uncertainty regarding natural climate variability.

Climate model projections of the 21st century climate are losing credibility because of:

- Failure to predict the early 21st century hiatus in surface warming
- Inability to simulate the patterns and timing on multidecadal ocean oscillations
- Lack of account for future solar variations and solar indirect effects on climate
- Apparent oversensitivity to increases in greenhouse gases

So, how will the 21st century climate evolve? Apart from lack of confidence in climate model projections that focus primarily on the impact of increases in greenhouse gases, we don't have sufficient understanding to project solar variations, future volcanic eruptions and decadal to century variations in deep ocean circulations. We can't rule out a continuation of the warming hiatus, or even cooling during parts of the 21st century. How solar variations, volcanic eruptions, ocean circulations and human influences will interact to determine the evolution of the 21st century climate is not known with any confidence, and scientists disagree as to which of these factors will dominate.

The climate change response challenge

Claims that the earth has been warming, that there is a greenhouse effect, and that man's activities have contributed to warming, are trivially true, but they are essentially meaningless by themselves in terms of alarm. These truths also do not mandate a specific policy response.

---

[13] Wyatt, MG and JA Curry, 2013: Role for Eurasian Arctic shelf sea ice in a secularly varying hemispheric climate signal during the 20th century. *Climate Dynamics*, http://curryja.files.wordpress.com/2013/10/stadium-wave1.pdf

[14] Abdussamatov, H 2013: Current long-term negative energy balance of the earth leads to the new little ice age. *Journal of Geology and Geophysics* http://omicsgroup.org/journals/grand-minimum-of-the-total-solar-irradiance-leads-to-the-little-ice-age-2329-6755.1000113.pdf

Is climate change dangerous?

Central to responding to climate change is this question: Is warming 'dangerous'? The UN Framework Convention on Climate Change (UNFCCC) international environmental treaty (1992) states as its objective:[15] "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent ***dangerous*** anthropogenic interference with the climate system."

The IPCC 3rd and 4th Assessment reports refer to 'reasons for concern.' It wasn't until 2010 that some clarification of 'dangerous' was provided by UN international negotiators:[16] "In 2010, governments agreed that emissions need to be reduced so that global temperature increases are limited to below 2 degrees Celsius." The target of 2°C remains the focal point of international agreements and negotiations, although this definition remains controversial and is being challenged.

The original rationale for the 2°C target is the idea that 'tipping points' - abrupt or nonlinear transition to a different state - become likely to occur once this threshold has been crossed, with consequences that are largely uncontrollable and beyond our management. The IPCC AR5 considered a number of potential tipping points, including ice sheet collapse, collapse of the Atlantic overturning circulation, and permafrost carbon release. Every single catastrophic scenario considered by the IPCC (Table 12.4) has a rating of *very unlikely* or *exceptionally unlikely* and/or has *low confidence*. The only tipping point that the IPCC considers *likely* in the 21st century is disappearance of Arctic summer sea ice (which reforms each winter, in any event).

In the absence of tipping points on the timescale of the 21st century, the 2°C limit is more usefully considered by analogy to a highway speed limit:[17] driving at 10 mph under the speed limit is not automatically safe, and exceeding the limit by 10 mph is not automatically dangerous, although the faster one travels the greater the danger from an accident. Analogously, the 2°C limit should not be taken literally as a real danger threshold.

Nevertheless, the 2°C limit is used politically to motivate the urgency of action to reduce CO_2 emissions. At a recent UN Climate Summit, Secretary-General Ban Ki-moon warned that: "Without significant cuts in emissions by all countries, and in key sectors, the window of opportunity to stay within less than 2 degrees [of warming] will soon close forever."[18] Actually, this window of opportunity may remain open for quite some time. The implications of the lower values of climate sensitivity found by Lewis and Curry and other recent studies is that human-caused warming is not expected to exceed the 2°C 'danger' level in the 21st century. A slower rate of warming means there is less urgency to phase out greenhouse gas emissions now, and more time to find ways to decarbonize the economy affordably. It also allows us the flexibility to revise our policies as further information becomes available.

Is it possible that something really dangerous and unforeseen could happen to Earth's climate during the 21st century? Yes it is possible, but natural climate variability (perhaps in conjunction with human-caused climate change) may be a more likely source of possible undesirable change than human causes. In any event, attempting to avoid such a dangerous and unforeseen climate by reducing fossil fuel emissions will be futile if natural climate is a dominant factor.

---

15 http://unfccc.int/essential_background/convention/items/6036.php
16 http://unfccc.int/essential_background/items/6031.php
17 http://www.carbonbrief.org/blog/2014/12/two-degrees-a-selected-history-of-climate-change-speed-limit/
18 http://newsroom.unfccc.int/unfccc-newsroom/un-climate-summit-ban-ki-moon-final-summary/

Biased information cascades

Climate change may exacerbate environmental problems that are caused by overpopulation, poorly planned land-use and over-exploitation of natural resources. However, it is very difficult to separate out the impacts of human caused climate change from natural climate change and from other societal impacts. Nevertheless, climate change has become a grand narrative in which human-caused climate change has become a dominant cause of societal problems.[19] Everything that goes wrong, and even pre-existing concerns, reinforces the conviction that that there is only one thing we can do prevent societal problems – stop burning fossil fuels. This grand narrative misleads us to think that if we solve the problem of climate change, then these other problems would be ameliorated.

Politicians, activists and journalists have stimulated a biased information cascade of alarm about human-caused climate change to support a political agenda of reducing fossil fuel emissions. An information cascade is a self-reinforcing process of collective belief formation that triggers a self-perpetuating chain reaction as a band wagon or snowballing process: the more attention a danger gets, the more worried people become, leading to more news coverage and greater alarm. Because slowly increasing temperatures don't seem alarming, the cascade facilitators push extreme weather events and public health impacts as being caused by human-caused climate change, more of which is in store if we don't quickly act to cool the planet by reducing fossil fuel emissions.

A deconstruction of this information cascade is needed to avoid bias in our thinking and to better understand the true risks of human caused climate change:

- The basis for this cascade originates from the 1992 UNFCCC treaty, to avoid dangerous human caused climate change through stabilization of CO_2 emissions. Note, it was not until 1995 that the IPCC 2nd Assessment Report identified a 'discernible' human influence on global climate. The policy 'cart' was clearly leading the scientific 'horse.'
- Then, the UNFCCC changed the definition of climate change to refer to a change of climate that is attributed directly or indirectly to human activity. This leads to the perception that all climate change is caused by humans.
- Sea level rise and extreme weather events such as hurricanes, drought and heat waves are attributed to climate change, which is assumed *de facto* to be caused by humans.
- Human health impacts, national security risks, etc. that are exacerbated by extreme weather events are then fallaciously inferred to be caused by human-cansed climate change.

A critical link in this cascade is the link between human-caused climate change and extreme weather. In 2012, the IPCC published a *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX).[20] The Report found low to medium confidence of a trend in droughts in some regions and the frequency of heavy rains in some regions, and high confidence of a trend in heat waves in Australia. There is no trend in hurricanes or wild fires. Attribution of any trend in extreme weather events to human cansed climate change cannot be done with any confidence. With regards to the perception (and damage statistics) that severe weather events seem more frequent and more severe over the past decade, there are several factors in play. The first is the increasing vulnerability and exposure associated with increasing concentration of wealth in coastal and other disaster-prone regions. The second factor is natural climate variability. Many extreme weather events have documented relationships with natural climate variability; in the U.S., extreme weather events (e.g. droughts, heat waves and hurricanes) were significantly worse in the 1930's and 1950's.[21]

---

[19] Korhola, E-R 2015 Climate change as a political process https://helda.helsinki.fi/bitstream/handle/10138/136507/Therisea.pdf?sequence=1

[20] IPCC SREX http://www.ipcc-wg2.gov/SREX/

[21] Curry, JA 2014 Senate EPW testimony http://judithcurry.com/2014/01/16/senate-epw-hearing-on-the-presidents-climate-action-plan/

The information cascade of climate change as apocalypse is impeding our ability to think rationally about how we should respond to climate change, and acts to narrow the viewpoints and policy options that we are willing to consider in dealing with complex issues such as public health, weather disasters and national security. Should we be surprised when reducing CO_2 emissions does not ameliorate any of these problems?

Wrong trousers: climate change as a wicked problem

In the decades since the UNFCCC Treaty and the Kyoto Protocol, global emissions have continued to increase, especially in developing countries. UN Climate Conferences have not produced a new treaty in this framework. Opposition to a new treaty arises from concerns over economic costs and the need to ameliorate energy poverty in less developed countries. A key issue in the climate policy debate is whether the proposed 'cure' (i.e. CO_2 emissions reduction and associated economic hardships) is worse than the 'disease' (i.e. warmer temperatures).

In their Wrong Trousers essay,[22] Prins and Rayner argue that we have made the wrong cognitive choices in our attempts to define the problem of climate change and its solution, by relying on strategies that worked previously for 'tame' problems. A tame problem is well defined, well understood, and the appropriate solutions are agreed upon. Cost-benefit analyses and mitigation techniques are appropriate for tame problems, and the potential harm from miscalculation is bounded.

By contrast, climate change is better characterized as a 'wicked' problem, which is a complex tangle characterized by multiple problem definitions, the methods of understanding are open to contention, and 'unknown unknowns' suggest chronic conditions of ignorance and lack of capacity to imagine future eventualities of both the problem and the proposed solutions. The complex web of causality may result in surprising unintended consequences to attempted solutions that generate new vulnerabilities or exacerbate the original harm. Further, the wickedness of the climate change problem makes if difficult to identify points of irrefutable failure in either the science or the policies.

As another pair of 'wrong trousers,' the enshrinement of the Precautionary Principle into the UNFCCC Treaty represents a mismatch between the problem and the proposed solution. The Precautionary Principle works fine for tame problems, but introduces many potentially undesirable consequences when applied to a wicked problem. The Precautionary Principle enjoins us to do our utmost to avoid the possibility of catastrophe or ruin, and is arguably a decisive consideration for ruin problems.[23] However, arguments that we face the possibility of ruin in the 21st century from climate change are very weak and not supported by the evidence that we have.

Overreaction to a possible catastrophic threat may cause more harm than benefits and introduce new systemic risks, which are difficult to foresee for a wicked problem. The known risks to human well-being associated with constraining fossil fuels may be worse than the eventual risks from climate change, and there are undoubtedly some risks that we currently don't foresee.

The wickedness of the climate change problem is further manifested in the regional variability of the risks. Balancing the risks of climate change and the policy response is very difficult across different regions and countries that face varying risks from climate change, energy poverty and threats to economic development. Some regions may actually benefit from a warmer climate. Regional perceptions of a preferred climate or 'dangerous' climate change depend on societal values and vulnerability/resilience, which vary regionally and culturally. Climate has always changed, independently of human activity, so

[22] Prins and Rayner, 2007. The wrong trousers: radically rethinking climate policy http://eureka.bodleian.ox.ac.uk/66/

[23] Taleb, N et al. 2014: The precautionary principle. Extreme Risk Initiative NYU http://arxiv.org/pdf/1410.5787.pdf

climate change is nothing new; there is no *prima facie* reason for thinking the climate of the past or present is better than the future. Further, our current preferences for avoiding a particular climate of the future fail to account for human creativity and ingenuity in creating new technologies and social and political structures that will condition our perceptions and the consequences of climate change.

Expanding the policy options for responding to climate change

There is reason to be concerned about climate change, and humans are influencing climate in the direction of warming. However, effectively responding to the possible threats from a warmer climate is made very difficult by the deep uncertainties surrounding the risks both from the problem and the proposed solutions. The climate change problem is characterized by deep uncertainties in the trajectory of 21st century climate change, long timescales of the risk over which there is much uncertainty about societal vulnerabilities and capacities to respond, and disagreement among experts regarding the efficacy of different strategies and the value of alternative outcomes.

The complexity and wickedness of the climate change problem argues against a 'command and control' solntion based on some guessed-at optimal policy. Attempting to deal with a wicked problem using strategies designed for tame problems can result in a 'cure' that is worse than the original 'disease.' Arguably the biggest problem with climate policy has been an overly narrow set of narratives and policy options. Expanding the frameworks for thinking about climate policy and its relation to other societal problems can lead to developing a range of more tractable policy options that would provide policy makers with a wider choice of options in addressing the risks from climate change.

Precautionary Principle – more sorry than safe?

The UNFCCC has formulated the climate change problem and solution as irreducibly global in context of the Precautionary Principle, with the solution focused on global reductions of greenhouse gas emissions.

Individual countries are submitting to the UNFCCC their INDCs. The U.S. INDC has a goal of reducing emissions by 28% below 2005 levels by 2025. Apart from considerations of feasibility and cost, it has been estimated[24] using the EPA MAGICC model that this commitment will prevent 0.03°C in warming by 2100. When combined with commitments from other nations, only a small fraction of the projected future warming will be ameliorated by these commitments. If climate models are indeed running too hot, then the amount of warming prevented would be even smaller. Even if emissions immediately went to zero and the projections of climate models are to be believed, the impact on the climate would not be noticeable until the 2nd half of the 21st century. It is not clear exactly what the INDC commitments are expected to accomplish.

The UNFCCC policies and the Precautionary Principle have brought us to a point between a rock and hard place, whereby the proposed policy with its extensive costs and questions of feasibility are inadequate for making a meaningful dent in slowing down the expected warming. And the real societal consequences of climate change and extreme weather events (whether caused by humans or natural variability) remain largely unaddressed.

Given that the policies proposed under the imprimatur of the Precautionary Principe are very costly, politically contentious and would not change the climate in any meaningful way, we should consider other decision making frameworks and risk management approaches for addressing climate change.

---

[24] http://www.cato.org/blog/002degc-temperature-rise-averted-vital-number-missing-epas-numbers-fact-sheet

Decision making strategies under deep uncertainty

Rather than negotiating an optimal policy based on a negotiated scientific consensus, robust and flexible policy strategies can be designed that account for uncertainty, ignorance and dissent. Robust strategies formally consider uncertainty, whereby decision makers seek to reduce the range of possible scenarios over which the strategy performs poorly. Flexible strategies are adaptive, and can be quickly adjusted to advancing scientific insights and new conditions that arise.

Under conditions of deep uncertainty, the following options are available to frame decision making:[25]

- Do nothing, or delay in order to gather more information
- Enlarge the knowledge base for decisions through broader perspectives
- Invoke the Precautionary Principle
- Adaptive management
- Build a resilient and anti-fragile society

Each of these strategies incorporates information about uncertainty into the decision making process, albeit in different ways. The politics surrounding the climate policy debate is framed as a choice between delaying a policy response until uncertainties are reduced versus invoking the Precautionary Principle aimed at emission stabilization targets determined largely by climate models.

The other decision framework options are receiving increasing attention, and justification for addressing the climate change problem are transitioning away from precaution to a risk management approach justified by the economics of preventing losses from climate change. The World Bank has a recent paper entitled *Investment decision making under deep uncertainty – application to climate change*[26] that summarizes existing decision-making methodologies that are able to deal with the deep uncertainty associated with climate change: cost-benefit analysis under uncertainty, cost-benefit analysis with real options, robust decision making, and Climate Informed Decision Analysis.

As an alternative to the Precautionary Principle, The Breakthrough Institute has proposed Climate Pragmatism,[27] a pluralistic approach based on innovation, resilience and no regrets. This pragmatic strategy centers on efforts to accelerate energy innovation, build resilience to extreme weather, and pursue no regrets pollution reduction measures. Each of these three efforts has justifications independent of their benefits for climate mitigation and adaptation. Further, this framework does not depend on any agreement about climate science or the risks posed by uncontrolled greenhouse gases.

Resilience and anti-fragility

The threats from climate change (whether natural or human caused) are fundamentally regional, associated not only with regional changes to the weather/climate, but with local vulnerabilities and cultural values and perceptions. In the least developed countries, energy poverty and survivability is of overwhelming concern, where there are severe challenges to meeting basic needs and their idea of clean green energy is something other than burning dung inside their dwelling for cooking and heating. In many less developed countries, particularly in South Asia, an overwhelming concern is vulnerability to extreme weather events such as floods and hurricanes that can set back the local economics for a generation. In the developed world, countries are less vulnerable to climate change and extreme weather events and have the

---

[25] Bammer, G and M Smithson 2008: *Uncertainty and Risk: Multidisciplinary Perspectives*. Taylor & Francis, 382 pp.
[26] http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-6193
[27] http://thebreakthrough.org/blog/Climate_Pragmatism_web.pdf

luxury of experimenting with new ideas: entrepreneurs want not only to make money but also to strive for greatness and transform the infrastructure for society.

Resilience is the ability to 'bounce back' from unexpected shocks. The difference in impact and recovery from Hurricane Sandy striking New York City in 2012 versus the impact of Tropical Cyclone Nargis striking Myanmar in 2008[28] reflects very different vulnerabilities and capacities for bouncing back. Nassim Taleb's concept of antifragility,[29] whereby you learn and grow from adversity. suggests strategies of economic development, reducing the downside from volatility, developing a range of options, tinkering with small experiments, and developing and testing transformative ideas.

A regional focus on addressing the risks of climate change allows for a range of bottom-up strategies to be integrated with other societal challenges, including overpopulation, environmental degradation, poorly planned land-use and over-exploitation of natural resources. Some of these problems can be carved out as tame problems, where everyone can agree on both the problem and the solution, in the context of traditional risk management approaches. And near-term benefits to the region can be realized in terms of reduced vulnerability to a broad range of threats, improved resource management, and improved environmental quality.

A focus on policies that support resilience and anti-fragility avoids the uncertainties of attributing climate change to humans versus nature and avoids the hubris of thinking we know what the future climate holds. The questions then become 'How much resilience can we afford?' and 'How can we best promote the development of transformative ideas and technologies?'

Conclusion

There is reason to be concerned about climate change. However, effectively responding to the possible threats from a warmer climate is made very difficult by the deep uncertainties surrounding the risks both from the problem and the proposed solutions. Uncertainty is a two edged sword; future climate outcomes might be better or worse than currently believed. However, recent research has sharpened the blade of the sword in the direction of less impact from human-caused climate change and greater political and economic infeasibility of meaningful reductions in CO_2 emissions.

Therefore, I am concerned that the proposed U.S. INDC to address the perceived problems of climate change will do essentially nothing to change the climate, and the U.S. and other nations will remain vulnerable to climate surprises and extreme weather events.

The framing of the climate change problem by the UNFCCC/IPCC and the early articulation of a preferred policy option has marginalized research on broader issues surrounding climate variability and change and stifled the development of a broader range of policy options.

The wickedness of the climate change problem provides much scope for disagreement among reasonable and intelligent people. Arguably the biggest problem with climate policy has been an overly narrow set of narratives and policy options. Expanding the frameworks for thinking about climate policy and its relation to other societal problems can lead to developing a range of more tractable policy options that would provide policy makers with a wider choice of options in addressing the risks from climate change.

[28] Webster, PJ 2008 Myanmar's Deadly Daffodil. *Nature Geoscience*, http://webster.eas.gatech.edu/Papers/Webster2008c.pdf
[29] Taleb, N 2012 *Antifragile: Things That Gain From Disorder*. Random House.

Short Biography

Judith Curry
Professor, School of Earth and Atmospheric Sciences
Georgia Institute of Technology
Atlanta, GA 30332-0349
curryja@eas.gatech.edu

Dr. Judith Curry is Professor and former Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology and President of Climate Forecast Applications Network (CFAN). Dr. Curry received a Ph.D. in atmospheric science from the University of Chicago in 1982. Prior to joining the faculty at Georgia Tech, she held faculty positions at the University of Colorado, Penn State University and Purdue University. Dr. Curry's research interests span a variety of topics in climate; current interests include air/sea interactions, climate feedback processes associated with clouds and sea ice, and the climate dynamics of hurricanes. She is a prominent public spokesperson on issues associated with the integrity of climate science, and is proprietor the weblog Climate Etc. judithcurry.com. Dr. Curry has recently served on the NASA Advisory Council Earth Science Subcommittee, the DOE Biological and Environmental Research Advisory Committee, and the National Academies Climate Research Committee and the Space Studies Board and the NOAA Climate Working Group. Dr. Curry is a Fellow of the American Meteorological Society, the American Association for the Advancement of Science, and the American Geophysical Union.

Financial declaration

Funding sources for Curry's research have included NSF, NASA, NOAA, DOD and DOE. Recent contracts for CFAN include a DOE contract to develop extended range regional wind power forecasts and a DOD contract to predict extreme events associated with climate variability/change having implications for regional stability. CFAN contracts with private sector and other non-governmental organizations include energy and power companies, reinsurance companies, other weather service providers, the Natural Resource Defense Council and the World Bank. Specifically with regards to the energy and power companies, these contracts are for medium-range (days to weeks) forecasts of hurricane activity and landfall impacts. CFAN has one contract with an energy company that also includes medium-range forecasts of energy demand (temperature), hydropower generation, and wind power generation. CFAN has not received any funds from energy companies related to climate change or any topic related to this testimony.

.
For more information:

http://curry.eas.gatech.edu/
http://www.cfanclimate.com/
http://judithcurry.com/about/

Chairman SMITH. Thank you, Dr. Curry, and Ms. Harbert.

TESTIMONY OF THE HONORABLE KAREN HARBERT, PRESIDENT AND CEO, INSTITUTE FOR 21ST CENTURY ENERGY, U.S. CHAMBER OF COMMERCE; FORMER ASSISTANT SECRETARY FOR POLICY AND INTERNATIONAL AFFAIRS, U.S. DEPARTMENT OF ENERGY

Hon. HARBERT. Thank you, Chairman Smith and the Ranking Members of the Committee. I want to make four points today regarding the Obama Administration's Intended Nationally Determined Contribution to the UNFCC.

First, the U.N.—the U.S. INDC lacks basic information to allow a rigorous assessment of the goal. The commitment is long on promises but short on data needed for a proper assessment. Nowhere does it explain how the Administration intends to get to its 26 to 28 percent reduction target. The Administration's math just doesn't add up. We estimate that the announced and forthcoming regulations out of EPA including EPA's Clean Power Plan still leave between 500 and 600 million tons or more of the Administration's commitment still unaccounted for, and without a sector-by-sector breakdown, we just don't know how the Administration expects to achieve its target.

Indeed, yesterday EPA Air Administrator McCabe acknowledged in House testimony that they have yet to do a comprehensive modeling of all of the regulations that constitute this proposal, and surprisingly, nowhere in the INDC is there any reference to industrial emission. It is hard to imagine getting there without addressing the industrial sector. EPA's current budget proposal notes the Agency will soon begin considering new regulations on the refining, pulp and paper sector, iron and steel sector, livestock, and cement sectors, so there is more to come.

It is also difficult to see how this plan can be sold to the international community, especially given the uncertain legal foundation upon which it rests. In its Utility Air Regulatory Group v. EPA ruling, the Supreme Court warned EPA against using "unheralded power to regulate a significant portion of the American economy." This certainly constitutes a significant portion of the American economy. Thirty-two states have now raised legal objections to it, and the first case will appear before the Supreme Court tomorrow, and EPA Air Administrator McCabe said yesterday they do expect litigation to last for years.

Secondly, the commitments are hugely unequal. If the world is serious about reducing greenhouse gas emissions, then developing countries will have to take on huge commitments. However, indications are that that is not happening. China provides a very useful example. It has pledged to peak its carbon emission around 2030 and to increase its share of non-fossil-fuel consumption to around 20 percent is business as usual. In fact, in the International Energy Agency's most recent outlook, which was released before China and the United States made this announcement, it actually models the Chinese proposals and policies currently in place and comes to the same conclusion, which is, they will peak just around 2030. This is nothing new. ExxonMobil's forecast confirms the same.

To put a finer point on it, yesterday in testimony here, the Arkansas Cooperative Executive that testified in front of the House said that the most advanced coal-fired power plant today in America is in Arkansas, the Turk power plant. Under EPA's proposal, it will close. In China, on the other hand, they have 46 of these plants, and under their proposal they can now build 44 more of these plants. India has declined to make a very aggressive proposal before Paris, and the Russian Federation's proposal actually allows it to increase its emission compared to the 2012 level.

Third, the Administration's plan is all pain. It is poised to be one of the most costly and burdensome regulations and rulemakings and proposals ever. Its own analysis suggests that electricity prices will go up 6 to seven percent by 2020 and up to 12 percent in other locations, and compliance costs could rise to about $8–1/2 billion by 2030. That is on top of what EIA released yesterday, which is an 18 percent increase in electricity rates between now and 2040 without the Administration's Clean Power Plan. NERA, an economic consulting firm, did another analysis which said it is probably going to increase more like 12 percent, and compliance costs would be much higher than EPA forecasts. We should take note of that because EPA has been wrong in the past. For their proposal of mercury air toxins reductions, which they promulgated in 2012, they estimated that there would be 5 gigawatts of coal-fired generation retired. Today, it is actually 50 gigawatts attributed to that rule, a factor of 10.

And fourth, the Administration's plan has no gain. It is important to note that despite all of these costs, EPA admits under the Clean Power Plan that the heart of this will have no discernible impact on the environment, and that is because of carbon leakage as U.S. energy-intensive industries move to other countries and deprive us of revenue, tax revenue, and employment. Our diverse electricity sector, which has afforded us very affordable energy as opposed to other parts around the world, will actually be taken away from us.

Conclusion: We need the industry that is investing here, the chemical industry, the manufacturing industry, the steel and pulp and paper industry, but those industries may move. We need a predictable environment, and this actually upends the predictable environment of investing in America, which is bad for the American economy.

Thank you very much.

[The prepared statement of Hon. Harbert follows:]

Statement of the U.S. Chamber of Commerce

ON: The President's UN Climate Pledge: Scientifically Justified or a New Tax on Americans?

TO: U.S. House of Representatives Committee on Science, Space, & Technology

DATE: April 15, 2015

1615 H Street NW | Washington, DC | 20062

The Chamber's mission is to advance human progress through an economic, political and social system based on individual freedom, incentive, initiative, opportunity and responsibility.

The U.S. Chamber of Commerce is the world's largest business federation representing the interests of more than 3 million businesses of all sizes, sectors, and regions, as well as state and local chambers and industry associations. The Chamber is dedicated to promoting, protecting, and defending America's free enterprise system.

The mission of the U.S. Chamber of Commerce Institute for 21st Century Energy is to unify policymakers, regulators, business leaders and the American public behind a common sense energy strategy to help keep America secure, prosperous and clean.

Thank you, Chairman Smith, Ranking Member Johnson, and members of the Committee. I am Karen Harbert, president and CEO of the Institute for 21st Century Energy (Institute), an affiliate of the U.S. Chamber of Commerce, the world's largest business federation representing the interests of more than three million businesses of all sizes, sectors, and regions, as well as state and local chambers and industry associations, and dedicated to promoting, protecting, and defending America's free enterprise system.

The mission of the Institute is to unify policymakers, regulators, business leaders, and the American public behind common sense energy strategy to help keep America secure, prosperous, and clean. In that regard we hope to be of service to this Committee, this Congress as a whole, and the administration.

There are four main points I wish to make regarding the Obama Administration's Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCC) and related issues:

1. The U.S. INDC Lacks Basic Information to Allow a Rigorous Assessment of the Goal
2. The Commitments are Hugely Unequal
3. The Administration's Plan is "All Pain . . .
4. . . . No Gain"—U.S. Industries and Emissions will Just "Leak" to Other Countries

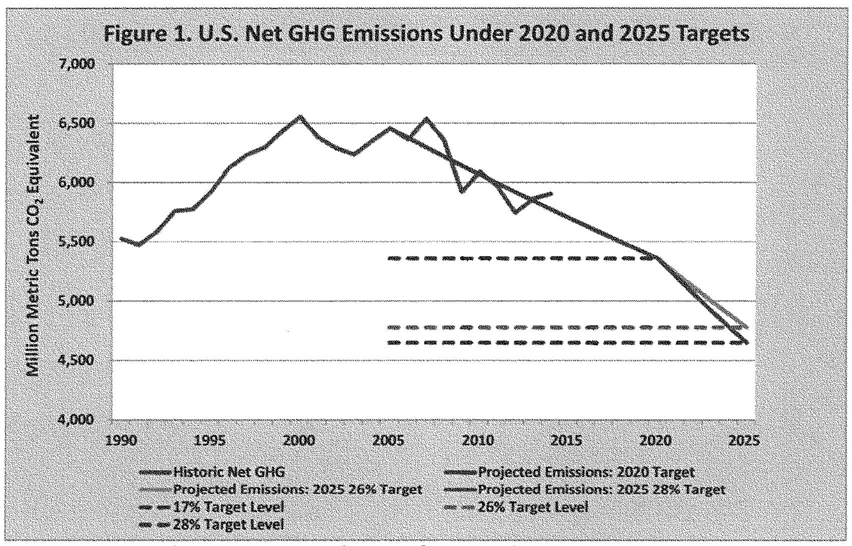
1. The U.S. INDC Lacks Basic Information to Allow a Rigorous Assessment of the Goal

The Obama Administration has set a goal to cut its net greenhouse gas emissions 26% to 28% from the 2005 level by 2025, with a "best effort" to achieve 28%. Its submission to the UNFCC is supposed to provide "information to facilitate the clarity, transparency, and understanding of the contribution." But rather than providing a clear roadmap to 2025, the INDC leads us instead into terra incognita.

This lack of transparency is all the more disappointing because the U.S. INDC claims that, "The target reflects *a planning process* that examine opportunities under existing regulatory authorities to reduce emissions in 2025 of all greenhouse gases from all sources in every economic sector" [emphasis added]. While regulatory proposals used to support the INDC are developed in a public process, the planning process the administration undertook to develop its international commitment did not allow for any opportunity to get input from the public, the business community, other stakeholders, and the Congress. This despite the fact that the outcome of this process—a national economy-wide emissions goal—will have far-reaching effects on the economy and employment.

A close examination of the INDC raises more questions than it answers. Nowhere does it explain how the administration intends to achieve the unrealistic goals it has set out. The lack of detail is all the more astonishing when one considers that this plan has been in the works for well over a year. In fact, there is nothing in the U.S. INDC that was not known already after the President's climate change announcement in China about five months ago. In the absence of a detailed explanation of how the administration intends to meet the goal, stakeholders in the U.S. and around the world have no basis through which to assess its cost or achievability.

So how do the numbers of the plan add up? In short, they don't. According to EPA's most recent greenhouse gas (GHG) inventory, net GHG emissions—which include sinks (e.g., removals of carbon dioxide from the atmosphere by forest growth)—were 6,455 million metric tons of carbon dioxide equivalent (MMTCO_2 eq.) in 2005 and 5,860 MMTCO_2 eq. in 2013. To achieve a 28% reduction by 2025, emissions would have to drop by a total of 1,808 MMTCO_2 eq. from the 2005 level, or 1,212 MMTCO_2 from the 2013 level, to meet the 28% goal (Figure 1).



Sources: Environmental Protection Agency and Energy Information Administration.

Reducing GHG emissions economy-wide by an additional 1.2 gigatons CO_2 eq. between 2013 and 2025 will be no easy matter. There is no indication in the plan from where the bulk of the emission reductions are expected to come.

We know that EPA has estimated that its proposed regulation of existing power plants, which *if* upheld by the courts and fully implemented as proposed (not a foregone conclusion), would result in an estimated 500 MMTCO_2 in reduction by 2025 from the power sector. The administration also has said it expects reduction from existing automobile efficiency standards and new standards for heavy trucks, regulations on methane emissions from oil and gas operations, appliance efficiency standards, voluntary measures to reduce hydrofluorocarbons under EPA's Significant New Alternatives Policy program, and programs to enhance carbon sinks through land use management. But nowhere in the INDC is there any estimate of the actual emission reductions that could be expected from each of these activities.

Even with aggressive implementation of the aforementioned regulations, emission reductions by 2025 will still fall well short of the 1.2 gigatons CO_2 eq. needed to meet the 26% to 28% reduction goal, though because the administration has not provided any modeling, it is not clear by how much. We estimate that announced and forthcoming rules could lead to nearly 700 $MMTCO_2$ in reductions, leaving between 500 and 600 $MMTCO_2$ eq. of the administration's commitment—or about 40% of necessary reductions—still unidentified. How does the administration intend to fill in this gap? We do not know, because the administration has not provided sector-by-sector and GHG-by-GHG breakdowns of how it expects to reach its target.

Conspicuous by its absence in the INDC is any reference to emissions from industry. It is hard to imagine that the administration does not intend to get at least some reductions from energy-intensive industrial sectors. Indeed, EPA's current budget proposal notes the agency will soon begin considering new GHG regulations on the refining, pulp and paper, iron and steel, livestock, and cement sectors. Again, none of this is detailed in the INDC.

Before the recent climate talks in Lima, Peru, this past December, Todd Stern, the administration's chief climate negotiator, said the Lima conference should agree on the "specific kinds of upfront information that Parties should provide so that their undertakings *can be readily understood and analyzed*" [emphasis added]. The administration's own INDC falls well short of even this modest mark.

It is difficult to see how this plan can be sold to the international community much less to constituencies here at home, especially given the uncertain legal foundation upon which the centerpiece of the INDC, EPA's Clean Power Plan, rests. In its *Utility Air Regulatory Group v. EPA* ruling, the Supreme Court warned the EPA that, "When an agency claims to discover in a long-extant statute an unheralded power to regulate 'a significant portion of the American economy,' we typically greet its announcement with a measure of skepticism. We expect Congress to speak clearly if it wishes to assign to an agency decisions of vast 'economic and political significance'" [citations omitted]. What EPA has proposed in using a little-used provision of the Clean Air Act to redesign fundamentally the electricity markets of the entire United States is exactly the type of regulatory extremism the Supreme Court cautioned against. As a result, at least 32 states have warned EPA that its rulemaking suffers from fundamental legal shortcomings. In 28 of these states, the warnings have come directly from governors and/or attorneys general.[1] Further, because the Obama Administration has decided to defy Congress and implement its climate plan through executive action, nothing it commits to at Paris, including the promise of billions of dollars in financial assistance, will be legally binding on any future administration, something other countries are beginning to notice. The legal limbo the administration's actions have created will have real consequences for business as it tries to plan for the future.

2. The Commitments are Hugely Unequal

The world has changed considerably since the UNFCCC was launched in 1992, and a new international agreement should take into account changing trends in global emissions and economic development. The old model of donor and recipient countries reflects neither the current nor future state of affairs.

If the world is serious about reducing GHG emissions, then developing countries will have to take on meaningful commitments. The International Energy Agency's most recent mid-range forecast suggests developing countries will account for 141% of the increase in carbon dioxide emissions from energy between 2012 and 2040.

The indications are, however, that large emerging countries especially have precious little desire to take on ambitious commitments, citing the principle of "common but differentiated responsibilities and respective capabilities" enshrined in the UNFCCC and the understandable desire to increase energy access and advance economically. These dynamics will lead to large disparities in the level of commitments being offered.

China—the world's largest GHG emitter—provides a useful example. It is generally acknowledged that an essential condition to a new and comprehensive international climate change agreement is persuading China to commit to meaningful limits on greenhouse gas emissions. In November, the U.S. and China made a joint announcement outlining in broad terms what each country will offer up ahead of the Paris climate change talks.

China pledged to peak its carbon dioxide emissions (at an undetermined level) "around" 2030 and to increase its share of non-fossil fuel energy consumption to "around" 20% of total demand by 2030. Trumpeted as a historic breakthrough by the president, the announcement earned glowing reviews at the United Nations climate change talks held in Lima last December.

It turns out there is very little new in the China announcement, and its commitment amounts to little better than business as usual. The central projection of the International Energy Agency's (IEA) most recent *World Energy Outlook*, for example, estimates that in the

---

[1] For examples, see: U.S. Chamber of Commerce Institute for 21st Century Energy. 2015. *In Their Own Words: A Guide to State and Stakeholder Concerns regarding the Environmental Protection Agency's Proposed Greenhouse Gas Regulations for Existing Power Plants*. Available at: http://www.energyxxi.org/eparule-stateanalysis.

2020s, China's GDP growth will slow appreciably and its industrial output and coal use will flatten, causing its carbon dioxide emissions to peak shortly after 2030 at a little over 10 billion metrics tons. Citing similar trends, ExxonMobil's latest forecast shows Chinese carbon dioxide emissions peaking five years earlier, in 2025, at nearly 11 billion metric tons and declining thereafter.[2] To put these growth forecasts into perspective, the very large 500 $MMTCO_2$ eq. reduction in U.S. power sector emissions EPA estimates it proposed existing power plant rule would deliver in 2025 would be offset by Chinese carbon dioxide emissions in about three weeks.

India—the world's third largest GHG emitter—is another country that has declined to propose ambitious GHG reductions ahead of Paris, citing its desire to industrialize and raise living standards. In fact, the Indian government has announced that it intends to double domestic coal output over the next five years to fuel economic expansion.

The Russian Federation—the world's fourth largest GHG emitter—has proposed a commitment of a 25% to 30% reduction in net GHG emissions by 2030 from a 1990 baseline "subject to the maximum possible account of absorbing capacity of forests." Data submitted by Russia to the UNFCCC, however, show that in 2012, the country's net GHG emissions were 50% below their 1990 level. This means Russia actually is proposing to *increase* its emissions in 2030 from 700 to 900 $MMTCO_2$ eq. compared to the 2012 level.

None of this should be taken as criticism of these goals. Countries do not check their national interests at the UN cloakroom. Like many other developing and emerging economies, China and India will continue to use fossil fuels because they have an overriding interest in boosting growth and lifting their people out of poverty. Cutting GHG emissions will always take a backseat to these goals. In comparison, the U.S. goal is well out of line with what many other governments (except the European Union) are proposing.

3. The Administration's Plan is "All Pain . . .

Achieving the president's U.S. goal would be very expensive and technically difficult. The public record of detailed review and analysis of the electricity sector and broader economic impacts of the Clean Power Plan is extensive and growing, and by all indications this regulation is poised to be one of the most costly and burdensome rulemakings ever promulgated by any agency.

EPA's own analysis of the rule projects that it will result in nationwide electricity price increases of between 6% and 7% in 2020, and up to 12% in some locations. EPA estimates

[2] Even China's current goal of reducing its carbon dioxide emissions intensity—that is, emissions per unit of GDP—by 40% to 45% from 2005 to 2020, a pledge it made under the 2009 Copenhagen Accord, represents a continuation of existing trends. Data from sources as varied as IEA, EIA, and the World Bank show that the during the previous 15 year period, from 1990 to 2005, China's emissions intensity fell anywhere from 39% to 47%.

annual electricity sector compliance costs between $5.4 and $7.4 billion in 2020, rising up to $8.8 billion in 2030. These are power sector compliance costs only, and do not capture the subsequent adverse spillover impacts of higher electricity rates throughout the rest of the economy.

Numerous additional state and stakeholder analyses show that EPA has significantly underestimated the compliance costs and energy price impacts of its rule. For example:

- A study by NERA Economic Consulting found that average U.S. electricity prices would increase by 12% per year and that compliance costs would be at least $41 billion annually and between $366 billion to $479 billion over a 15 year timeframe.

- The National Rural Electric Cooperative Association estimates that the rule would raise average electric rates for co-op consumers more than 10% in 2020 and more than 17% in 2025, with some locations seeing rate hikes as high as 33% in 2020 and 46% in 2025.

- The United Mine Workers of America estimates that the rule would result in 187,000 direct and indirect job losses in the utility, rail, and coal industries in 2020, and cumulative wage and benefit losses from these sectors of $208 billion between 2015 and 2035.

- A study by the Midcontinent Independent System Operator estimates that utility compliance costs for its operating region through 2033 would be between $55 billion and $83 billion. The costs would obviously be passed along to residential, commercial, and industrial consumers in the form of higher electricity prices.

- Kansas Corporation Commission (KCC): "The KCC estimates a base case that the EPA's CPP as proposed would cost the state of Kansas $8.75 billion with a possible range of costs between $5 billion and $15 billion. The corresponding increase in rates is between 10% and 30% over 13 years."

- Kentucky Energy and Environment Cabinet: "[T]he Cabinet determined through its own econometric modeling that the six% change in electricity prices alone estimated by EPA would cause a net loss in the United States of 439,000 full time jobs, over half (236,000) of which would come from energy-intensive manufacturing sectors...Cabinet modeling suggests that a ten% increase in the real price of electricity, which could be intensified by the proposed rule, would, on average, be associated with a 1.1% reduction in state GDP (SGDP). This would result in a loss of almost $2 billion to the state of Kentucky".

- Texas Commission on Environmental Quality: "The carbon emission limits for Texas...will result in significantly increased costs for Texas electricity customers. Some estimates of these increased costs include:
    - $10-$15 billion total annual compliance costs by 2030;

  - total electricity-related costs in Texas alone could be in excess of $10 billion;
  - increased energy costs for consumers in ERCOT of up to 20% in 2020, which does not include additional costs of transmission upgrades, procurement of additional ancillary services, energy efficiency investments, capital costs of new capacity, and other costs associated with the retirement or decreased operation of coal-fired capacity in ERCOT.
  - $3 billion per year to comply with the energy efficiency mandate alone."

- Virginia State Corporation Commission: "SCC Staff analyses of utility planning data indicate that, using conservative assumptions, the incremental cost of compliance for one utility alone (Dominion Virginia Power) would likely be between $5.5 billion and $6.0 billion on a net present value basis."

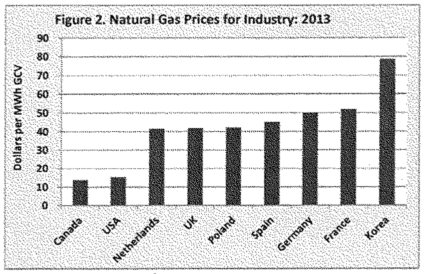
4. . . . No Gain"—U.S. Industries and Emissions will Just "Leak" to Other Countries

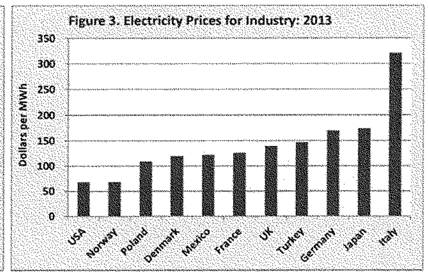
It is important to note that despite these costs, EPA admits that its Clean Power Plan, the heart of the U.S. INDC, will have no discernable impact on the climate, and that all of the benefits will come from reductions in other pollutants EPA already regulates within a margin of safety.

The administration's plan will be ineffective largely because any emissions reductions achieved will be more than offset by increases in emissions from other countries, in particular developing countries. Addressing climate change will be of considerably less interest to these countries, where the main priority of governments is poverty eradication.

Another reason GHG emissions in these other countries would continue to grow is because of "carbon leakage" from the U.S. as energy intensive industries flee to more countries with less regulation and lower energy costs.

It is well understood that America's abundance of affordable, reliable energy provides businesses a critical operating advantage in today's intensely competitive global economy. Figures 2 and 3 illustrate the comparative energy advantage in natural gas and electricity prices for industry. Affordable and reliable fuel and electricity, supplied by a diverse mix of coal, nuclear, and increasingly natural gas, give American industry an enormous economic edge, and they are driving a manufacturing revival in areas of the country desperately in need of jobs and investment.





Source: International Energy Agency.

Unfortunately, EPA's Clean Power Plan and other burdensome EPA regulations threaten to throw away this national energy advantage. Instead of attracting foreign investment to the United States, EPA rules could repel this investment into the United States and perhaps even more critically force U.S. companies to shift their investment focus overseas.

Because U.S. businesses compete on a global scale, the electricity and related price increases resulting from EPA's rule will severely disadvantage energy intensive, trade-exposed industries such as chemicals, manufacturing, steel, and pulp and paper. As a result, GHG emissions would not be reduced in the global sense, but simply *moved* to other countries that have not implemented similar restrictions.

Europe provides a cautionary tale. According to EIA, Europe's residential electricity prices have increased at a much faster rate than in the United States. Regulatory structures—including the Emissions Trading System, taxes, user fees, large (and unsustainable) subsidies and mandates renewable energy technologies, and the mix and cost of fuels all conspire to make Europe's electricity prices among the highest in the world. Europe is learning that its exorbitant energy prices, largely policy-driven, are ruining its competitiveness and turning energy-intensive industries into endangered species. More and more, we are seeing European companies fleeing sky-high energy costs and shifting production to the United States and other countries.

This is consistent with the conclusion of the Intergovernmental Panel on Climate Change Fourth Assessment report, which found that actions governments took to implement the Kyoto Protocol resulted in economy-wide leakage on the order of 5% to 20%, not insignificant amounts. Similar results could be expected in the United States as a result of EPA regulation.

Conclusion

Business needs a predictable environment in which to operate and plan. Unfortunately, the administration's INDC adds to the already large uncertainty surrounding a new international agreement. Its INDC does not provide any guidance in how it intends to meet its goal of a 26% to 28% reduction in net GHG emissions by 2025 from the 2005 level. By our estimates, emissions reductions due to existing and proposed regulations would fall short of the administration's goal by 500 to more than 600 $MMTCO_2$ eq., a not insignificant amount. Clearly, the administration plans to target the industrial sector to make up for most if not all of this shortfall. But without any detail, neither domestic stakeholders nor Parties to the UNFCCC know how this might come about.

Moreover, based on what we have seen so far, large emerging economies have shown very little interest in reducing emissions in any meaningful way, certainly nothing coming close to what the administration is proposing for the United States, which would be extraordinarily costly to achieve. An agreement locking such disparities in emissions pledges into place would jeopardize America's energy advantage and leak U.S. industries, their jobs, and their emissions overseas. As a result, the U.S. will see no environmental gain for a great deal of economic pain.

Back in 1997, the Clinton Administration disregarded clear guidance from the Senate and signed the Kyoto Protocol, a treaty it knew was political poison and that it never bothered to submit to the Senate for ratification. Judging from this latest episode in U.S. climate diplomacy, the Obama Administration looks likely to repeat the mistake of signing onto a lopsided deal and making promises future presidents and congresses may neither be willing nor able to keep. As Yogi Berra might say, "It's déjà vu all over again."

Karen Alderman Harbert

President and Chief Executive Officer
Institute for 21st Century Energy
U.S. Chamber Of Commerce

Karen Alderman Harbert is president and chief executive officer of the U.S. Chamber of Commerce's Institute for 21st Century Energy (Institute). Harbert leads the Institute's efforts to build support for meaningful energy action nationally and internationally through policy development, education, and advocacy.

Under Harbert's leadership, the Energy Institute has evolved into a premier national and international organization dedicated to advancing a constructive energy agenda with the business community, policymakers, and consumers. Harbert frequently testifies in front of Congress and provides analysis to the media, policymakers, and industry leaders.

Harbert led the Energy Institute's development of its comprehensive *Energy Works for US* platform, which provides policy recommendations to secure our nation's energy future and create millions of jobs, billions of dollars in revenue, and trillions of dollars of private investment. The Institute has attracted grassroots advocates across the nation supporting its efforts to capitalize on America's tremendous energy promise. Under Harbert's leadership, it established the groundbreaking *Index of Energy Security Risk* and the *International Index of Energy Security Risk*, the first tools to quantify America's energy security on an annual basis.

Harbert is the former assistant secretary for policy and international affairs at the U.S. Department of Energy (DOE). She was the primary policy adviser to the secretary of energy and to the department on domestic and international energy issues. She negotiated and managed bilateral and multilateral agreements with other countries and also served as vice chairman of the International Energy Agency, which advises its 28 member nations on energy policy issues and orchestrates international responses to energy supply disruptions.

Prior to joining the DOE, Harbert was deputy assistant administrator for Latin America and the Caribbean at the U.S. Agency for International Development (USAID). She had oversight of programs in 11 countries, totaling more than $800 million and 1,000 employees. In the private sector, Harbert worked for a developer of international infrastructure and power projects valued at more than $9 billion in countries in the Middle East, Asia, and Latin America.

Harbert gained experience on issues associated with economic reform and privatization through earlier positions at the USAID, the Organization of American States, and the International Republican Institute. She received a degree in international policy studies and political science from Rice University in Houston, Texas.

Harbert resides in Washington, D.C., with her husband and two children.

The mission of the U.S. Chamber of Commerce's Institute for 21st Century Energy is to unify policymakers, regulators, business leaders, and the American public behind a common sense energy strategy to help keep America secure, prosperous, and clean. Through policy development, education, and advocacy, the Institute is building support for meaningful action at the local, state, national, and international levels.

The U.S. Chamber of Commerce is the world's largest business federation representing the interests of more than 3 million businesses of all sizes, sectors, and regions, as well as state and local chambers and industry associations.

Institute for 21st Century Energy
U.S. CHAMBER OF COMMERCE

1615 H Street, NW
Washington, DC 20062
202-463-5558
@Energy21
www.energyxxi.org
facebook.com/energyinstitute

Rev. May 2014

Chairman SMITH. Thank you, Ms. Harbert.
And Mr. Schmidt.

TESTIMONY OF MR. JAKE SCHMIDT, DIRECTOR, INTERNATIONAL PROGRAM, NATURAL RESOURCES DEFENSE COUNCIL

Mr. SCHMIDT. Thank you. Thank you, Chairman Schmidt—sorry—Chairman Smith, Ranking Member Johnson, and distinguished members of the Committee. Thank you for inviting me to present the Natural Resources Defense Council's views on the U.S. target to cut emission 26 to 28 percent below 2005 levels by 2025 to address climate change.

We have a responsibility to protect our children and future generations from the effects of climate change by reducing emission of carbon dioxide and other heat-trapping pollutants. This can be done in a manner that protects public health, spurs job creation, and helps address the significant damages from climate change. Acting responsibly at home is also an essential component of efforts to secure strong global action including for major emitters. Our actions at home show other countries that the world's largest economy is prepared to rise to the challenge to address climate change.

The consequences of inaction on climate change are grave. We are already seeing the impacts of climate change on our communities and facing substantial costs from these impacts. Strong and sustained efforts to address carbon pollution and other heat-trapping pollutants can significantly decrease these impacts on the U.S. and other countries.

The new U.S. climate target is essential to helping stave off the worst of these impacts. The U.S. target can be achieved under existing law cost-effectively. Under existing law, President Obama has set in motion a number of carbon-cutting actions including carbon pollution standards for America's power plants, improved vehicle efficiency standards, appliance efficiency standards, efforts to address methane leakage, and standards to reduce the climate pollution of coolants used in air conditioners and refrigerators. This new target will build upon these efforts as all these standards have time frames that extend past 2020 to give businesses longer-term certainty for their investment decisions.

The U.S. can meet both its 2020 and 2025 targets using existing laws like the Clean Air Act, energy efficiency laws, and steps to protect our public lands and waters. These cuts can be achieved cost-effectively while helping to create jobs and achieving important health benefits for our children. Time and again, American ingenuity, entrepreneurs, and workers have risen to address great challenges. That opportunity to address this challenge is why more than 140 entrepreneurs recently wrote in support of the new U.S. target to cut its emissions.

As you know, U.S. action at home also helps spur global action. For almost two decades, inaction on climate change in the U.S. has been a major stumbling block to securing strong international action on climate change. When the United States is willing to step forward domestically, it can have a catalyzing impact in other countries. This is evident in the new commitments from China and the recent one from Mexico. As part of the U.S.-China agreement, China's president committed to peak its emission by 2030 with the intention to peak earlier and to build an increased amount of non-fossil-fuel energy to amount to 20 percent of its energy by 2030. This is a commitment to even deeper cuts in its climate pollution that many expected was achievable just a few short years ago. In fact, prior to the announcement, many experts including the U.S. Energy Information Administration predicted that China's emission wouldn't peak until well after 2040, and you can see that in other analysis.

This U.S. action couldn't come at a more critical juncture. As leaders meet later this year to finalize a new commitment to address climate change, this agreement will solidify even deeper commitments from key countries around the world. Already the European Union, Switzerland, Norway, Mexico, and China have announced the outlines of their new commitments as a part of this agreement and more countries around the world like India, South Korea, Brazil, South Africa, and Indonesia are diligently working on their proposed targets as a part of the international agreement.

In summary, let me conclude with, if the U.S. target can be achieved cost-effectively under existing law, when the world's largest economy acts, it sends a powerful signal to other governments that they also can and must act aggressively on this grave challenge of climate change.

Thank you.

[The prepared statement of Mr. Schmidt follows:]

TESTIMONY OF JAKE SCHMIDT

DIRECTOR, INTERNATIONAL PROGRAM,

NATURAL RESOURCES DEFENSE COUNCIL

HEARING ON

"THE PRESIDENT'S UN CLIMATE PLEDGE: SCIENTIFICALLY JUSTIFIED OR A NEW TAX ON AMERICANS?"

BEFORE THE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

APRIL 15, 2015

Chairman Smith, Ranking Member Johnson and distinguished members of the Committee, thank you for inviting me to present the Natural Resources Defense Council's (NRDC's) views on the U.S. target to cut emissions 26-28 percent below 2005 levels by 2025 in order to address climate change.

We have a responsibility to protect our children and future generations from the effects of climate change by reducing emissions of carbon dioxide and other heat-trapping pollutants. This can be done in a manner that protects public health, spurs job creation, and helps address the significant damages from climate change. Acting responsibly at home is also an essential component of efforts to secure strong global action, including from other major emitters. Our actions at home show other countries that the world's largest economy is prepared to rise to the challenge to address climate change.

The new target from the U.S. to cut its emissions 26-28 percent below 2005 levels by 2025 shows a commitment to strong continued action from the U.S. to cut its carbon pollution at home and sends a powerful signal to the world. This announcement comes forward as a part of the international effort to secure a new agreement this December in Paris, France. The target was first announced in November 2014, alongside a commitment from China to peak its carbon pollution and expand clean energy.

The consequences of inaction on climate change are grave. We are already seeing the impacts of climate change on our communities and facing substantial costs from these impacts. But the costs that our children and grandchildren will face if we fail to act now are simply unacceptable. The latest U.S. Third National Climate Assessment found that if greenhouse gas emissions are not reduced it is likely that American communities will experience: increased severity of health-harming smog and particulate pollution in many regions; intensified precipitation, hurricanes, and storm surges; reduced precipitation and runoff in the arid West; reduced crop yields and livestock productivity; increases in fires, insect pests, and the prevalence of diseases transmitted by food, water, and insects; and increased risk of illness and death due to extreme heat.[1] A recent bipartisan study of the economic risks of climate inaction in the Midwest put these impacts in stark context. This study found that:

> "Rising heat resulting from increased greenhouse gas emissions is likely to affect the Midwest region's ten major metropolitan areas through higher heat-related mortality,

[1] U.S. National Climate Assessment, *Climate Change Impacts in the United States*, 2014, available at: http://s3.amazonaws.com/nca2014/low/NCA3_Full_Report_0a_Front_Matter_LowRes.pdf?download=1

increased electricity demand and energy costs, and declines in labor productivity. Meanwhile, without significant adaptation on the part of Midwest farmers, the region's thriving agricultural sector—particularly in the southern states—is likely to suffer yield losses and economic damages as temperatures rise."[2]

Strong and sustained efforts to address carbon pollution and other heat-trapping pollutants can significantly decrease these impacts on the U.S. and other countries. The new U.S. climate target is essential to helping stave off the worst of these impacts.

The U.S. target can be achieved under existing law, cost-effectively. Under existing law, President Obama has set in motion a number of carbon-cutting actions pursuant to an earlier target to reduce U.S. carbon emissions 17 percent below 2005 levels by 2020. These actions include carbon pollution standards for America's power plants, improved vehicle efficiency standards, appliance efficiency standards, efforts to address methane, and standards to reduce the climate pollution of coolants used in air conditioners and refrigerators. This new target will build upon these efforts as all these standards have timeframes that extend past 2020 to give businesses longer-term certainty for their investment decisions.

The U.S. can meet both its 2020 and 2025 targets using existing laws like the Clean Air Act, energy efficiency laws, and steps to protect our public lands and waters. New acts of Congress may be needed in the long-term, but the U.S. can take a big bite out of its climate pollution using the laws already on the books. Analysis from groups like the World Resources Institute (WRI) has found that cuts on this order are achievable under existing laws. WRI found

[2] Risky Business Project, *Heat in the Heartland: Climate Change and Economic Risk in the Midwest*, 2015, available at: http://riskybusiness.org/uploads/files/RBP-Midwest-Report-WEB-1-26-15.pdf

under its "go-getter" scenario cuts of 28 percent were achievable based upon existing federal and state laws and policies.[3]

These cuts can be achieved cost-effectively while helping to create jobs, and achieving important health benefits for our children. For example, NRDC's analysis of cost-effective cuts in the carbon pollution from the power sector found that emissions reductions of 36 percent below 2005 levels by 2020 and 44 percent by 2030 can be accomplished with net benefits estimated to be up to $70 Billion and $108 Billion respectively.[4]

Time and again American ingenuity, entrepreneurs, and workers have risen to address great challenges. Why would some question our ability to unleash these same dynamics on climate change? That opportunity to address this challenge is why more than 140 entrepreneurs recently wrote in support of the new U.S. target, stating:

> "The commitment to further cut U.S. emissions by 2025 will send an even stronger market signal than existing policies can do alone. It will build upon these current efforts and help drive even more innovation, job creation, and pollution reduction. We have seen first-hand the ability of robust U.S. policies to spur clean energy deployment. Although clean energy is still an emerging energy sector, representing only 6 percent of generation, it is a strong economic growth sector. Including all clean energy sectors, the U.S. has an estimated 3.4 million clean jobs as of 2013 – a number which is steadily growing. In the last two years E2 has tracked nearly 700 clean energy and clean transportation project announcements that could create more than 233,000 jobs when

[3] See: World Resources Institute, *Can The U.S. Get There From Here?: Using Existing Federal Laws and State Action to Reduce Greenhouse Gas Emissions,* 2013, available at:
http://www.wri.org/sites/default/files/pdf/can_us_get_there_from_here_full_report.pdf

[4] See NRDC comments on EPA's draft carbon pollution standards, available at:
http://docs.nrdc.org/air/files/air_14120101a.pdf

completed. Well-designed additional measures will capitalize on these existing investments in clean energy and support new investments that create more opportunities to unleash America's clean energy economy."[5]

U.S. action at home spurs global action. For almost two-decades, inaction on climate change in the U.S. has been a major stumbling block to securing strong international action on climate change. Other countries often perceived that the U.S. wasn't willing to walk-the-walk. But strong domestic action from the U.S. in the past couple of years has begun to change that perception. I now hear more positive reactions about U.S. climate action from government officials in London, Delhi, and Beijing than just a few years ago.

When the U.S. is willing to step forward domestically, it can have a catalyzing impact in other countries. This is evident in the new commitment from China to peak its emissions - a commitment no one thought was possible just a few short years back. This commitment occurred only after the U.S. showed that it was taking strong domestic action by implementing a series of measures as outlined in the *Climate Action Plan* and after it was prepared to strengthen that commitment with even stronger targets for 2025. When the world's largest economy acts it sends a powerful signal to other governments that they also can and must act aggressively on climate change.

---

[5] The letter was organized by Environmental Entrepreneurs (E2) a national, nonpartisan group of business leaders, investors and others who promote smart environmental policies that drive economic growth. Their members, active in nearly every state in the country, have built or financed more than 1,700 companies, created more than 570,000 jobs, and manage more than $100 billion in venture and private equity capital. For full letter and signatories see: http://cleanenergyworksforus.org/wp-content/uploads/2015/03/InternationalCommitment_Release_FINAL2.pdf

This U.S. action couldn't come at a more critical juncture in efforts to address climate change as leaders meet later this year to finalize a new international agreement to address climate change. This agreement will solidify even deeper commitments from key countries around the world. Already the European Union, Switzerland, Mexico, and China have announced the outlines of their new commitments as a part of this agreement. To date, countries accounting for 58 percent of carbon pollution from the energy sector have announced post-2020 climate targets. And more countries around the world like India, South Korea, Brazil, South Africa, and Indonesia are diligently working on their proposed targets as a part of the international agreement.

Other countries are acting and prepared to do more. For almost two decades opponents of climate action in the U.S. have argued that the U.S. shouldn't act until other major emitters also act. In the past couple of years one of the key shifts is the perception that countries like China aren't doing anything on climate change – a relic of the debate almost two decades ago – to a new reality – that China is taking serious action.

As a part of the U.S.-China agreement, China's President Xi Jinping committed to peak its carbon pollution by 2030, with the intention to try to peak early, and committed to increase the non-fossil fuel share of all energy to around 20 percent by 2030.[i] This is a commitment to even deeper cuts in the country's climate pollution than many expected was achievable just a few short years ago. In fact, prior to the announcement many experts predicted that China's emissions wouldn't peak for several more decades. The U.S. Energy Information Administration's reference scenario, for example, projected that China's CO_2 emissions wouldn't peak until well after 2040, and other estimates followed a similar trend.[ii]

Despite the perception that this new commitment doesn't require China to "do anything for 16 years", China is taking a number of actions that will help reduce its emissions in the near-term. To date China has taken a number of steps including:

- *Renewable energy.* China has a National Renewable Energy Law that has helped the country increase its domestic wind and solar energy deployment from almost nonexistent levels a decade ago to the largest in the world today. The National Energy Development Strategy Action Plan has set ambitious targets for wind power and solar PV capacity to reach 200 GW and 100 GW by 2020 – from 96 GW (grid connected) and nearly 28 GW, respectively, at the end of 2014.
- *Energy efficiency.* China's 12th Five Year Plan set a binding energy efficiency target to cut energy consumption per unit of GDP by 16 percent from 2011-2015. They are meeting this target through a set of measures, including mandatory energy efficiency programs for the top 15,000 energy consuming companies in the country. Last year, China surpassed its key energy efficiency target by cutting energy intensity by 4.8 percent below 2013 levels, putting it on track to meet its 16 percent reduction target.
- *Coal consumption caps.* In response to China's air pollution, mandatory coal consumption caps have been adopted in many of China's largest coal consuming provinces. Beijing, Tianjin, Hebei and Shandong, some of the largest coal-consuming provinces, have announced a target to reduce their coal consumption by 83 million tons by 2017, compared to 2012 levels. Shanghai, Zhejiang, Jiangsu and Guangdong (for its industrial Pearl River Delta) will announce their 2017 coal reduction targets by June this

year. The State Council in the new Energy Development Strategy Action Plan established a national coal consumption cap of 4.2 billion tons for 2020.

Similar dynamics are occurring in India. Prime Minister Modi has recently reemphasized that climate change is a priority for India, and announced ambitious clean energy goals to help provide energy access throughout the country. India's current climate actions include efforts to spur more renewable energy and energy efficiency:

- *Renewable energy.* India's flagship National Solar Mission, which originally aimed to install 20 GW of solar power capacity by 2022, is now targeting 100 GW of solar by 2022. In just four years, India's solar market has grown more than 100 fold to nearly 3 GW of commissioned projects by the end of December 2014. India is also the world's fifth largest wind energy producer. The Modi government is aiming to achieve 40 GW of onshore wind power by 2019, doubling its currently installed wind capacity.
- The government launched the Energy Conservation Building Code in 2007 and plans to make it mandatory nationally by 2017. This code would establish energy efficiency codes and standards for buildings. Seven of India's 29 states have made the code mandatory as of June 2014, and 15 more plan to follow. India also has a program called Perform, Achieve, and Trade (PAT) to encourage energy-intensive industries in India, such as thermal coal power plants and cement and steel manufacturing, to become global efficiency leaders. India also has a strong standards and labeling program for key appliances, such as lighting, fans, and air-conditioners.

Conclusion. The U.S. target to cut its carbon and other heat-trapping pollution 26-28 percent below 2005 levels by 2025 has broad support from leading businesses, entrepreneurs, Latino leaders, faith-based organizations, and labor groups stated their support for the target. These include: more than 140 business leaders[6]; Ceres, which directs the Investor Network on Climate Risk which has collective assets totaling more than $13 trillion[7]; the BlueGreen Alliance, a partnership that unites America's largest labor unions and environmental organizations[8]; forty Latino leaders from across the nation representing the health, business, academic, financial, entertainment, and leadership development and civic engagement sectors[9]; and two leading faith-based organizations – The Maryknoll Office for Global Concerns[10] — and the Religious Action Center of the Union for Reform Judaism[11].

The U.S. target is achievable and sends an important signal to the world. It can be achieved cost-effectively under existing law. Strong domestic action at home by the U.S. has already helped secure meaningful commitments from other major emitters. It has already spurred key major emitters like China and Mexico to come forward with new commitment to cut their carbon pollution.

Thank you.

---

[6] See: http://cleanenergyworksforus.org/wp-content/uploads/2015/03/InternationalCommitment_Release_FINAL2.pdf
[7] See: http://www.ceres.org/press/press-releases/ceres-commends-u.s.-offer-of-domestic-emissions-cuts-towards-an-international-climate-agreement
[8] See: http://www.bluegreenalliance.org/news/latest/statement-emissions-reduction-pledge-reinforces-u-s-commitment-to-lead-on-climate-change
[9] See: http://www.vocesverdes.org/in-the-news/489/letter-38-national-latino-leaders-applaud-the-us-commitment-to-strengthen-climate-action
[10] See: http://maryknollogc.org/statements/mogc-applauds-indc-contribution
[11] See: http://www.rac.org/reform-jewish-movement-applauds-us-proposed-emission-reduction

[i] See White House fact sheet: https://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c

[ii] For example, the International Energy Agency didn't project Chinese CO_2 emissions peaking until after 2040 – the latest date in their projection – under their "current policies scenario" (IEA, *World Energy Outlook* 2014). The U.S. Energy Information Administration projected that China's CO_2 emissions wouldn't peak until after 2040 – the latest date for the projection – under their "reference case" (EIA, International Energy Outlook 2013). A study conducted by the MIT Joint Program on the Science and Policy of Global Change found that China's CO_2 emissions wouldn't peak until after 2050 in their "no policy" case, and not until some time between 2035 and 2045 in their "continued effort" scenario – which assumes a CO_2 price is applied in the Chinese economy of $26/ton in 2030 and $58/ton in 2050 (MIT, *Carbon emissions in China: How far can new efforts bend the curve?*, 2014).

Jake Schmidt, Director, International Program at the Natural Resources Defense Council (NRDC), has fourteen years of experience in international climate policy. Jake directs NRDC's International Program with a team of experts and partners working on climate change, clean energy, biogems, and sustainable development in India, Latin America, Canada, and at the international level. He works closely with NRDC's China team, as well as helps coordinate NRDC's international efforts to tackle the challenges of health, oceans, and wildlife. He leads NRDC's policy development and advocacy on international climate change, including through the climate negotiations and direct work with key countries around the world. He led a dialogue of senior climate change negotiators from more than 30 developed and developing countries to discuss options for the future international climate change regime while at the Center for Clean Air Policy. Jake has also worked on the Europe's strategy to reduce greenhouse gas emissions, European air quality policy, U.S. federal climate change policy, state climate change policy, aviation emissions, and carbon sequestration.

Jake holds a B.A. in economics from Muhlenberg College and a M.P.P. in environmental policy, with a certificate in ecological economics from the School of Public Policy at the University of Maryland.

Chairman SMITH. Thank you, Mr. Schmidt.
Dr. Thorning.

TESTIMONY OF DR. MARGO THORNING, SENIOR VICE PRESIDENT AND CHIEF ECONOMIST, AMERICAN COUNCIL FOR CAPITAL FORMATION

Dr. THORNING. Thank you, Chairman Smith, Ranking Member Johnson, for the opportunity to appear before this committee.

I'd like to make three or four points, picking up on some of what the other witnesses have said. First, it's not clear that developing countries like China and India will actually implement strong measures to slow the growth of their emissions.

Second, reaching the Administration's target of 17 percent below 2005 levels by 2020 seems unlikely since we're only 9.5 percent down right now from 2005. So how we would reach a 26 to 28 percent reduction by 2025 seems very challenging.

And third, how will the various regulatory measures described in the INDC to reduce carbon emissions impact the U.S. economy?

Looking at trends in global energy use, the International Energy Agency's 2014 statement suggests that energy use is going to grow by 37 percent to 2040. Why do we think the developing countries will actually be able to meet stringent reduction targets? Their emissions are the ones that are growing fast. The United States' emissions are relatively flat. So it's questionable that the targets that are being discussed will actually be met.

What is the economic impact on the United States of the INDC? Investment in the United States is already quite sluggish. It hasn't recovered to the 2007 levels. Net investment, net depreciation is sluggish, productivity growth is slow, wage growth is slow. We need to be sure that the policies that we undertake aren't going to negatively impact our attempt to recover a strong economy.

The question of whether developing countries will actually follow projected emission cuts, if they look at the European Union, the European Union over a decade ago was implementing strong policies to reduce GHGs to switch toward renewables. They have enjoyed very sluggish economic growth, very high unemployment rates, about 11 percent. So looking at the European lesson, why would developing countries want to follow that kind of a path?

On the other hand, there are ways that the United States can move forward to try to slow the growth of emissions. There are policies that we can undertake that will actually be no-regrets policies, will actually increase economic growth. For example, tax reform. Congress and Senate Finance and Ways and Means are discussing tax reform. Scholarly research suggests that allowing expensing for all new investment would pull through cleaner, less-emitting technologies and help us reduce GHG growth, as well as other emissions.

A study by the ACCF and Ernst & Young last year showed that allowing expensing for all new investment would reduce the cost of capital by about 25 percent, whereas the Bowles-Simpson plan, if implemented, would actually increase the cost of capital. Research shows that each ten percent reduction in the cost of capital for new investment increases investment by five percent. So tax reform should be on the table as a way of addressing GHG reductions.

Second, we should encourage the export of liquefied natural gas. Cleaner-burning fuel to our allies and trading partners in China and India and Europe would help them reduce their emissions while growing their economies. And recall that over 2 billion people have no electricity; 1.3 billion are cooking with biomass and dung and coal, so we need to try to export our surplus of LNG, which is—seems to be growing every year.

Then we also should encourage international financing for clean coal technology. My colleague George Banks recently produced a research paper on that topic and I'd like to request that that paper be submitted for the record.

Chairman SMITH. Without objection, so ordered.

[The information appears in Appendix II]

Dr. THORNING. So a third thing I think we should do to try to stimulate our economy, as well as reduce GHG growth, is be careful to use cost-benefit analysis. Other witnesses have discussed the fact that reducing U.S. emissions significantly will have no impact on the temperature or on concentrations of GHG, so we should be using cost-benefit analysis, and we should also be adopting—encouraging the adaptation to climate change through no-regrets strategies in agriculture, for utilities, and other industries.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Thorning follows:]

The U.S. Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change: Is there a Better Path Forward?

By
Margo Thorning, Ph.D.
Senior Vice President and Chief Economist
American Council for Capital Formation
Before the
Committee on Science, Space and Technology
U.S. House of Representatives
April 15, 2015

Executive Summary

Questions about the U.S. INDC: The U.S. submission to the UNFCCC leaves many questions unanswered. First, how likely are developing economies like China, India, and Brazil, whose emissions are growing rapidly, to implement strong measures to reduce fossil fuel use? Second, reaching the Administration's previous target of reducing CO2 emissions to 17 below 2005 levels by 2020 seems unlikely to be achieved, how will we reach the new tighter INDC target of 26-28 percent reduction below 2005 levels by 2025? Third, how will the various regulatory measures described in the INDC to reduce U.S. CO2 emissions, which are already in place or in the planning stage, be implemented and what will their impact be on our economy?

Trends in Global Energy Use: The IEA's WEO 2014 states that global energy demand will grow by 37 percent by 2040.How likely are developing countries like China and India to adopt strong measures to curb energy use and switch away from fossil fuels to more expensive renewables? Developing countries will likely continue to add natural gas and LNG to their energy portfolios along with nuclear power in an effort to reduce particulate emissions from coal and biomass but the strongest driver for these countries will be the need for energy for economic growth, not CO2 reductions.

Economic Impact of INDC Policies: A key part of the INDC is EPA's Clean Power Plan; a NERA study shows that the present values in 2014 of extra spending on energy incurred over the 2017-2031 ranges from $366 billion to $479 billion. Global CO2 emission forecasts suggest that developing countries will continue to be the major source of growth over the next 25 years and that reducing U.S. CO2 emission growth will make little difference to global GHG concentrations.

Strengthening the U.S. Economy and Slowing Growth of CO2 Emissions: Several polices could help strengthen the U.S. economy as well as slowing global CO2 emission growth. Federal tax reform which allows expensing for all new investment would stimulate economic growth and pull through cleaner less emitting technology. Encouraging the export of U.S. LNG and clean coal technology to developing countries would strengthen the economy and slow the growth of global emissions. The consistent use of cost/benefit analysis to review existing regulations and analyze proposed regulations would also strengthen the economy.

The U.S. Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change: Is there a Better Path Forward?

By
Margo Thorning, Ph.D.
Senior Vice President and Chief Economist
American Council for Capital Formation
Before the
Committee on Science, Space and Technology
U.S. House of Representatives
April 15, 2015

Introduction

Chairman Smith, Ranking Member Johnson and members of the Committee, my name is Margo Thorning, senior vice president and chief economist, American Council for Capital Formation (ACCF),* Washington, D.C. I am pleased to present this testimony on the potential economic and environmental impacts of United States' Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) and to offer suggestions for cost effective policies that both encourage U.S. economic growth and help slow increases in GHG emissions.

The American Council for Capital Formation represents a broad cross-section of the American business community, including the manufacturing and financial sectors, Fortune 500 companies and smaller firms, investors, and associations from all sectors of the economy. Our distinguished board of advisors includes cabinet members of prior administrations, former members of Congress, prominent business leaders, and public finance and environmental policy experts. The ACCF is celebrating over 30 years of leadership in advocating tax, regulatory, energy, environmental, and trade policies to increase U.S. economic growth and environmental quality.

The Chairmen and Committee members are to be commended for asking how the U.S. INDC could impact overall U.S. economic activity as well as global GHG emissions.

Background

The United States' Intended Nationally Determined Contribution (INDC) which was recently submitted to the United Nations Framework Convention on Climate Change (UNFCCC) leaves many questions unanswered.[1] First, how likely are developing economies like China, India, and Brazil, whose emissions are growing rapidly, to implement strong measures to reduce fossil fuel use?

---

* *The mission of the American Council for Capital Formation is to promote economic growth through sound tax, regulatory, energy, environmental, and trade policies. For more information about the Council or for copies of this testimony, please contact the ACCF, 1001 Connecticut Ave. N.W., Suite 620, Washington, D.C. 20036; telephone: 202.293.5811; fax: 202.785.8165; e-mail: info@accf.org; website: www.accf.org*

[1] https://www.whitehouse.gov/the-press-office/2015/03/31/fact-sheet-us-reports-its-2025-emissions-target-unfccc and file:///C:/Users/mthorning/Downloads/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information%20(1).pdf

Second, since the latest data from the U.S. Department of Energy predict that U.S. CO2 emissions in 2015 will be only 9.5 percent below 2005 levels it seems unlikely that the Administration's previous target of reducing CO2 emissions to 17 below 2005 levels by 2020 will be achieved. Thus, reaching the new tighter INDC target of cutting U.S. emissions by 26-28 percent below 2005 levels by 2025 seems very challenging.[2]

Third, how will the various regulatory measures described in the INDC to reduce U.S. CO2 emissions, which are already in place or in the planning stage, be implemented and what will their impact be on the economy? Among these are the existing fuel economy standards for light and heavy-duty vehicles and energy conservation standards for buildings and appliances. Proposed regulations under the Clean Air Act to regulate CO2 emissions from new and existing power plants, curb methane emissions from landfills and the oil and gas sector, and reduce the use of high global warming potential HFCs through its Significant New Alternatives Policy program are also key elements of the INDC.

Policymakers need to balance environmental goals with the need to promote strong economic growth. They must consider the potential impact of regulations implementing the INDC since the U.S. economic recovery remains weak. Real GDP growth has averaged only 1.1 percent since 2008 and the number of discouraged workers who have dropped out of the work force is large. Wage growth has also fallen behind that of previous recoveries. Another important economic indicator, U.S. investment, continues to lag that of previous recoveries. As a forthcoming study prepared by MAPI and The Aspen Institute notes:

"Net private investment totaled $860 billion in 2006; by 2013 it totaled just $524 billion. The slowing pace of investment has contributed to slower productivity, economic growth and, ultimately, to a slower rate of improvement in living standards. Labor productivity increased at an average annual rate of 3.3 percent between 1947 and 1973. It declined after 1973 and then picked up in the 1990s, growing at an average annual rate of 3.2 percent between 1996 and 2004. But then, between 2006 and 2014 it grew an annual rate of 1.5 percent. Since 2011, it has increased by just 0.7 percent per year." [3]

Trends in Global Carbon Dioxide Emissions

Reducing GHG emissions usually means using less energy, increasing the energy efficiency of machines, buildings and electricity generation, switching to less carbon intensive fuel and using more renewable energy. These changes tend to make energy more expensive and have negative impacts on competitiveness and job growth. For example, the European Union's (EU) climate change policies, which include an emission trading scheme, energy efficiency requirements and renewable portfolio standards, have had a significant impact on electricity prices. German electricity prices are triple those of the U.S. and electricity prices in Italy are also quite high compared to the U.S. It seems likely that the sluggish GDP and high unemployment rate in the EU is due in part to the impact of its climate change policies on energy prices.

The International Energy Agency's 2014 World Energy Outlook states that global energy demand will grow by 37 percent by 2040. Given the example set by the slow-growing European Union, how likely are developing countries like China and India to adopt strong measures to curb energy use and switch away from fossil fuels to more expensive renewables? Developing countries will likely continue to add natural gas and LNG to their energy portfolios along with nuclear power in an effort to reduce particulate

[2] http://www.eia.gov/environment/

[3] Thomas A. Duesterberg and Donald A. Norman, "Why is Capital Investment Consistently Weak in the 21st Century U.S. Economy?", p. 1, forthcoming, MAPI and The Aspen Institute.

emissions from coal and biomass but the strongest driver for these countries will be the need for energy for economic growth, not CO2 reductions.

The most recent data from the U.S. Department of Energy suggest that under current policies, CO2 emissions in developing countries will continue to grow while remaining flat in developed countries (See Figure 1). Similarly, the International Energy Agency's latest World Energy Outlook shows that under its Current Policies Scenario, which assumes only energy policies already in place, emissions continue to grow strongly in developing countries. For example, China's CO2 emissions increase to 12,938 million tons in 2040; in contrast, the U.S. emissions are only 5,390 million tons in 2040 (see Table 1). The WEO also projects a New Policies Scenario which assumes that policies currently under discussion are implemented; even under that scenario China's emissions remain higher than those projected for 2020 (see Table 1 and Figure 2). In describing it's New Policies Scenario, the WEO states:

"As in previous *Outlooks*, we deliberately focus on the results of the New Policies Scenario to provide a clear picture of where currently planned policies would take us. Nonetheless, this scenario should not be interpreted as a forecast: even though it is likely that many governments around the world will take firm policy action to tackle energy-related problems, the policies that are actually put in place in the coming years may deviate markedly from those assumed in this scenario".

In addition to the Current and New Policies Scenarios, the WEO provides an estimate of the global CO2 reductions needed to stabilize GHG concentrations in the atmosphere at 450 ppb (see Table 1 and Figure 2). Holding concentrations at this level is considered key to keeping global temperatures from rising more than 2 degrees Celsius. To meet this target, world CO2 emissions would need to decline by 60 percent by 2040 and those of the U.S. and China by 64 and 71 percent, respectively. Given the need for increased energy supplies to improve living standards for the 1.3 billion people who have no electricity and the 2.8 billion who cook using biofuels (dung, biomass and coal) in their stoves, achieving this reduction in CO2 seems unlikely.

If the U.S. attempts to meet the targets set forth in its INDC while others continue on a "business as usual" path, we will experience leakage of jobs and carbon emissions and reduced competitiveness in international markets.[4] To meet the possible challenges from global climate change, U.S. policymakers should base regulations on careful cost/benefit calculations. They also need to support policies that promote strong economic growth and develop adaptation strategies for coastal areas, industry and agriculture.[5]

Impact of Clean Air Act Regulation of Existing Power Plants

One of the most significant components of the U.S. INDC is EPA's proposed regulation of carbon emissions from existing power plants under the Clean Air Act. As a recent analysis by NERA explains, the proposed Clean Power Plan (CPP) sets state-specific CO2 emission rate targets (in lbs/MWh) based upon EPA's calculation of the emission rates that EPA believes could be achieved in each state by implementing four types of changes, referred to as Building Blocks.[6] The Building Blocks include heat

[4] See recent ACCF Special Report on the implications of the U.S/. China announcement on climate change at http://accf.org/wp-content/uploads/2015/03/ACCF_ChinaReport_FINAL2.pdf

[5] See previous ACCF testimony on Adaptation before the U.S. Senate Committee on Environment and Public Works at http://accf.org/wp-content/uploads/2012/08/120801-Senate-EPW-Testimony_FINAL.pdf

[6] http://americaspower.org/sites/default/files/NERA_CPP%20Report_Final_Oct%202014.pdf

rate improvements at coal units (Building Block 1), increased utilization of existing natural gas combined cycle (NGCC) units (Building Block 2), increases in renewables and nuclear energy (Building Block 3), and increases in end-use energy efficiency (Building Block 4). EPA identified two options based upon alternative stringencies and compliance timeframes. Option 1, which is EPA's preferred option, is projected by EPA to reduce U.S. CO2 power plant emissions by 30% in 2030 (relative to the 2005 emission level). Option 2 would have less stringent emission rate targets and is projected by EPA to reduce U.S. CO2 power plant emissions by about 24% by 2025 (relative to the 2005 level).

The costs of the two approaches to power plant emission reductions are expressed as present values in 2014 of extra spending on energy incurred over the 2017-2031 period (see Table2). The present value the higher energy cost for the state unconstrained scenario is $366 billion, the costs under the state constrained scenario is $479 billion.

Many experts conclude that the timetables in EPA's Clean Power Plan will force the retirement of one-third of America's coal fired power plants by 2020. As Ameren's Warner Baxter notes:

"The EPA proposal calls for states to cut emissions by 30% from 2005 levels by 2030. It also imposes aggressive interim targets starting in 2020 that will test states' ability to meet these standards without disrupting service. For example, 39 states must achieve more than 50% of their final target by 2020.

Reliable power requires decades of careful planning. The appropriate amount and type of round-the-clock generation capacity, transmission and distribution lines must be finely balanced in advance to ensure the lights go on when a switch is flipped anywhere in the U.S. The EPA plan will significantly impair that planning process."[7]

Other utility experts echo Baxter's concern and suggest ways to improve the CPP proposal. In its EPA filing, the National Rural Electric Cooperative Association observes that:

"Given both the complexity of the electric generating sector and the vital importance of a reliable supply of electricity for the Nation's security and the economic wellbeing and physical safety of its citizens, any final emission guideline *must* allow the States to respond dynamically to the wide range of sometimes unpredictable conditions that affect the Nation's generating resources. If a nuclear plant must close for safety reasons, if natural gas generation cannot be dispatched at predicted levels, if necessary infrastructure is unavailable or delayed, if renewable generation proves unable to be delivered because of transmission limitations, if economic growth exceeds expectations, or if reliability and safety requires additional dispatch of higher-emitting resources, States should not be forced to choose between compliance and leaving their citizens and businesses without heat or power. Nowhere does the Clean Air Act expect or authorize such heavy-handed treatment of state authorities."[8]

Many businesses, especially those in energy and capital intensive sectors, are concerned about the impact of higher electricity prices on investment, job and GDP growth. For example, in its comments to EPA, the Independent Petroleum Association of American states that:

---

[7] http://www.wsj.com/articles/the-dirty-secret-of-obamas-carbon-plan-1428875418

[8] NRECA filing on December 1, 2014 to EPA's Air Docket.

"... as an association representing thousands of American businesses that both consume and provide American energy, IPAA is concerned that the imposition of the CPP will result in American businesses being significantly disadvantaged compared to their foreign competitors. Energy costs are a major factor in determining a business's global competitiveness. Currently, the United States is realizing a competitive advantage because of low-cost natural gas resulting from shale gas development in the United States. The natural gas renaissance in the United States will result in America having the lowest long term natural prices of any industrial nation. The United States, for example, could have natural gas at half the cost of European natural gas and at one third of the cost in Asia. As a result, the United States has a built-in price advantage, for energy costs, compared to any of its industrialized competitors. The CPP threatens to jeopardize this American success story. The manner in which the CPP is implemented, and whether EPA acquiesces to fossil fuel opponents' demands that EPA create a Section 111(d) regime to target minor, individual GHG-emitting sources, will determine whether America's competitive advantage is maintained in the future. The use of natural gas as a power generating fuel could be significantly impeded if the CPP results in the imposition burdensome compliance requirements and mandated usage of Carbon Capture and Storage or other unnecessarily costly and unproven technologies. Further extension of Section 111(d) to target methane emissions from the oil and natural gas sector will accelerate the decline of America's competitive advantage associated with low-cost natural gas.

Of additional concern is the fact that the increased costs and decreased competitiveness accruing to American consumers and business will result in few, if any, total global GHG reductions. For example, the projected CO2 emission reduction from EPA's proposed rule is, at most, 555 million metric tons (mmt) in 2030, which represents only 1.3 percent of projected global CO2 emissions in that year."[9]

Strengthening the U.S. Economy While Slowing the Growth of Global CO2 Emissions

As mentioned above, U.S. investment has been sluggish since the 2007-08 recession and GDP and job growth have lagged previous recoveries. Several polices could help strengthen the U.S. economy as well as slowing global CO2 emission growth.

- **Reform of the U.S. Federal Tax Code**

  As the House Ways and Means and the Senate Finance Committees discuss how to reform the U.S. federal tax code, they need to consider options that would reduce the cost of capital for new investment. Since over the last three decades, each $1 billion in investment in the U.S. is associated with almost 20,000 new jobs, the loss of key tax code provisions that impact the cost of capital for new investment could have profound implications for the U.S. economy. Given the slow recovery from the 2007 recession, policymakers need to understand the likely consequences for new investment of alternative tax reform plans.

  As an ACCF/E&Y analysis makes clear, replacing the income tax with a consumption tax that allows expensing (first year write off) for all new investment and taxes business profits at a 30 percent rate would reduce the cost of capital by over 20 percent and stimulate new investment in the U.S.[10] In

[9] IPAA's December 1, 2014 filing with EPA 's Air and Radiation Docket and Information Center Office

[10] See full report at http://accf.org/wp-content/uploads/2014/04/ACCF-White-Paper_d101.pdf

contrast, adopting a Bowles/Simpson approach to tax reform which lowers the income tax rate to 28 percent but repeals accelerated depreciation, the domestic production deduction (Section 199), LIFO and other deductions used by corporations and pass-throughs would raise the cost of capital by 3 percent. Academic studies suggest that a 10% increase in the cost of capital would result in a 5% to 10% decrease in investment and vice-versa.

Thus, tax reform which reduces the cost of capital for new investment could have a significant impact on GDP, job growth and also pull though cleaner new technologies which emit fewer GHGs.

- **Encourage the Export of Liquefied Natural Gas**

Numerous studies by academic and respected consulting firms have concluded that allowing the export of LNG to countries, with which the U.S. does not have a free trade agreement such as China and India or the European Union would increase U.S. investment, employment and GDP growth (see www.actonlng.org). In addition, multiple, non-partisan reports from the government and private sector suggest that exporting U.S. LNG will improve trends in global GHG emissions. The use of natural gas for power generation in the U.S. has already slowed the growth of carbon emissions, by displacing coal in the U.S. Exporting LNG could provide the same benefit around the world.

A recent report by the Department of Energy's National Energy Technology Laboratory concludes that, when comparing equal emissions scenarios, exporting U.S. LNG for power generation overseas would result in lower global greenhouse gas emissions compared to scenarios where regionally sourced coal is used for power generation. And more recent data for the natural gas liquefaction, storage, and ship loading process shows even greater environmental benefits.[11]

- **Allow the U.S. Government to Support the Export of Clean Coal Technology to Developing Countries**

A new report by ACCF Executive Vice President George D. Banks highlights the challenges in helping developing countries get access to cleaner electric generating capacity, especially if they want to burn coal.[12] Banks notes that "The role of the federal government in the international financing of coal plants has become controversial in recent years. Some policymakers as well as environmental activists oppose the use of any public funds for any overseas coal plant, including highly-efficient units, while some fiscal conservatives want an end to all government financing of exports and projects. At the same time, the developing world is seeking financial assistance from the United States and other major economies to provide basic electricity access, which is indispensable to poverty eradication and improvements in environmental quality and health care. Current U.S. policy—backed by a number of European countries—places unrealistic conditions on power generation projects in developing countries."[13] He concludes that there is a need to impose certain environmental conditions—such as the need to install highly-efficient technology to mitigate greenhouse gas emissions and traditional pollutants. These requirements should, however, take into account the circumstances of the country in question, including ambient environmental conditions and coal quality (i.e., not all coal projects should be ultra-supercritical). The determination should also consider what current feedstock a coal plant would be displacing, including solid fuels and petroleum.

---

[11] http://accf.org/op-ed-lng-exports-will-bring-environmental-and-other-benefits/

[12] http://accf.org/wp-content/uploads/2015/02/ACCF-CPR-Special-Report_Coal-Financing-FINAL.pdf

[13] Ibid.p.1

Furthermore, carbon capture and storage (CCS) technology should not be imposed as a standard on any part of the developing world, including India, which has roughly 300 million people without access to electricity.[14]

- **Encourage Adaptation to Climate Change**

  Climate models are still in the development stage and the various models yield significantly different predictions about future temperature and precipitation. Accordingly, for companies which rely on cost/benefit analysis to guide their investment decisions, a policy of "no regrets" will continue to shape their approach to adaptation to climate change. In addition, adapting to variations in the climate will be much easier for countries and businesses which have the resources to invest in new technology, new products and innovations across all sectors. Strong U.S. economic growth can be promoted through sound fiscal policies and a tax code that promotes economic growth with robust capital cost recovery rules. Conflicting regulations, regulatory uncertainty and permitting delays are often factors hindering U.S. companies from making investments to improve or expand their facilities in order to adapt to extreme weather events or climate variability. For example, in addition to permits to meet federal regulations there are often additional state and local permit requirements which add time and cost to a project getting underway.[15]

Conclusions

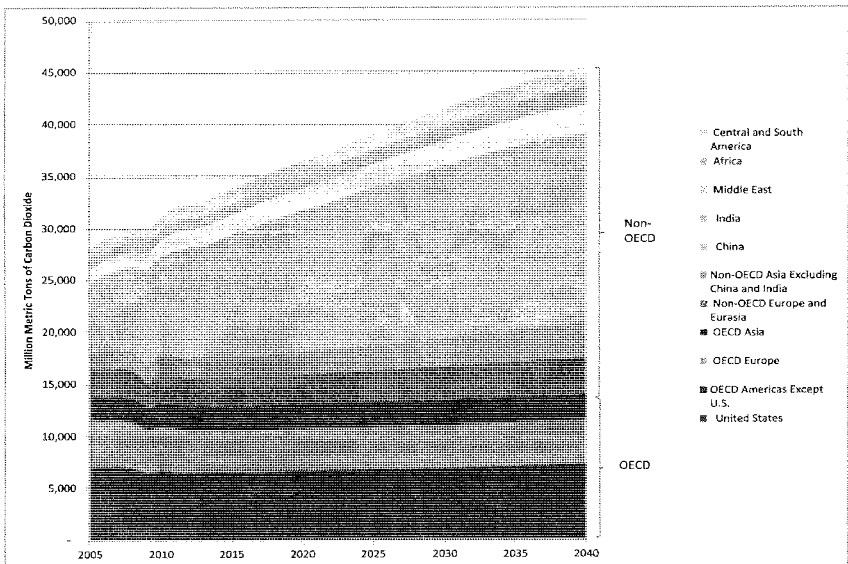
Global CO2 emission forecasts suggest that developing countries will continue to be the major source of growth over the next 25 years and that reducing U.S. CO2 emission growth will make little difference to global GHG concentrations. Developing countries will need to meet the expectations of their citizens for higher living standards and that will dictate their choices about energy demand and fuel sources. Accordingly, the prudent path for U.S. policymakers is to focus on strengthening the U.S. economy through tax and regulatory reforms. The consistent use of cost/benefit analysis to review existing regulations and analyze proposed regulations would also strengthen the economy. A stronger U.S. can adapt to a changing climate if necessary. In addition, the U.S. should encourage LNG exports and the transfer of clean coal technology to help other countries develop while emitting fewer GHGs.

---

[14] Ibid, p.3.

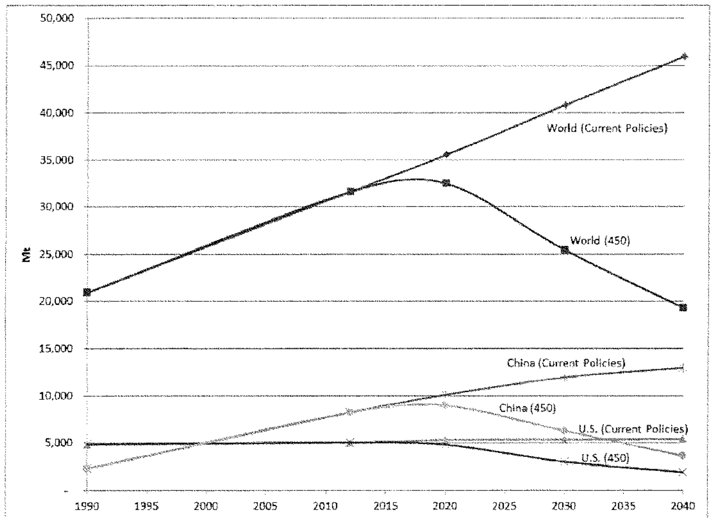
[15] See http://accf.org/wp-content/uploads/2012/08/120801-Senate-EPW-Testimony_FINAL.pdf for more on adaptation strategies.

Figure 1. World Carbon Dioxide Emissions by Region



Source: International Energy Outlook 2013, Energy Information Administration, U.S. Department of Energy.

Figure 2. CO2 Emissions under Alternative Scenarios



Source: International Energy Agency, World Energy Outlook 2014

Table 1. CO2 Emissions (Mt) Under Alternative Scenarios

			Current Policies			New Policies			450 Scenario		
	1990	2012	2020	2030	2040	2020	2030	2040	2020	2030	2040
World	20,938	31,615	35,523	40,848	45,950	34,203	36,291	38,037	32,479	25,424	19,300
U.S.	4,850	5,043	5,300	5,336	5,390	5,075	4,513	4,119	4,819	3,001	1,902
China	2,278	8,229	10,058	11,927	12,938	9,459	10,200	10,018	8,962	6,290	3,630

Source: International Energy Agency, World Energy Outlook 2014

Table 2. Energy System Costs of State Unconstrained (BB1-4) and State Constrained (BB1-2) Scenarios

	State Unconstrained (BB1-4)	State Constrained (BB1-2)
Present Value (Billion 2013$)		
Cost of Electricity, Excluding EE	-$209	$335
Cost of Energy Efficiency	$560	$0
Cost of Non-Electricity Natural Gas	$15	$144
Total Consumer Energy Costs	$366	$479

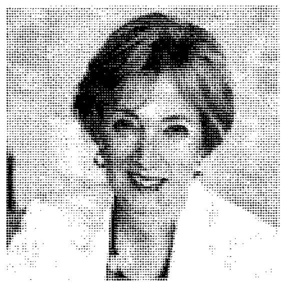
Notes: Present value is from 2017 through 2031, taken in 2014 using a 5% real discount rate

Source: NERA calculations as explained in the text

Source: Potential Energy Impacts of the EPA Proposed Clean Power Plan, NERA, October 2014, http://americaspower.org/sites/default/files/NERA_CPP%20Report_Final_Oct%202014.pdf

ACCF
AMERICAN COUNCIL FOR CAPITAL FORMATION

Margo Thorning



Margo Thorning is senior vice president and chief economist with the American Council for Capital Formation and director of research for its public policy think tank, the ACCF Center for Policy Research. In North America, Dr. Thorning has frequently testified as an expert witness on capital formation, tax, energy and environmental policies before multiple U.S. congressional committees, including the Senate Finance Committee, the Senate Environment and Public Works Committee, the Senate Finance Committee, the House Ways and Means Committee and the House Committee on Energy and Commerce. Thorning has also traveled coast to coast to present findings to state and local lawmakers, business organizations and the media on the economic impact of climate change policies on local job and economic growth.

The U.N. Commission on Sustainable Development invited her to deliver a presentation "Investing in Energy and Industrial Development: Challenges and Opportunities." Thorning also served on DOE's Electricity Advisory Board's Subcommittee on Standards of Conduct and Corporate Practices and has testified before the Senate of Canada on that country's proposals for tax reform.

Dr. Thorning is an internationally recognized expert on tax, environmental, and competitiveness issues. She writes and lectures on tax and economic policy, is frequently quoted and has op-eds published in publications such as the *Financial Times*, *New York Times*, *Wall Street Journal*, *Forbes*, and *E&E Daily* and has appeared internationally on public affairs news programs. Dr. Thorning has made presentations on the economic impact of climate change policy at in China, India, other Asian countries, the European Union, and Russia.

Dr. Thorning is co-editor of numerous books on tax and environmental policy, including "Climate Change Policy and Economic Growth: A Way Forward to Ensure Both" and "The U.S. Savings Challenge: Policy Options for Productivity and Growth." (See www.accf.org and www.iccfglobal.org for complete list of publications.)

Previously, Dr. Thorning served at the U.S. Department of Energy, the U.S. Department of Commerce, and the Federal Trade Commission.

Dr. Thorning received a B.A. from Texas Christian University, an M.A. in economics from the University of Texas, and a Ph.D. in economics from the University of Georgia.

Chairman SMITH. Thank you, Dr. Thorning.

I will recognize myself for five minutes for questions.

And, Dr. Curry, let me address my first one to you.

Earlier this year, NASA claimed that 2014 was the warmest year on record, and then they put in a footnote a disclaimer that they were actually only 38 percent sure that that was the case, less than 50/50. That's amazing. But quite frankly, you seldom hear disclaimers from the so-called experts who always seem to be 100 percent certain that they are right. Actually, as you know, the scientific method itself actually says that we should continue to question and challenge our hypotheses, not just assume we're 100 percent right. So in many instances I'm thinking these so-called scientists really aren't acting very scientifically.

But in any case, I have a couple quick questions for you. One is that the President keeps talking about or keeps trying to connect human-caused climate change to extreme weather examples such as hurricanes and wildfires, and he keeps being contradicted by his own Administration officials. Why he keeps doing it, I don't know. But who is right, the President or others who say there's really no demonstrable connection between these extreme weather events like hurricanes and wildfires and human-caused climate change?

Dr. CURRY. Well, the Intergovernmental Panel on Climate Change, who I regard as a little bit on the alarmist side frankly, even they acknowledge in their Special Report on Extreme Events—Weather Events and Climate Change published in 2012 that there was essentially no connection observed in the historical record between human-caused climate change and extreme weather events. They found a few regional examples where there was a trend like heat waves in Australia and things like that but really no——

Chairman SMITH. Yes.

Dr. CURRY. They didn't find anything. And why this continues to be touted by the Administration is pure politics. I mean people respond a lot more to extreme weather events than they do to like a 2 degree temperature change or something.

Chairman SMITH. It's regrettable that we have the political leader of our country saying statements that we have reason to believe he must know are not accurate, so I thank you for your comment on that.

Another question is that the two percent increase in global temperature is often seized upon as a tipping point, and if the temperature increases by two percent, all kinds of dire consequences will result. Is there anything magic about two percent. Where did we get that figure? Is it arbitrary or is there some scientific validity to 2 percent and not 2.5 or not 1.5 or something like that?

Dr. CURRY. Well, the 2 degree target was a carefully negotiated number, okay, that doesn't have much basis, you know, in science. The one scientific concern that was put forward was that this would be the amount of warming that would cause some of these tipping points like a shutdown in the Atlantic circulation or collapse of the major ice sheets. But again, the IPCC, in its recent assessment report, found these to be extremely unlikely in the timescale of the 21st century. So there's really not much to that number other than a politically negotiated——

Chairman SMITH. Yes.

Dr. CURRY. —danger sign.

Chairman SMITH. And thank you for that. And by the way, just as a side comment, the experts that make predictions as to what's going to happen 85 years from now or 100 years from now and are absolutely certain that that's going to occur, whatever those dire consequences are, the only thing I will say about a 100-year prediction is that it's not going to be what is predicted. And it's too bad that again the scientists are actually not using the scientific method on that.

Ms. Harbert, let me ask you, you did a great job of going through those countries and what they are contributing or not contributing to the UN Treaty, but going back to China for a second, we have heard this from—we have heard the promises that we have recently heard from China for years and years and years and they never really come through on those promises. Is there any reason for us to believe that China is suddenly going to do what it claims it's going to do and much of what it claims it's going to do isn't going to occur for years from now? Why should we be suspicious about some of these countries' commitments?

Hon. HARBERT. Well, China's priority is economic growth. And we look at all of the forecasts and China's economy is beginning to slow down. If you look at the International Energy Agency's World Energy Outlook, they forecast a slowdown which would actually show that China's emissions will peak just around the 2030 time frame, which is what they agreed to in this announcement. Now, let's be clear. This was an announcement. This was not an agreement; this was not any type of binding commitment that the United States and China agreed to in the visit to Beijing.

I think it's highly unlikely that we will see anything happen before that. China is building coal-fired power capacity faster than we are. They are building lots of things faster than we are. And we're looking at an emissions trajectory that was going to peak at the time frame they are agreeing to. So this is business as usual. They had already agreed to the renewables targets. They had already agreed to everything in that agreement they had already put down on paper before.

Chairman SMITH. Okay. Thank you.

And with the indulgence of my colleagues, I'm going to try to squeeze in one more question even though my time is up and that's to Dr. Thorning.

Dr. Thorning, you're aware of this, but President Obama, when he was in law school, had as a professor a well-known constitutional expert by the name of Laurence Tribe. Recently, Professor Tribe testified, "The EPA is attempting to exercise lawmaking power that belongs to Congress and judicial power that belongs to the Federal courts." He added that, "Burning the Constitution should not become part of our national energy policy," amazing statement with which I happen to agree.

Well, both Ms. Harbert and you have mentioned the litigation that is out there. What happens if the clean power rule is thrown out, as many legal experts, including Professor Tribe, expect?

Dr. THORNING. Well, I think the question of how that uncertainty about future directions will impact the business community is significant. Uncertainty retards investment, raises the cost of capital, so we need certainty and clarity and transparency about what our policies are going to be.

Chairman SMITH. Okay. Thank you all for your answers today.

And the gentlewoman from California, Ms. Lofgren, is recognized for questions.

Ms. LOFGREN. Well, welcome to the Science Committee, the last place on the planet where we question whether climate change is being caused by human activity.

Mr. Schmidt, it seems to me that the reality of anthropogenic climate change is really impossible to deny by reliable scientists all over the world. People are facing new challenges resulting from the rapid increase in greenhouse gas emissions, heavier precipitation events, consistently higher-than-average global temperatures, warming ocean, rising sea levels, increased incidence of extreme weather, severe droughts, changes in the spread of infectious disease, changes in ocean chemistry, and other ecological and public health impacts. Now, the scientific consensus about the contributions of humans to climate change is overwhelming. However, Dr. Curry and our Chairman appear to deny such consensus exists, and Dr. Curry suggests, "If humans are not the dominant cause of climate change, then attempts to modify the climate through reducing GHG emissions will have little impact on future climate change."

Do you believe, Mr. Schmidt, that human activities are the main cause of climate change?

Mr. SCHMIDT. Yes, we do. We draw our conclusions from the vast majority of the climate scientists through the Intergovernmental Panel on Climate Change, as well as the U.S. National Climate Assessment, which surveys the landscape in terms of opinion and views and research analysis of the vast majority of the climate science community. And they have consistently found for the past 15 or more years that, yes, in fact humans are causing climate change, that our contributions are significant, and that there are severe damages coming forward. We are at .8 degrees centigrade increase in temperature since preindustrial levels, and many of the impacts that you have outlined are already being felt.

Ms. LOFGREN. I would ask unanimous consent that we place in the record of this hearing the report entitled "Climate Change 2014 Synthesis Report Summary for Policymakers" from the IPCC. And I would note that contrary to the testimony of one of the witnesses, on page 7 of that report they find that changes in many extreme weather and climate events have been linked to human influences, including a decrease in cold temperature increases, an increase in warm temperature extremes and an increase in extreme high sea levels, and an increase in the number of heavy precipitation events in a number of regions.

Chairman SMITH. Without objection.

[The information appears in Appendix II]

Ms. LOFGREN. I would also ask unanimous consent that the report entitled "Climate Change: Evidence and Causes, An Overview from the Royal Society and the U.S. National Academy of Sciences" be placed in the hearing record and would note that on page 15 of that report they find that lower atmosphere is becoming warmer and moister as a result of human-emitted greenhouse gases. This gives the potential for more energy for storms and certain severe weather events, consistent with theoretical expectations, heavy rainfall and snowfall events, which increase the risk of flooding. And heat waves are generally becoming more frequent trends and extreme rainfall vary from region to region. The most pronounced changes are evident in North America and parts of Europe, especially in winter.

Chairman SMITH. That will be made a part of the record but I don't know if that's necessary since you read it all.

[The information appears in Appendix II]

Ms. LOFGREN. I—no, the rest of the report, I would need more than my five minutes.

Let me just ask you, Mr. Schmidt, as you're aware, critics of the EPA rule have a sky-is-falling attitude towards actions that would protect the health of Americans and do something about emissions, which I think kind of ignores the fact that the U.S. economy has tripled in size since the adoption of the Clean Air Act in 1975. Concerns are raised that the Clean Power Plan is going to cause residential electricity rates to increase dramatically. Those most in need are going to suffer the most. Is that the case, and how will the efforts to reduce carbon emissions such as the Clean Power Plan affect low-income Americans?

Mr. SCHMIDT. Well, I think you are right to point out that oftentimes there is a sky-is-falling analysis that's presented, and we have seen this time and again in terms of environmental protection when the United States first took steps to deal with acid rain. The cost of—the cost estimates for many of the modelers predicted very significant impacts across the economy, and I think we have found that the economy has grown significantly and we, lo and behold, have very much lower acid rain as a result of that. And we have seen that—excuse me—across the board in terms of many environmental challenges.

When we have analyzed what EPA has proposed and what's possible in the power sector, we have found that you can actually make cuts on the order of 36 percent below 2005 levels by 2020 and 44 percent by 2030 in the power sector with net benefits estimated to be up to 70 billion and 108 billion respectively. So these are significant benefits that can be achieved very cost-effectively through things like energy efficiency, you know, assuming real cost of energy efficiency, real cost of renewables like wind and solar, and reasonable transitions in terms of natural gas and so forth.

And so with these kinds of efforts we can see significant benefits to the public and to low-income families as well and still deal with this challenge of climate change.

Ms. LOFGREN. Thank you, Mr. Schmidt.

And, Mr. Chair, my time is expired. I yield back.

Chairman SMITH. Thank you, Ms. Lofgren.

And the gentleman from Alabama, Mr. Palmer, is recognized for his questions.

Mr. PALMER. Thank you, Mr. Chairman.

Dr. Curry, you mentioned uncertainty and the importance of understanding the actual climate variability. Before inferring sensitivity to greenhouse gases and how there has been a hiatus in global warming since '98, could you explain how the Administration claims that 2014 is the warmest year on record?

Dr. CURRY. Okay. There have been a number of—there's about a half a dozen different groups doing these analyses and all but one of them found that 2014 was right at the top. But if you look at the uncertainty in these measurements, even knowing that, most of them found that 2014 was in a statistical tie with two other years, 2005 and 2010, and the U.K. group, with a far more realistic assessment of the uncertainty, found that 2014 was tied with nine other years statistically. You really couldn't distinguish them statistically. That, however, is not the way all this was communicated to the public. It was touted as warmest year.

Mr. PALMER. Can you discuss to what degree our understanding of these issues are uncertain? You know, what are the current key gaps in our understanding? Talk about the models if you don't mind.

Dr. CURRY. Okay. In terms of the climate models, the key issues—I mean if you compare the climate models with the observed temperature over the past decade, you see that the climate models are running way too hot. Since 1998 surface—global surface temperature has increased a tiny bit and it's not statistically significant given the uncertainties, whereas climate models were predicting 2/10 of a degree per decade in the early years of the 20th century. So you're seeing this growing divergence between the climate models and the observations.

The key uncertainties are how the models treat aerosols in the atmosphere like little tiny particles. That's a major uncertainty. They don't get the ocean circulations in—particularly in terms of the timing, the magnitude, and the pattern of these major oscillations. They don't include a lot of the indirect effects from solar variations and they don't correctly simulate the effects of clouds, which have a very big impact on the climate. So there's a large number of uncertainties in these climate models and things that we know we don't have right.

Mr. PALMER. When you mention clouds, you're referring to water vapor as well, right?

Dr. CURRY. Well, yes, water vapor.

Dr. CURRY. The biggest uncertainty and the biggest impact is from the actual condensed clouds themselves.

Mr. PALMER. Is it also true that what we found in measurements in terms of deep atmosphere is in conflict with what the models should have shown?

Dr. CURRY. Yes. The temperature—the atmospheric temperatures from satellite also diverge even more from the climate models.

Mr. PALMER. Is it also true that the modeling does not reflect what has actually occurred over the last 30 or so years? There's a discrepancy—a wide variance in what the models would have shown that the temperature would be versus what it actually was?

Dr. CURRY. Yes, that's correct.

Mr. PALMER. Then in your experience do you think this sort of rhetoric coming from the White House is unprecedented to the scientific community?

Dr. CURRY. Well, there have been some rather extreme statements coming from the White House that don't seem to be justified by even the—you know, the basic evidence and the assessment reports from the IPCC and so on.

Mr. PALMER. Given the status of some of the scientists who raised these issues about the fallibility of the models——

Dr. CURRY. Um-hum.

Mr. PALMER. —and the uncertainty of the science, does that reflect well on how these issues should be debated?

Dr. CURRY. We have gotten caught in this really toxic mess where these politics have become scientized and the science has become politicized, and I'm not exactly sure how to break out of this. But again, it's the job of the scientists to continually evaluate evidence and reassess conclusions.

Mr. PALMER. If I may, I'd like to ask one question of Dr. Thorning.

Dr. Thorning, the Administration continues to assert that the United States can substitute renewable energy for fossil eco-energy without negative consequences. As a matter of fact, they think that we should be at 80 percent renewables within the next two or three decades. Can you explain why we can't just rely on renewables?

Dr. THORNING. Well, renewable energy—pardon me; I have allergies, too. Renewable energy tends to be a lot more expensive than conventional energy from fossil fuel or nuclear. EIA's most recent assessment of the capital cost for renewable energy shows that new natural gas is about $60 a kilowatt hour versus for offshore wind about $240 a kilowatt hour. Solar is also more expensive, and because the wind doesn't blow all the time and the sun doesn't shine all the time, you have to back those up with conventionals. So renewable energy——

Mr. PALMER. May I interject something right there just for a moment? If you have to back them up with natural gas or other fossil fuels, does that not indicate that renewables are not reliable?

Dr. THORNING. Well, that's one of the drawbacks because we don't have the capacity to store solar right now and the wind doesn't blow all the time. So—and we did an analysis of States with renewable portfolio standards compared to those that don't and the States with the renewable portfolio standards had energy costs on average about 20—electricity costs about 20 percent higher than the States without portfolio standards. So if you're thinking of how to grow the U.S. economy, forcing renewable energy is probably going to retard growth, not help it. And—you know, because it has to be backed up, you're not really having much of an impact on U.S. emissions.

Mr. PALMER. Thank you, Mr. Chairman.

Chairman SMITH. Thank you, Mr. Palmer.

The gentleman from Virginia, Mr. Beyer, is recognized.

I'm sorry. We will go back to the gentlewoman from Oregon, Ms. Bonamici is recognized. I didn't realize you had returned.

Ms. BONAMICI. Thank you, Mr. Chairman. And I appreciate that and I hope that my having to be in two places at once does not indicate my lack of interest in this important topic. We are also working on child nutrition in another committee.

Thank you so much to the witnesses for being here today. Climate change is an important issue to my constituents in northwest Oregon, and whether I'm talking about people who live on the coast who rely on a healthy ocean or growers of our famous pinot grapes in Yamhill County or entrepreneurs who are developing new clean energy technologies, there are many people who are working to address and mitigate the impacts of climate change in my State of Oregon.

Now, there have been several statements here about how reducing carbon emission has costs, but we should also consider the costs of inaction. We have shellfish growers on our coast and many of them have spoken with me about the significant losses because of ocean acidification. Oyster production is an $84 million industry on the West Coast and supports more than 3,000 jobs in my State. Ocean acidification is threatening this industry, as well as those in the Gulf of Mexico, New England, mid-Atlantic. And this just doesn't matter to coastal representatives; it's important to restaurants and grocery stores and people who eat shellfish across the country.

Now, later today, I'm going to have an opportunity to visit with some of the Oregonians who grow wine grapes in my district, and I want to mention that the wine economy in Oregon is valued at more than $3 billion and supports more than 17,000 jobs. Wine grapes are especially vulnerable to temperature extremes. Excess heat can raise the sugar level of grapes, for example, which, along with drought, threatens this important industry.

So, Mr. Schmidt, you discussed in your testimony some of the increased costs associated with climate change. Do you agree that if we continue to do little or nothing, these costs will continue to rise? And can you talk just a little bit about the terms of lost jobs, for example, and areas like agriculture if we refuse to act? And I do want to have time for another question as well.

Mr. SCHMIDT. Well, thank you. I will keep it brief then.

I think it's true. When you think about the impacts that come from climate change, they are at this—sort of fundamental components of the American economy. How often does it rain, when does it rain, how much temperature variability at certain points? And you're seeing some real-world examples of that in California where they are suffering from very severe droughts that are having a huge ripple effect across the entire economy, in agriculture, and happy to share with you some of our analysis of ocean acidification, which shows devastating impacts potentially across the entire fishing economy of the United States, which is significant, as you know.

Ms. BONAMICI. Thank you. And, yes, we also have outdoor recreation activities that have been seriously hampered here because no snowpack.

So in taking a leadership role to address climate change, the United States has an opportunity to further spur innovation and development of sustainable technologies. And, Dr. Thornburg, thank you for mentioning the States that have renewable energy portfolios. I was actually in the Oregon Legislature when we passed the legislation, and I'm proud to have supported that, to require that the State's largest utilities derive 25 percent of their 2025 sales from renewable sources.

We have a significant amount of hydropower as well in Oregon, and one way that our State is working to meet this benchmark is to be a leader in areas like wind energy. We are involved in generation, manufacturing, and the industry employs more than 1,000 Oregonians. We have also made a strategic decision to become an international leader in the development of wave energy technology, and we have partnered with the government on some research in that area.

So, Mr. Schmidt, you have established that we are already paying significant costs driven by climate change. Can you talk about how the U.N. Framework Convention will positively impact our domestic clean energy sector and innovation and economy nationwide?

Mr. SCHMIDT. Well, it will have very significant positive impacts we believe. What you're seeing in places like China and India is a massive expansion of wind and solar demands. India has a target to get to 100 gigawatts of solar by 2022. And I was just there in February and I can tell you that there's a huge amount of attention and focus on delivering that. They have lots of sun. They have 300 days of sun, you know, some of the best sun in the world. They also have significant wind potential.

China does as well. Despite this perception that China is not going to do anything for 16 years under this new commitment, that's just not true. They are building a massive amount of wind and solar.

And so what you see happening is that the more that these clean energy markets are growing internationally, that American companies are tapping into this. And this is a key component when we talk to entrepreneurs. They see this huge sort of market potential both within the United States and externally. So the products that they build to meet standards and regulations in the United States now become the kinds of technologies that they can export around the world and tap into those opportunities.

Ms. BONAMICI. Well, thank you very much. I see my time is expired and I yield back. Thank you, Mr. Chairman.

Chairman SMITH. Thank you, Ms. Bonamici.

And the gentleman from Texas, Mr. Neugebauer, is recognized for his questions.

Mr. NEUGEBAUER. Thank you, Mr. Chairman.

A lot of different areas here and I kind of want to explore two or three of them.

One of the issues is let's say we move forward with some kind of an agreement with these other countries. What kind of a verification process will be put in place? Are they going to allow us to fly drones over their countries and do satellite imaging? I mean how do we know that they are playing by the rules? Because one of the things that I have seen in other areas of our government is we play by the rules but some of the people that we make agreements with don't necessarily play by the rules. And so how do we make sure everybody is playing by the rules? Ms. Curry—Dr. Curry?

Dr. CURRY. I will defer to the other witnesses on that. That's something that I don't have much expertise on.

Mr. NEUGEBAUER. Yes.

Hon. HARBERT. The answer is we won't know. It's a voluntary, you know, monitoring and self-reporting, as we have seen under—that's why we had the Foreign Corrupt Practices Act. We play by the rules; many other countries don't, and that's something we need to be concerned about. Even though they have vague commitments, they will have even a vaguer ability to ensure that they are meeting their commitments.

Mr. NEUGEBAUER. Yes. One—and also I guess the other question along with that, so it's voluntary, but what is the regulatory infrastructure in those countries and what kind of regulations do they have? The President is proposing pretty rigorous regulatory proposals and this Administration has put out a lot of very extraneous proposals. But how do they compare with the United States, these other countries?

Hon. HARBERT. The answer is that there are—very few commitments have been made. The deadline was March the 31st to make the commitments to the United Nations and less than a dozen countries have made the commitment, so we don't know what the commitments will be going forward.

Mr. NEUGEBAUER. Do they have EPAs—I mean are they organized? Is there enforcement mechanisms that are as organized as the United States?

Hon. HARBERT. I think it's fair to say the United States has the most rigorous environmental—most stringent regulations on the books of the developed world.

Mr. SCHMIDT. Do you mind if I add some perspective to that? From our work in China we have a major effort in China working on environmental challenges because it has many, as you know—what we have found consistently—and I think that they are at a critical tipping point. Any time you travel to anywhere in China now you see that the air pollution is terrible. That's a major challenge for the government and they get that because social instability is the thing that scares them the most. And so the number one issue around social unrest today is air pollution in the country, and so that's why we have seen them begin to control the amount of air pollution and coal consumption in some of the key provinces. And just last year was the first time in over—almost two decades that China's emissions actually declined by about two percent. Their coal consumption declined as a result of many of these measures.

Mr. NEUGEBAUER. I think you have made one of my points there is that everywhere you go in China it's foggy and it is a problem.

I think the other issue is—and, Dr. Curry, you're talking about modeling and how the actual temperatures and projected temperatures and various models that have been put together. I remember I had an opportunity to travel to the South Pole a number of years ago and there were some climate people there and they were showing me these projections of temperatures back 5,000 years moving forward, and they were models because obviously they probably didn't have thermometers 5,000 years ago. If we do, we haven't been able to find any of the recordings. So when those models aren't correct and we make a huge amount of policy based on what we think the models are and the potential outcomes and we miss those models, what are the consequences of that?

Dr. CURRY. Well, this is why I argued that for a very wicked, complex problem, some sort of, you know, explicit targets and command and control really isn't a very good policy choice. And this is why I suggest that we need a broader range of policy options on the table that leave us less vulnerability—less vulnerable to really getting it wrong.

Mr. NEUGEBAUER. Aren't we kind of betting the ranch on an outcome we're not even sure about and a problem we have not quite defined?

Dr. CURRY. Yes. There are two possibilities. One, that we could spend all this money and really nothing happens with the climate and we have sunk—you know, it's an opportunity lost. On the flipside, if the climate really is going to turn out worse than we think, what will be left is inadequate solutions, damaged economies, and technologies that aren't up to scratch. So, you know, we risk of both of these things by, you know, focusing on these technologies that are really inadequate to the problem. We need to invest in better energy technologies that are really up to the challenge. Wind and solar aren't going to do it.

Mr. NEUGEBAUER. I see my time is expired, Mr. Chairman.

Chairman SMITH. Thank you, Mr. Neugebauer.

The gentleman from Virginia, Mr. Beyer, is recognized for his questions.

Mr. BEYER. Thank you, Mr. Chairman, very much.

I found myself deeply troubled by Dr. Curry's written and oral testimony, and I respect your career and your academic background and am grateful that you're here, but I found the testimony just full of internally conflicting facts and opinions and in almost total conflict with everything I have read in the last 15 years in every journal I could get my hands on. So let me offer three examples and ask Dr. Curry for a response.

First, you are highly critical of the precautionary principle. By the way, there's a third option there, which is we do nothing and the worst happens and we're embarrassed for the generations to come because we didn't react.

But you are highly critical of the precautionary principle. You said, "Extensive costs and questions of feasibility are inadequate for making a dent in slowing down the expected warming." Then the very next sentence you state, "The real societal consequences of climate change in extreme weather events remain largely unaddressed."

A second, you—I'm quoting from your written testimony, "Is it possible that something really dangerous and unforeseen could happen to Earth's climate during the 21st century? Yes, it's possible, but natural climate variability, let me emphasize, perhaps in conjunction with human-caused climate change, may be a more likely source of possible undesirable change that human causes. In any event, attempting to avoid such a dangerous and unforeseen climate by reducing fossil fuel emissions will be futile if natural climate is a dominant factor."

And then the very next page, "Climate change may exacerbate environmental problems that may be caused by overpopulation, poorly planned land use, over-exploitation of natural resources. However, it's very difficult to separate out the impacts of human-caused climate change from natural climate change and from other societal impacts. So does it really make any difference? We can't change sunspots or ocean circulation or even cloud cover, but we can impact the human-caused part of this wicked problem."

And finally, at the end of your written testimony you say, "There is reason to be concerned about climate change," which sort of undoes the first 8 pages.

Dr. CURRY. Okay.

Mr. BEYER. "Uncertainty is a two-edged sword. Future climate outcomes might be better or worse than currently believed." And then you propose a different set of solutions based on climate pragmatism, accelerated energy innovation, building resilience to extreme weather, and no-regrets pollution reduction. So it's almost like climate change is real but let's not talk about fossil fuel burning and the impact on greenhouse gases on what that does to all this.

Dr. CURRY. Okay. The confusion is this: Scientifically, the term climate change means a changing climate and it has changed for, you know, the past 4 billion years or so. Okay. This whole issue of human-caused climate change is a relatively recent notion. So climate is always changing and it's going to change in the future. The issue is how much of the change is caused by humans. We don't know. We don't know what the 21st century holds. The climate change may be really unpleasant and that may happen independently of anything that humans do.

My point is is that we don't know how much humans are influencing climate and whether it's going to dominate in the 21st century. Given that we don't know this, we're still going to see extreme weather events whether or not humans are influencing the climate. This is what I'm talking about, that we really don't know how the 21st century is going to—climate is going to play out, and we should figure out how to reduce our vulnerability to whatever might happen, and that includes extreme weather events are going to happen regardless of whether humans are influencing climate change. So maybe that clarifies my testimony.

Mr. BEYER. A little but not much. I mean all science is contingent. We continue to learn. We continue——

Dr. CURRY. Yes.

Mr. BEYER. You must be humble at all times with what we know.

Dr. CURRY. Yes.

Mr. BEYER. But it seems to me very much sticking our head in the sand to look at all of the evidence of what has happened with global warming in the last 30 years. By the way, the debate over whether it's 2004 or 2009 or 2014——

Dr. CURRY. Okay.

Mr. BEYER. —is the warmest year seems silly——

Dr. CURRY. Okay.

Mr. BEYER. —when 10 of the last——

Dr. CURRY. Okay. The climate has been warming since the 1700s, okay, since we came out of the Little Ice Age. We don't know what is causing that warming in the 18th century, in the 19th century. It's not attributed to humans so there are other things going on in the climate system that has been contributing to a warming over several centuries. We can't blame all of this on humans, okay, and we don't know how all of this is going to play out in the 21st century. We just don't know.

Mr. BEYER. We just had a vice president who was willing to argue for enhanced interrogation and torture on the one percent chance of that Al Qaeda might someday get a nuclear weapon. Are we going to do nothing because there's a greater than one percent chance that climate change——

Dr. CURRY. There's nothing in my testimony that said we do nothing. I'm saying that what is being proposed is ineffective. It's not going to do anything. Even if the United States is successful at meeting 80 percent reductions by 2050, this is going to reduce warming by about 1/10 of a degree centigrade. It's not going to do anything. So should—I'm saying we need to acknowledge that and rethink how we are going to deal with the risk from future climate change, whether it is caused by human or natural processes. That's what I'm saying.

Mr. BEYER. Okay. Thank you, Dr. Curry, very much.

Mr. Chairman, my time is up. Thank you.

Chairman SMITH. Thank you. Mr. Beyer, those were good questions.

By the way, you mentioned head in the sand. The best example I know of head in the sand is the Los Angeles Times announcing a policy that they will no longer cover climate change skeptics, nor will they publish letters to the editor on the subject.

I not going to ask you whether you agree or disagree because I have a hunch you might agree that we need to be open-minded and continue to challenge our hypotheses. But——

Mr. BEYER. I will always agree, Mr. Chair.

Chairman SMITH. Thank you, Mr. Beyer.

The gentleman from Oklahoma, Mr. Bridenstine, is recognized for his questions.

Mr. BRIDENSTINE. Thank you, Mr. Chairman.

Dr. Curry, you're the professor and former chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology, Georgia Tech. You have a Ph.D. in atmospheric science from the University of Chicago. Prior to joining the faculty at Georgia Tech, you had faculty positions at the University of Colorado, Penn State University, and Purdue University.

There are a lot of us probably especially on this side of the aisle who are confused because during this conversation we have heard that climate change has caused snowpack in some States, it has caused drought in other States, it has caused extreme weather, you know, experiences in other States. I come from Oklahoma. We know what extreme weather is. This is very confusing to us, that climate change is causing these vast changes, you know, I guess weather events. And really when you're talking about States that are next door to each other in one State it's causing snowpack, in the next-door State it's causing drought, can you share with us what your professional judgment is on that analysis?

Dr. CURRY. Well, climate—extreme weather events and weather patterns is really, you know, just dominated by random chaotic variations in the atmosphere and ocean circulations. There are some regimes that get established that allow you some predictability. In the large ocean circulations like the Pacific decadal oscillation and the Atlantic multi-decadal oscillation have a big decadal controls on the weather patterns, and a lot of the extreme weather that we're seeing now has analogues back in the 1950s when the patterns were sort of similar. So trying to blame this on human is really rather pointless. It happens to be weather variability.

The strange weather that we have seen in the United States this past winter with warmth and dry in the West and a lot of snow and cold in the East has been associated with a blocking pattern triggered by a warm blob in the Pacific that has been there, you know, for almost a year now. And scientists don't know how to explain the appearance of that warm blob but it's something related to natural variability, not human causes. So——

Mr. BRIDENSTINE. Thank you for your analysis. I think you have pretty much answered it.

I'd like to direct my questions to Ms. Harbert. By the way, welcome from a fellow Rice Owl. It's good to see you here.

In your opinion, how much—or if you know—you probably have the facts—how much coal-fired power generation in the United States—will the United States lose under the EPA's latest most recent round of power plant regulations? I have heard it is about 100 gigawatts. Is that your assessment as well?

Hon. HARBERT. Well, we already know that between 2012 and 2016, so we are almost at the end of that period, that close to 60 gigawatts of closures have already been announced and are underway. Beyond that, we expect and we see announcements every day of an additional 40 to 50 gigawatts. So your number is accurate. That's taking a tremendous amount of power off of the system with little plan to replace it with anything sustainable.

Mr. BRIDENSTINE. So one of the things I'm hearing is that that's about one third of total coal-fired capacity in our country. Is your analysis similar? Is that about right?

Hon. HARBERT. That's accurate.

Mr. BRIDENSTINE. Okay. For my State of Oklahoma we derive most of our electricity from coal, and those coal-fired power plants are being shuttered. Can you explain for my constituents at home what this means to their electricity prices?

Hon. HARBERT. Absolutely. In the State of Oklahoma the estimate is that the prices of electricity under this proposal would go up between 18 and 21 percent, 21 percent at the peak. Now, it's very important to understand that 21 percent is on top of what is already forecast by EIA of an 18 percent increase. So you're looking at a huge increase in Oklahoma, and particularly when you're looking at 55 percent of the households in Oklahoma contribute more than 20 percent of their income, they are low-income households, this is going to hit 55 percent of those the hardest.

Mr. BRIDENSTINE. So it hurts the poor the most?

Hon. HARBERT. It hurts the poor and the elderly the worst.

Mr. BRIDENSTINE. So anything about current and proposed regulations, the Clean Power Plan, CAFE standards, among others, these lead to necessary reductions to achieve the United States—will these achieve the United States' intended nationally determined contribution?

Hon. HARBERT. Today, we're enjoying low electricity prices and low natural gas prices. These proposals will eliminate that comparative advantage and still not meet the goals that are laid out in the INDC.

Mr. BRIDENSTINE. If we're to reach our commitments of 26 to 28 percent reduction, will that mean also shuttering natural gas-fired power plants?

Hon. HARBERT. With the multitude of regulations, including ozone, you're not going to be able to build at new capacity, so that won't even shutter ones. It will not allow you to build new ones. So we are looking at a very big different economy by 2025. And I think you should note that 40 percent of the commitment the Administration made in their INDC, they have not accounted for how they are going to reach it, so more to come.

Mr. BRIDENSTINE. My constituents have been very concerned about coal. This shocks me that they also need to be worried about natural gas-fired power plants.

With that, Mr. Chairman, I'm out of time and I will yield back.

Chairman SMITH. Thank you, Mr. Bridenstine.

The gentleman from Arkansas, Mr. Westerman, is recognized for his questions.

Mr. WESTERMAN. Thank you, Mr. Chairman.

Thank you, Mr. Chairman.

Ms. Harbert, you mentioned in your testimony the Turk plant, which happens to be in my district, and I have had the opportunity to visit the Turk plant. I'm also an engineer and have designed many industrial facilities, and it is a very impressive plant. And I will say this about all of manufacturing in the United States, the facilities I have been involved with, they go to great extents to meet all permitting requirements. They are very conscientious about being good stewards of the environment. But when we see a plant like the Turk plant that is a super hypercritical coal facility, best technology in the world, if that plant can't meet emissions, that's simply saying that we are going to abandon coal as a fuel source if we can't use technology like at the Turk plant.

And when we look across the renewable energy spectrum, which I have done projects in renewable energy as well, they are not nearly as economically competitive as traditional fuels, and we also see that they have got technical problems with peak demand and baseline loads.

So I think my question is more questioning the overall premise of our energy policy and our effort to use more renewables. Wouldn't it make more sense, while traditional energy prices are low, to divert more research into renewables to make those technologies more efficient so that as we make our traditional fuels more scarce in the future, our renewables become more economic and will provide a much better energy source for the future? So I know you have worked with the 21st Century—you know, Institute for 21st Century Energy. I'd like to get your input and maybe even Dr. Curry's input on how we need to maybe rethink the premise of our whole energy policy and the way we address using renewables in the future.

Hon. HARBERT. I think two quick points. It's ironic that under the Administration's proposal that we would be forced to close the Turk plant because it cannot meet the expectations of the proposal, and yet to highlight the disparity in obligations, China will continue to be able to build those plants, 54 new plants just like that one and yet we can't build one here.

You know, the idea should be—you know, the idea under this Administration's proposal is to make today's affordable energy more expensive. And what we should be focusing on is making a broad variety of energy more affordable, including alternatives like wind and solar, make it more competitive and let the market work. That's what is good for the American economy, that's what is good for the consumer, that's what is good for your constituents.

But this is going to raise electricity prices in Arkansas. And particularly, you know, if you look at Arkansas, you have got 61 percent of the households in Arkansas which are considered low-income households which spend 20 percent of their income on energy, they are going to be hit the worst. We should be offering them more options, not fewer, more expensive options.

Mr. WESTERMAN. Dr. Curry, would you like to add to that?

Dr. CURRY. I will just make a comment about wind energy and solar energy, the great intermittence and the challenges of integrating wind and solar power into the grid. My company provides weather forecasts, and one of the things we do is predict wind power, and it's enormously variable. Ramps are very unpredictable and you basically have to have a backup power supply ready. And so you have to make—you know, the day before you have to make a commitment as to whether you're going to fire up the coal burner, the gas burner, whatever backup power source, and you just don't know. There's a great deal of uncertainty. And so it's very difficult to integrate into the grid and it's not clear because of the backup power sources and the extra power required to ramp up these burners, you know, whether you're actually saving any CO_2 emissions in this process. So we really need substantially better technologies that this is going to meaningfully reduce the CO_2 emissions.

Mr. WESTERMAN. Yes. When we talk about CO_2 emissions, even, you know, some of the policies that come out of here seem to be counterproductive to reducing CO_2 emissions, even with our forests that we fail to manage properly that emits, you know, 70, 80, 90 million tons per year of carbon into the atmosphere because we haven't managed those forests correctly. So I think we just need to focus on the science and how to make all of our energy sources more economical for the future. And with that, Mr. Chairman, I think I'm out of time.

Chairman SMITH. Thank you, Mr. Westerman.

And the gentleman from Florida, Mr. Posey.

Mr. POSEY. Thank you, Mr. Chairman.

Ms. Harbert, in your testimony you said that the numbers that the United States pledged to the United Nations do not add up. I wonder if you would expound on that a little bit for me.

Hon. HARBERT. Certainly. If you take all of the stated regulations that they have put into their INDC and add up the EPA's estimated carbon reductions, they still come up 40 percent short. So it is evident that there is more action that's going to be needed to meet that 26 to 28 percent cut. On top of that, in that submission to the United Nations, they say that we are going to meet an additional target of an 80 percent reduction by 2050 with absolutely no plan, no proposal, no narrative, no evidence of how we're going to get there. So the math does not add up.

Mr. POSEY. Okay. I remember when Australia passed the Australian version of cap-and-trade, national energy tax, whatever, and I met with two members of Parliament yesterday, one of them I guess was the essential representative of our Senate and the other one represented essentially our House, and they told me that Australia rescinded their national energy tax cap-and-trade plan, said it was the biggest mistake, both of them, and they were a liberal party, by the way. Both of them said it was in their opinion the biggest mistake their government ever made.

Hon. HARBERT. And largely—and hugely unpopular with the Australian people, which is why the subsequent government, in listening during their election campaign, then rescinded that pledge. And by the way, Australia has yet to make a pledge to the United Nations for this round.

Mr. POSEY. Okay. Well, I was going to ask why you thought that they rescinded it because we didn't get that far in the conversation, and now you have told me. I guess the cost of it was unbearable on the citizens and they were losing business left and right is what they told me. They didn't tell me about the grassroots uprising.

Hon. HARBERT. And they have a very dependent economy on coal and coal production and that was certainly under threat. They are a mining, you know, economy.

But we also just don't have to look to Australia. I think somebody mentioned in testimony earlier we just need to look across the pond to Europe about what we don't want to do and look at what has happened under the cap-and-trade trading system in Europe and electricity prices have gone up, emissions have not gone down, they have not met their Kyoto requirements. And here in the United States without all of these government mandates and based on the private sector initiative and innovation, we have in essence met what would have been our Kyoto targets.

So we can prove that energy and the environment can coexist, and those that would like to have the argument that it's energy or the environment need to understand that that's not the path that the economies of the world and the developing economies are going to pursue.

Mr. POSEY. I know during the National Prayer Breakfast I guess—and I don't remember the title from Spain but pretty much lectured us on the responsibility of adopting a cap-and-trade policy. Are you familiar with where they are with their policy in Spain?

Hon. HARBERT. I know that Spain has heavily relied on subsidizing renewable energy and subsequently hemorrhaged a tremendous amount of jobs, about a 2-for-1 job loss in the renewable industry, and so they have largely abandoned that proposal.

You know, I would call your attention to an article in today's New York Times about this exact issue, and the New York Times itself says that, you know, no poor nation can take care of its environment and so we should be very careful in how we approach this. But if you don't offer people an opportunity, we're never going to get to a point to resolve this on a global basis.

Mr. POSEY. Thank you for your comments.

Thank you, Mr. Chairman. I yield back.

Chairman SMITH. Thank you, Mr. Posey.

The gentleman from Michigan, Mr. Moolenaar, is recognized for his questions.

Mr. MOOLENAAR. Thank you, Mr. Chairman.

And thank you for being here today and for your testimony.

And I wanted to just share a story with you and then ask you maybe some questions. The situation we had in Michigan a while back in my district where we had a major manufacturer of polycrystalline silicon, which goes into solar panels, and very excited about the solar markets, one of the challenges with that is the main criteria for that company to be successful making that product that goes into solar panels was low-cost electricity. And so we actually had an investment go from our State to a different State because there was a lower-cost electricity.

Now, what I'm hearing in Michigan is that we're going to be losing a number of our coal plants, and I think and my understanding is in China they are building more and more coal plants, which will then allow them to be much more competitive actually in building solar panels.

And so I guess one of the questions I had, Dr. Thorning, and I think it was in Mr. Schmidt's testimony he stated that China's president Xi Jinping—I'm probably not pronouncing that right—committed to peak the carbon pollution by 2030, but I think the actual agreement released by the White House says China intends to achieve the peaking of carbon dioxide emissions around 2030 rather than by 2030.

And I guess my question, Dr. Thorning, is this. You know, if other countries don't make the same level of commitment that we are making and we sort of unilaterally disarm our coal plants that would actually allow us to be leaders in manufacturing because of the low cost of electricity, aren't we paying a huge political price or a competitive price for kind of a political statement that says we are doing something at the same time when others may not be equally committed to that in a sort of a unilateral disarmament if you will?

Dr. THORNING. That's really the central theme of my testimony, that we would be incurring substantial cost. And as Dr. Curry and others have said, the overall impact on global GHG emissions is almost nonexistent. So—and to pick up on points that others have made, a strong economy is able to weather and adapt to climate change. A strong economy can make the investments needed to slowly bring in the type of equipment that would allow us to grow and reduce GHG emissions.

So if we go down this path that this Administration is trying to push us toward, we will certainly lose competitiveness, we will lose jobs, we will slow our growth. The Clean Power Plan is certainly not going to be helpful to the environment.

I would like to clarify on Chairman Smith's question. If the courts rule this as a legal, the question is what comes next? It would certainly be a good thing if it were ruled illegal, but the question is what comes next? Because uncertainty is what is retarding investment, so we need transparency in our energy policy. So I think policymakers need to weigh very carefully as we go forward. If we make these enormous sacrifices, loss of jobs, low-income people disproportionately hit, States dependent on coal suffering the consequences of higher prices, what do we gain for it? And I make the case we gain almost nothing.

Mr. MOOLENAAR. Okay. Thank you.

And then, Dr. Curry, I just wanted to get your perspective as a scientist. You know, my understanding is, you know, science moves forward when people are skeptical. They come up with new ideas and they test those ideas and there's a peer-review process and there's an opportunity to criticize and the academic freedom to criticize people's findings, and it creates a whole new scientific debate based on that. What strikes me about a lot of the argument around climate change is you have people who are saying the debate is over or they are saying scientists, you know, unanimously agree. And to me any time someone says a debate is over in science it strikes me as not really scientific. And I'm sure you have encountered some of that, and what are your thoughts on that?

Dr. CURRY. Well, I have definitely encountered that, and whenever I despair over what is going on in the climate field, I look at the recent collapse of the consensus on cholesterol and heart disease, okay, and, you know, even though it's, you know, strongly enforced by funding and reputation and authority and groupthink, that these things, if they are not correct, will eventually collapse.

Skepticism is one of the four norms of science. It's absolutely essential for scientific progress. It's our job to question the evidence and reassess conclusions. And that's what we are supposed to do. However, in the climate field there is this manufactured consensus that we are all supposed to step in line and follow, and it's rather bizarre given this very complex and poorly understood climate system. We need lots more debate. We need to explore natural climate variability in particular if we are ever going to understand all this. And it's—disagreement and debate is really what moves the knowledge frontier forward, and this is being stifled and it is of great concern to me.

Mr. MOOLENAAR. Thank you very much.

And thank you, Mr. Chairman.

Chairman SMITH. Thank you, Mr. Moolenaar.

The gentleman from Kentucky, Mr. Massie, is recognized.

Mr. MASSIE. Mr. Chairman, thank you.

I yield as much time as he may consume to Mr. Palmer.

Mr. PALMER. Thank you, Mr. Massie. Thank you, Mr. Chairman.

Dr. Curry, it's very timely that you would end that last comment on talking about climate variability. It was mentioned earlier about the drought in California. Isn't it true that the recent research has indicated that California has been through much more severe droughts in the immediate ancient past? And we have had a series of droughts. We had a drought in the American Southwest in the 13th century that apparently contributed to the decline of the Pueblo cities. Tree rings indicate that we had a major drought in the Mississippi River basin between the 14th and 15th centuries that contributed to the disappearance of the Mississippian culture. And we have had three major droughts in the 19th century, mid-1850s, 1870s, 1890s, and then the Dust Bowl drought of the 1930s. Could you comment on that, what might have caused those?

Dr. CURRY. Well, drought is nothing new in the American West. We have seen droughts in the American West. In the 20th century there was a drought of comparable magnitude in California in the 1890s and then the mega-droughts, you know, 13th, 14th centuries. Again, these were caused by natural variability, some combination of something going on in the sun, the ocean circulation, whatever. The exact mechanisms contributing to those previous droughts are unknown but we can't guarantee that it was not human-caused drought in the 13th century. So natural climate variability can bring some unpleasant surprises. And in terms of extreme weather events, I would say that natural climate variability is far and away the dominant factor of what we have seen in terms of recent extreme weather.

Mr. PALMER. Would you conclude that a drought that lasted a century or more would be considered a severe weather event?

Dr. CURRY. No, I guess I would call that, you know, climate event but it is, yes, where you draw the line between weather and climate. Drought really goes into the climate territory.

Mr. PALMER. All right. Well, that makes my point, though, I think that when you have major changes in climate and attribute it to anything manmade, I think it calls into question some of the modeling. And I think it was you that made the point about the Little Ice Age, but not much is discussed about the warming period, the medieval warming period that occurred prior to that that I don't think can be attributed to anything anthropogenic.

So thank you, Mr. Massie.

Mr. Chairman, I appreciate it.

Chairman SMITH. Okay and——

Mr. PALMER. I yield the balance of my time.

Mr. MASSIE. Mr. Chairman, I yield back.

Chairman SMITH. Thank you both.

And the gentleman from Texas, Mr. Babin, is recognized.

Mr. BABIN. Thank you, Mr. Chairman. I really appreciate it.

Thank you for being here, all of you esteemed witnesses.

Dr. Thorning, I would ask you—first a comment. I worry that regulations associated with climate change will increase the costs of energy to American citizens. It's a big issue in my district in Texas 36, especially hardworking families who are already struggling to get by. Could you describe how increased energy costs impact the macroeconomic health of the United States both for primary energy users and end-use consumers?

Dr. THORNING. Well, certainly. The overall impact of higher energy prices impacts low-income minority communities severely because low-income people may spend, you know, 15 to 20 percent of their income on energy. In your State of Texas, which has one of the highest electricity prices in the country, I think is due in part to the renewable portfolio standards that have been put in place there.

So macroeconomic studies over the last decade analyzing cap-and-trade proposals, many of which the ACCF has prepared and put forward, show significant impacts across the economy because as electricity prices rise, you tend to see loss of manufacturing jobs, you tended to see outsourcing of jobs, you tend to see people substituting—spending more on energy and less on other goods and services. So the whole economy is dragged down as one important component is increased in price. So that's why I think it is imperative that our policymakers weigh the costs and the benefits of the proposals that this Administration has put forward and EPA's plans because, as we have already discussed, the impact of curbing our emissions here will have almost no impact on global concentrations.

Mr. BABIN. So I assume that high energy prices are spilling over and impacting everyday items as well——

Dr. THORNING. Yes, and the——

Mr. BABIN. —and you say the entire economy.

Dr. THORNING. The converse is true. Due to the fall in the price of natural gas because of hydraulic fracturing, we have seen a moderation of electricity prices. We have seen the resurgence of manufacturing industries who use natural gas as a feedstock. We have seen a lot more activity and job growth in the sector, so that has been a great boon to the economy. And policies that make those more difficult are certainly going to slow our economic recovery.

Mr. BABIN. Absolutely. Okay. So do you think going right along with those same—along those same lines, do these energy prices impact national security as well and the stability of our financial markets?

Dr. THORNING. Yes, because as energy prices rise, that means we're diverting resources to—you know, to the consumption of energy that could perhaps be devoted toward infrastructure spending, healthcare, national security. You know, if you look at our economy as a whole, if resources are going into a sector needlessly in the case of, you know, the climate plans this Administration has put forward, it will certainly weaken our ability to be competitive and to be strong nationally in terms of defense.

Mr. BABIN. Okay. And, Mrs. Harbert, would you like to comment on that as well? We are talking about stability of financial markets and impact on national security.

Hon. HARBERT. Keeping, you know, energy affordable and reliable here allows us to have a very healthy economy, and we need a healthy economy to be a very healthy, you know, national security apparatus and to be able to exert our power around the world. They are inextricably linked, and to the extent that we make our economy less competitive, that we are more focused on domestic problems, the less able we are to focus on the growing threat of terrorism.

Let us not forget that also our ability to produce more energy here at home and use it here at home is allowing us not to import and not to finance some of those countries and organizations around the world that don't like us so much.

Mr. BABIN. All right. Thank you so very much. And to follow up where my colleague here, Mr. Palmer, I think we don't have to go too much farther into the history books to see that we have had climate change over the centuries, even during human existence and not just going back pre-human. And this is something that's very common in—when we see our environment and our climate change for the warmer or for the cooler for that matter.

But I want to thank each and every one of you. I yield back my time, Mr. Chairman.

Chairman SMITH. Thank you, Mr. Babin. And the gentleman, Mr. Palmer, is recognized to put something into the record here.

Mr. PALMER. Yes, Mr. Chairman. I would like to enter into the record a report called "Activist Facts."

Chairman SMITH. Okay. Without objection, that will be made a part of the record as well.

[The information appears in Appendix II]

Mr. PALMER. Thank you.

Chairman SMITH. We have no other Members to ask questions, and so before we adjourn, I just want to thank all four of you again for your testimony today. It has just been outstanding. We appreciate the time and effort you contributed to this hearing. And stay in touch with us. Thank you all.

We stand adjourned.

[Whereupon, at 11:47 a.m., the Committee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Judith Curry

Responses to questions submitted by the Committee on Science, Space and Technology

By Judith Curry
Georgia Institute of Technology
May 5, 2015

Questions from the Honorable Lamar Smith:

1. President Obama has warned that, "for the sake of our children and our future, we must do more to combat climate change." He said we must "choose to believe in the overwhelming judgment of science – and act before it is too late."
A. Is there an overwhelming judgment of science or any science, showing that the President's regulatory actions will prevent the threat that he is so concerned about?

If you believe the climate models, then President Obama's INDC commitment (total of 80% emissions reduction by 2050), then warming would be reduced by 0.011 degrees Centigrade by the end of the 21st century. This number that was provided to me by Chip Knappenberger of CATO using the MAGICC model with an equilibrium climate sensitivity of 3.0°C http://www.cato.org/blog/002dcgc-temperature-rise-averted-vital-number-missing-epas-numbers-fact-sheet. If the climate models are indeed running too hot, then the warming would be reduced by an even smaller number.

2. We have heard a lot of doomsday scenarios about what will happen if we do nothing on climate change. However, there has been less attention to what the results of any actions we take to combat climate might be.
A. Suppose we cut all greenhouse gas emissions in the United States. Would this avert the supposed catastrophic impacts?

Eliminating all U.S. greenhouse gas emissions by 2050 would reduce the warming by 0.014°C by the end of the 21st century (using the same calculations in 1A). This is an amount of warming that is much smaller than the uncertainty in even measuring the global average temperature.

3. Dr. Curry, what happens to academics who step out of line on climate change?
A. Why would experts be afraid to question climate change orthodoxy?

The censure of scientists disagreeing with the IPCC consensus was particularly acute during the period 2005-2010. As revealed by the Climategate emails, there was a cadre of leading climate scientists that were working to sabotage the reviews of skeptical research papers (and presumably proposals for research funding). Further, scientists challenging climate change orthodoxy are subjected to vitriolic treatment in news articles, op-eds and blogs, damaging the public reputation of these scientists. I have heard from numerous scientists who are sympathetic to my efforts in challenging climate change orthodoxy, but are afraid to speak out or even publish skeptical research since they are fearful of losing their job.

Since 2010, things have improved somewhat especially in Europe; I think this has largely been due to reflections following Climategate and the fact that disagreement about climate change is not as starkly divided along the lines of political parties (i.e. the science is somewhat less politicized). In the U.S., President Obama's recent pronouncements about climate denial and climate deniers (as anyone who does not agree with the consensus) has increased the toxicity of the environment (both academic and public) for scientists that question the IPCC consensus on climate change.

4. Dr Curry, have climate models been in the same as actual, observed temperatures?
A. Does the failure of climate models matter?
B. Have the U.S. climate models ever been run with lower sensitivity? If so, have these results been archived for public access?

Particularly for the past decade, climate models have been running too hot, predicting more warming than has been observed (refer to the figure on page 6 of my testimony http://www.climate-lab-book.ac.uk/comparing-cmip5-observations/.

The discrepancies between observed surface temperatures and climate model simulations indicates that climate models are not useful for predicting climate on decadal time scales (out to 20 years) or for regional spatial scales. If the slow down in warming continues for another few years, then the observations will be completely outside of the envelope of climate model predictions.

I have argued that climate models are not fit for the purpose of simulating decadal scale and regional climate variability. Climate models are mainly useful for scientific exploration of mechanisms in the climate system. Whether they are at all useful for projections of century scale climate change remains to be seen, but I am doubtful.

For the main climate models used in the CMIP5 simulations for the IPCC AR5, climate sensitivity is an emergent property and not one that is easily specified in the models. For simpler climate models, such as MAGICC http://www.cgd.ucar.edu/cas/wigley/magicc/, climate sensitivity can be specified, see http://www.cato.org/blog/002degc-temperature-rise-averted-vital-number-missing-epas-numbers-fact-sheet

5. The input to the models is the aggregate emissions, not the annual emissions. Do you have any estimate of the aggregate emissions of China, India, and Russia between 2005 and 2030?
A. How does this compare to the aggregate emissions REDUCTIONS claimed by the Obama Administration for the U.S.?

This is sufficiently outside of my expertise that I am respectfully declining to answer this question.

6. Dr. Curry, you mention uncertainty and the importance of understanding natural climate variability better before inferring sensitivity to greenhouse gases.
A. What are the current key gaps in our understanding of natural climate variability?

- Solar impacts on climate (including indirect effects). What are the magnitudes and nature of the range of physical mechanisms?
- Nature and mechanisms of multi-decadal and century scale natural internal variability. How do these modes of internal variability interact with external forcing, and to what extent are these modes separable from externally forced climate change?
- Deep ocean heat content variations and mechanisms of vertical heat transfer between the surface and deep ocean.
- The strength of carbon cycle feedbacks (both land and ocean)
- Climate dynamics of clouds: Could changes in cloud distribution or optical properties contribute to the global surface temperature hiatus? How do cloud patterns (and TOA and surface radiative fluxes) change with shifts in in atmospheric circulation and teleconnection regimes (e.g. AO, NAO, PDO)? How do feedbacks between clouds, surface temperature, and atmospheric thermodynamics/circulations interact with global warming and the atmospheric circulation and teleconnection regimes?

B. What are the most glaring or problematic uncertainties, ambiguities and areas of ignorance at this state in our understanding of climate change?

In my opinion, the IPCC has oversimplified their treatment of uncertainty, and fail to include ambiguities and areas of ignorance in their confidence levels

There are three overarching issues in our understanding of climate change:
- Whether the warming since 1950 has been dominated by human causes
- How much the planet will warm in the 21st century
- Whether warming is dangerous

In addition to the points in A above I would add:
- Sensitivity of the climate system to external forcing, including fast thermodynamic feedbacks (water vapor, clouds, lapse rate).
-

C. What might happen if we miscalculate the atmosphere's sensitivity to greenhouse gases and incorporate this miscalculation into global policies and strategies that are not flexible and adaptive?

We risk damaging our economy and current energy infrastructure

D. Would you characterize any of the policies discussed in the U.S., such as major industrial CO2 restrictions, as flexible and adaptive?

Drastic emissions reductions that require rapid and major changes to energy infrastructure are not flexible and adaptive. Among flexible and adaptive policy responses, I would include the following:

- Energy conservation and efficiency measures
- Elimination of methane leaks
- Management of air pollution issues (ozone, small particulates)
- Reducing vulnerability to extreme weather events

7. In October 2014, you co-authored a paper that discussed climate sensitivity. Climate sensitivity is a simple metric for estimating how much warming should occur from a doubling of CO2. The IPCC has bounced around in the last 3 reports, being unwilling to provide a "best estimate" in the latest report.
A. How important is it to understand how sensitive the climate is to changes in greenhouse gases like CO2 (climate sensitivity) to determine actual impacts from the "national commitments" made by the Obama Administration and other governments?

Climate sensitivity is a direct input into the EPA MAGICC model, and into impact assessment models used to calculate the social cost of carbon. Therefore, climate sensitivity is a key input into policy making.

B. How well do we understand or "know" what the climate sensitivity is? What does the IPCC think the best estimate of climate sensitivity is?

Since the IPCC AR4 in 2007, estimates of climate sensitivity have overall been lowered. There is a dichotomy between climate model estimates (higher) and observation based estimates (lower).

C. What do actual observations (vs. models) suggest about climate sensitivity?

The most recent estimates from observations suggest a transient climate response of 1.05 to 1.45 ^{o}C and equilibrium climate sensitivity of 1.2 to 1.8 ^{o}C [17-83% range] http://judithcurry.com/2015/03/19/implications-of-lower-aerosol-forcing-for-climate-sensitivity/

These values are significantly lower than climate model estimates of climate sensitivity.

8. In the next 50 years (or 100 years), how much projected climate warming is expected to be the result of humans and how much is expected to be due to various natural causes?

The IPCC does not even attempt to project future climate change from the various natural causes.

A. What is our confidence level in these estimates?

Under the IPCC's scenario of highest emissions (RCP8.5), the IPCC AR5 projects a *likely* increase of global mean surface temperatures for 2081–2100 relative to 1986–2005 to be 2.6°C to 4.8°C (RCP8.5). The *likely* confidence implies that there is a 34% chance that the increase could lie outside this range. Personally, I think the IPCC is overconfident in their estimate; I would expect the warming to lie below this range.

B. When we hear projections of climate impacts, how much of these can we avoid with modest actions, and how much of this is basically unavoidable?
C. Can we stop hurricanes, tornadoes, earthquakes – "mother nature" with the actions that the president is promising?

Extreme weather and climate events have always occurred and will continue to occur. Further, sea level has been rising since the last ice age. Even if you believe the climate models and the IPCC assessment and we are successful at eliminating CO_2 emissions, we would not expect to notice any significant difference in extreme events at the end of the 21st century. Measures to reduce our vulnerability to weather and climate extremes make sense whether or not humans are influencing climate in any significant way.

9. Are the current global temperatures running above or below that has been predicted by computer models? Why?

For the past decade, global surface temperatures have been running cooler than the model projections. The lack of recent warming appears to be caused by changes in ocean circulations in the Pacific and Atlantic Oceans, with perhaps some contribution from the sun.

10. Setting aside the uncertainties surrounding the science of climate change, some have argued that climate mitigation policies are like an insurance policy. Some claim that this "climate insurance policy" would protect us from the most severe consequences of climate change.

If we are to view climate mitigation policies as an insurance policy, the cost of the policy needs to be commensurate with the possible damage, and the policy has to actually be effective at shielding the policy holder from losses.

Further, there are also risks in implementing a premature response with inadequate technologies.

A. Would taking these emission reduction steps, like those outlined in the President's INDC, actually mitigate the potentially severe impacts activists are pointing to?

The President's INDC is not a good insurance policy since it it costs more than it saves (at least on the timescale of the 21st century) and cannot deliver its promised benefits.

B. When people talk about potential economic consequences of inaction of delayed action, are they only counting what the actions they are advocating would prevent? Or is there some fuzzy math going on here?

The concern about inaction comes from concern about passing the 2°C 'danger' threshold, possibly by mid-century. This concern relies on a very weak assessment that 2°C of warming is actually 'dangerous' and that we can believe the climate models (which seem to be running too hot).

Questions from the Honorable Barry Loudermilk:

1. In the past decade, and more predominantly in the past eight years, the federal government has spent a great deal of financial resources chasing the idea that humans are the primary cause of climate change and global warming.

2. Are there other areas of federally supported critical scientific research and development that have suffered of fallen behind due to the heightened focus on climate change?

I will restrict my comments to funding allocation WITHIN the field of climate change. Too much funding is being allocated to climate modeling and climate impact assessments, and not enough to observing systems and to understanding natural variability – in particular the sun and ocean circulations. Paucity of funding to support research in natural climate variability has resulted in bias in our understanding of the causes of climate change.

3. Have we seen improvements in environmental factors related to climate change in the past several decades? For example, have we seen growth or resurgence in tropical rainforests or growth of ice caps and glacial areas?

Satellite observations show that the planet has been getting greener for the past two decades, in terms of vegetation growth. This is attributed to an increase in CO_2 and also a generally warmer, wetter climate
http://visibleearth.nasa.gov/view.php?id=1804

4. Is there potentially a negative impact of overbearing environmental regulations? For example, would higher energy prices force more Americans to use their fireplaces as a source of heat, which might product more CO_2 per household than the ratio generated by power plants?

Energy regulations that push premature implementation of technologies (e.g. wind and solar) risk diverting resources away from genuine energy technology innovation. Energy regulations that raise energy prices will be a disproportionate burden to the poor.

Responses by The Honorable Karen Harbert

QUESTIONS FOR THE RECORD

The Honorable Lamar Smith (R-TX)
U.S. House Committee on Science, Space, and Technology

The President's UN Climate Pledge: Scientifically Justified or a New Tax on Americans?

Questions for The Honorable Karen Harbert

1. **President Obama has warned that, "for the sake of our children and our future, we must do more to combat climate change." He said we must "choose to believe in the overwhelming judgment of science—and act before it's too late."**
   A. **Is there an overwhelming judgment of science, or any science, show that the President's regulatory actions will prevent the threat that he is so concerned about?**

Not matter how one views the science, it is generally recognized, even by the Environmental Protection Agency (EPA), that the administration's unilateral actions will have little impact on the climate. As Dr. Curry notes in her written testimony, "It has been estimated that the U.S. INDC of 28% emissions reduction will prevent 0.03°C in warming by 2100."

2. **We have heard a lot of doomsday scenarios about what will happen if we do nothing on climate change. However, there has been less attention to what the results of any actions we take to combat climate might be.**
   A. **Suppose we cut all greenhouse gas emissions in the United States. Would this avert the supposed catastrophic impacts?**
   B. **What could be the impacts to the U.S. economy if we cut all greenhouse gas emissions? Why couldn't we just switch to renewables?**

Cutting U.S. greenhouse gases to zero would only slow the growth in global greenhouse gas emissions, the vast majority of which will come from emerging and developing countries that place economic development well ahead of addressing climate change. The International Energy Agency's World Energy Outlook 2014's central estimate suggest that while global carbon dioxide emissions from energy will increase 20% between 2012 and 2040, carbon dioxide emissions from developing (i.e., non-Organization for Economic Co-operation and Development) countries will jump by 46% over the same period. In other words, emissions growth in developing countries will more than make up for expected emissions declines in developed countries. EPA's Clean Power Plan will not alter this dynamic in any meaningful way.

Switching to all renewables would be impracticable for many reasons, not least of which is the cost this would impose on U.S. consumers and businesses. While the costs of many forms of renewable energy continue to decline, these technologies remain uncompetitive with more traditional forms of energy. Renewables such as solar and wind provide power intermittently, not necessarily when needed, a huge drawback that complicates the smooth, reliable operation of the power grid. Large-scale electricity storage technologies may help relieve this conundrum, but these are still many years if not decades away. In the meantime, relying strictly on renewables would require back-up sources of power. Moreover, because renewable sources are tied to the location of the energy resource, a huge build-out of transmission infrastructure would be required to move electricity from renewable facilities to demand centers.

My written testimony points out how the United States has a tremendous energy advantage that makes our energy-intensive industries much more competitive, with electricity and natural gas prices for industry two to four times cheaper than many of our overseas competitors. Moving to more expensive sources of energy jeopardizes this hard-won economic advantage.

3. **How can we verify foreign countries compliance with their commitments?**
    A. **For example, Russia is claiming forest offsets. How does that get counted and verified?**
    B. **How can we trust countries that are willing to invade other countries to be honest reporting partners?**
    C. **Are other countries agreeing to drone or satellite surveillance for monitoring and verification purposes?**

Measuring, reporting, and verification of country pledges will be a big part of any international agreement. The measurement of carbon dioxide emissions and removals from land use and land use change is very difficult, and the use of forest offsets in emissions reduction efforts is subject to a great deal of controversy. Many countries also have voiced concerns about how intrusive this process might be and what it might mean for national sovereignty. There is probably no surefire way to prevent a country that is determined to cheat from cheating.

Questions of transparency are tangled up in questions about the legal form of the ultimate agreement coming out of Paris later this year. The United States backs a system proposed by New Zealand where, according to the U.S. Special Envoy for Climate Change, Todd Stern:

> *"[T]here would be a legally binding obligation to submit a 'schedule' for reducing emissions, plus various legally binding provisions for accounting, reporting, review, periodic updating of the schedules, etc. But the content of the schedule itself would not be legally binding at an international level."*

It is interesting to note that under this approach, compliance would revolve around implementation measures, not whether a country actually meets its stated goal:

> *"[T]he content of the schedule itself would not be legally binding at an international level."*

4. **Ms. Harbert, Mr. Schmidt references a World Recourses Institute study as evidence that the U.S. target is achievable under current laws. This seems to conflict with your**

testimony that the U.S. will come up about 40% short of its commitment. Do you agree with Mr. Schmidt?

A. **Are there any other studies you know of that back up this WRI analysis?**

Fundamentally, our analysis differs from the World Resources Institute (WRI) analysis in that we estimate emissions reductions based on new policies that have been *announced* by the administration, not *potential* policies that may be announced at some future date. We find that what the administration has proposed falls well short of meeting a 26% to 28% reduction in U.S. net greenhouse gas emissions from the 2005 level by 2025, something the WRI study also shows. Its analysis includes a "Go-Getter" scenario that is consistent with the 26% to 28% reduction goal the Obama Administration outlined in its Intended Nationally Determined Contribution (INDC). WRI's paper notes, however, that to achieve the "Go-Getter" goal:

> *". . . **additional federal and state actions will be required** to move U.S. GHG emissions from the current 'Base Case' trajectory to a more ambitious 'Go-Getter' trajectory that achieves the targets."*

So WRI's analysis agrees with our analysis that a sizeable gap exists between announced policies and what is needed to meet the administration's 26% to 28% goal for 2025.

5. **Could US jobs could be lost if electricity and natural gas prices increase for US energy intensive, trade exposed manufacturers?**
    A. **How are job losses considered by the Administration?**
    B. **Is the potential for new "green jobs" enough to offset the manufacturing jobs we are talking about losing?**
    C. **Is "carbon leakage" something that the Administration accounts for?**

It is well understood that America's abundance of affordable, reliable energy provides businesses a critical operating advantage in today's intensely competitive global economy. Affordable and reliable fuel and electricity, supplied by a diverse mix of coal, nuclear, and increasingly natural gas, give American industry an enormous economic edge, and they are driving a manufacturing revival in areas of the country desperately in need of jobs and investment. Unlike many green jobs, the jobs these industries create do not depend on government subsidies. They are instead an outgrowth of greater economic activity and private-sector capital investment spurred on by lower energy prices.

The administration's goal almost certainly will lead to "carbon leakage" from the U.S. as energy intensive industries flee to countries with less regulation and lower energy costs. We are seeing something similar happening in Europe, which has some of the highest electricity prices in the world. More and more, we are seeing European companies fleeing sky-high energy costs and shifting production to the United States and other countries. This experience is consistent with the conclusion of the Intergovernmental Panel on Climate Change Fourth Assessment report, which found that actions governments took to implement the Kyoto Protocol resulted in economy-wide leakage on the order of 5% to 20%. Similar results could be expected in the United States as a result of EPA regulation.

6. **Which technologies that the Administration has included in their analysis are actually being used in commercial facilities? For example, in the Administration's explanation of its INDC in Peru in December, cellulosic biofuels were given as a specific solution, but cellulosic isn't commercial yet.**
   A. **Why should the rest of the world believe a President that plans to rely on "phantom fuels"?**
   B. **What portions of the commitments are merely speculative because they haven't been proven commercially?**
   C. **What portions are on shaky legal footing?**

It is very problematic to bank on the significant penetration of technologies—like cellulosic ethanol or carbon capture and storage—that are not commercially available today. Technology development is unpredictable and can move in fits and starts. Given the sparse information supplied by the administration, it is difficult to determine what portions of the commitment may be dependent on unpredictable technology change.

In addition, there is also the question of whether existing technologies would be able to be built-out to support the goal. The natural gas pipeline network, for example, needs to be expanded dramatically if states are to meet EPA's proposed Clean Power Plan goals for switching from coal to natural gas in power production. If this infrastructure cannot be built in a timely manner, it will be very difficult to meet one of the key requirements EPA has laid out in its proposed rule for existing power plants.

But all of that is dependent on the legality of the rule itself. EPA's attempted takeover of the U.S. electricity system through its Clean Power Plan rests on unprecedented and highly-questionable legal interpretations of the Clean Air Act. States and other stakeholders have raised countless legal concerns with the proposed rule, but the following fundamental issues have emerged as common themes:

- Prohibition on double-regulation of sources: First, the Agency claims it can regulate greenhouse gas emissions from fossil fuel power plants under a rarely-used portion of the Act, §111(d), despite statutory language prohibiting EPA from regulating power plants under this section if they are already subject to regulation under §112.

- Prohibition on outside-the-fence-line mandates: Second, the Agency claims it can compel states to impose legal obligations on entities "outside the fence line" of the regulated plants—such as requiring greater dispatch of electricity from plants fired by natural gas instead of coal, increasing electricity generation from renewable sources, and even mandating a reduction in consumer electricity demand—despite statutory language requiring EPA to set emission standards based solely on what can be achieved "inside the fence line." Indeed, absent the submission of conciliatory State Implementation Plans, EPA would not be able to require "outside the fence line" emissions reductions because it lacks authority in these areas.

In addition, there are the questions of whether EPA is justified in setting state standards for existing power plants that in total exceed the stringency of the standards set for new plants and whether the EPA's underlying technical assumptions are unrealistic.

7. **Ms. Harbert, said that the math doesn't seem to add up with the U.S. international commitment.**
    A. **Does this mean that the President is going to ask Americans to sacrifice even more?**
    B. **If the math doesn't add up on the goal for the next decade of 26-28%, and highlights even greater uncertainty related to the idea of ever reaching 80% reductions, why should the rest of the world believe the President?**
    C. **The President has also made promises about the US paying billions things like the Green Climate Fund. Can he really do this without Congress?**
    D. **Does the rest of the world realize that under our system a President can't give money unilaterally?**
    E. **If the President doesn't bring a Paris agreement to the Senate for advice and consent, can't another president undo this with the stroke of the pen?**

It is clear that the administration has not identified in any detail how it expects to reach the 26% to 28% emissions target in its INDC. Based on our analysis of the INDC and announced policies to date, we believe that other policies will have to be put into place. Conspicuous by its absence in the INDC is any reference to emissions from the industrial sector. I think it is more than likely that the administration plans to get at least some reductions from energy-intensive industrial sectors. In fact, EPA's fiscal year 2015 budget proposal stated the agency will soon begin considering new regulations governing greenhouse gas emissions from the refining, pulp and paper, iron and steel, livestock, and cement sectors. Reaching an 80% emissions reduction by 2050 would be even more challenging. Achieving such a goal would put our emissions intensity and emissions per capita on par with countries like present-day Haiti, Afghanistan, North Korea and Chad. It is hard to imagine how an energy-hungry, highly-developed country with a population projected to grow to more than 400 million people by 2050 could realistically cut emissions so drastically in such a short space of time.

The larger point is that other countries are beginning to take notice of the lack of transparency in the administration's pledge. This goes not just for the emissions goal itself, but also in regards to funding for mitigation activities in developing countries, primarily through the Green Climate Fund. The billions of dollars the administration has pledged to the fund would, as you suggest, require Congressional approval, something other countries are beginning to understand. They are also beginning to understand that without Congressional approval, any agreement reached in Paris will be political only and could be undone by a subsequent president.

8. **If other countries don't commit to sacrifices as painful as the US, could that put them at a competitive advantage?**

Yes. In today's very competitive trade environment, policies that could drive up energy costs, like those being implemented and considered by the administration, could wipe out the U.S. energy advantage.

9. **Setting aside the uncertainties surrounding the science of climate change, some have argued that climate mitigation policies are like an insurance policy. An insurance policy that some claim would protect us from the most severe consequences of climate change.**
   A. **Could taking steps now actually mitigate the potentially severe impacts activists are pointing to?**
   B. **When people talk about potential economic consequences of inaction or delayed action, are they only counting what the actions they are advocating would prevent? Or is there some fuzzy math going on here?**

Climate change is an intergenerational challenge, both in terms of potential climate impacts and policies needed to transition to a low-carbon economy while at the same time ensuring economic growth. Such long timelines make it extraordinarily difficult to answer these questions with any precision. One thing we know about current forecasts is that they will be wrong, but how and why they will be wrong is something we cannot anticipate. We do know, however, that robust economies are much more resilient to climate variability and much more able to make investments in new technologies.

10. **Ms. Harbert, current negotiations with Iran over a nuclear deal has striking parallels. It might seem unrelated, but it demonstrates that the President can't go-it-alone. He has to convince Congress that it's a good idea—otherwise he can't make deals.**
    A. **Does the Administration plan to bring anything agreed to in Paris to Congress so that it is actually binding?**

The administration's reticence to seek Congressional approval for any new climate agreement means that whatever the U.S. agrees to in Paris will not be binding on future presidents and Congresses. Congress should be given the opportunity to weigh in on an agreement of such economic significance.

Responses by Mr. Jake Schmidt

Answers to Questions for the Record Following a Hearing on *The President's UN Climate Pledge: Scientifically Justified or a New Tax on Americans?*

On April 15, 2015, the U.S. House Committee on Science, Space, and Technology convened a hearing at which Jake Schmidt, Director, International Program, Natural Resources Defense Council (NRDC). This document provides NRDC's answers to Questions for the Record posed by The Honorable Eddie Bernice Johnson.

1. In her written testimony, Ms. Harbert suggested that the United States would be getting the "raw end of the deal" if it were to implement the President's UN Climate Pledge because "large emerging countries...have little desire to take on ambitious commitments." Her testimony also stated that the U.S.-China announcement from November 2014 "amounts to little better than business as usual" for China. Your written testimony seemed to suggest that you disagree with Ms. Harbert's position.
   A. Question: How would you respond to those who claim the cuts proposed by the U.S. and other countries are unrealistic or achievable?
      Answer: A number of independent analysts have found that the U.S. can meet its target to cut emissions up to 28 percent below 2005 levels by 2025. These analysis has found that it can be done under existing law, cost effectively, and through known technologies. The World Resources Institute (WRI) found that: "Federal and state actions can promote economic growth and reduce emissions 26-30 percent below 2005 levels by 2025".[1] Their analysis looked at a series of measures across key sectors of the U.S. economy, using readily available technologies and policies. Similarly, analysis conducted by Energy and Environmental Economics, Inc. for the Sustainable Development Solutions Network (SDSN) and Institute for Sustainable Development and International Relations (IDDRI) found that: "it is technically feasible for the U.S. to reduce CO2 emissions from fossil fuel combustion to less than 750 MtCO2 in 2050, which is 85% below 1990 levels".[2] This project also found similar results for the 15 countries where they conducted detailed analysis of a pathways to significant cuts in greenhouse gas emissions.[3]

      In addition, one of China's most important think tanks - the National Center for Climate Change Strategy and International Cooperation (NCSC) - released two reports detailing how a national cap on coal consumption can help China peak its CO_2 emissions earlier than its official 2030 commitment date. This analysis was released by the China Coal Cap Project, a joint initiative of 20 academic, government and non-profit researchers led by NRDC. This analysis found that China's CO_2 emissions could peak by 2025 if it enacts a strong national coal cap policy that controls coal consumption to four billion tons by 2020 and 3.5 billion tons by 2030.

---

[1] See: World Resources Institute, 2015, Delivering on the U.S. Climate Commitment: A 10-Point Plan Toward Low-Carbon, available at: http://wri.org/sites/default/files/Delivering_on_the_US_Climate_Commitment_ES.pdf

[2] See: Deep Carbonization Pathways Project (2014), *Pathways to Deep Decarbonization: United States Chapter*, available at: http://unsdsn.org/wp-content/uploads/2014/09/DDPP_2014_report_United_States_chapter.pdf

[3] See: Deep Carbonization Pathways Project (2014), *Pathways to Deep Decarbonization:*, available at: http://unsdsn.org/wp-content/uploads/2014/09/DDPP_Digit_updated.pdf

This level of coal cap is under serious discussion as a new target in China's next Five Year Plan.[4] This is a similar finding to a recent study from researchers at the London School of Economics which looked at some of the structural changes occurring in the country and found that emissions could peak by 2025 or sooner.[5]

B. Question: Can you please explain the policy changes and shifts that have occurred in China and other developing countries toward significant action on climate change?
Answer: Key developing countries like China and India are implementing a number of actions to significantly cut their emissions. Since they made international commitments during the Copenhagen Climate Summit, they have implemented a series of domestic actions to spur more renewable energy, expand energy efficiency, and implement other measures to curb greenhouse gas emissions. For example, in China coal consumption is such a large part of China's CO_2 emissions, steps it is taking to increase renewable energy, increase energy efficiency, and put in place limits on total coal consumption will go a long ways towards helping meet its climate target. These include:
   - *Renewable energy*. China has a National Renewable Energy Law that has helped the country increase its domestic wind and solar energy deployment from almost nonexistent a decade ago to the largest in the world today. The National Energy Development Strategy Action Plan has set ambitious targets for wind power and solar PV capacity to reach 200 GW and 100 GW by 2020 – from 96 GW (grid connected) and nearly 28 GW, respectively, at the end of 2014. China already has the world's largest installed wind capacity and will likely overtake Germany as the country with the most installed solar PV capacity this year.
   - *Energy efficiency*. China's 12th Five Year Plan set a binding energy efficiency target to cut energy consumption per unit of GDP by 16 percent from 2011-2015. They are meeting this target through a set of measures, including mandatory energy efficiency programs for the top 15,000 energy consuming companies in the country. Last year, China surpassed its key energy efficiency target by cutting energy intensity by 4.8 percent below 2013 levels, putting it on track to meet its 16 percent reduction target.
   - *Coal consumption caps*. In response to China's air pollution, mandatory coal consumption caps have been adopted in many of China's largest coal consuming provinces. Beijing, Tianjin, Hebei and Shandong, some of the largest coal-consuming provinces, have announced a target to reduce their coal consumption by 83 million tons by 2017, compared to 2012 levels. Shanghai, Zhejiang, Jiangsu and Guangdong (for its industrial Pearl River Delta) will announce their 2017 coal reduction targets by June this year. As discussed above, the State Council in the new Energy Development

---

[4] For more see: http://switchboard.nrdc.org/blogs/bfinamore/how_capping_coal_can_help_chin.html
[5] Green and Stern, 2015, China's "new normal": structural change, better growth, and peak emissions, available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/06/Chinas_new_normal_green_stern_June_2015.pdf

Strategy Action Plan established a national coal consumption cap of 4.2 billion tons for 2020.

- *Carbon Emissions trading*. Eight pilot emissions trading programs have been established: six in the cities of Beijing, Tianjin, Shanghai, Shenzhen, Chongqing and Qingdao and two in Guangdong and Hubei provinces. The government announced plans to establish a national emissions trading program as early as 2016. The National Development and Reform Commission (NDRC) published the "Interim Measures for Carbon Emissions Trading" (Chinese) that provide the basic rules for the national trading program.

At the Copenhagen climate summit India committed to reduce the emission intensity of its GDP 20-25 percent by 2020 compared to 2005 levels. As part of its overall strategy, in 2007 India released its National Action Plan on Climate Change, which includes priority missions such as energy efficiency and solar initiatives. Prime Minister Modi has recently reemphasized that climate change is a priority for India, and announced ambitious clean energy goals to help provide energy access throughout the country. India's current climate actions include efforts to spur more renewable energy and energy efficiency:

- *Solar targets*. India's flagship National Solar Mission, which originally aimed to install 20 GW of solar power capacity by 2022, is now targeting 100 GW of solar by 2022. In just four years, India's solar market has grown more than 100 fold to nearly 3 GW of commissioned projects by the end of December 2014. A 2014 assessment of India's solar capacity revealed the India could install as much as 700 GW of solar energy. Scaling their solar effort to meet this more aggressive target is a critical priority for the Modi Administration.
- *Wind targets*. India is also the world's fifth largest wind energy producer. The Modi government is aiming to achieve 40 GW of onshore wind power by 2019, doubling its currently installed wind capacity. In 2015, the Modi government renewed its commitment to launch a National Wind Mission, targeting a goal of 60 GW of utility-scale wind power and 1 GW of distributed wind power by the end of 2022.
- *Energy efficiency*. The government launched the Energy Conservation Building Code in 2007 and plans to make it mandatory nationally by 2017. This code would establish energy efficiency codes and standards for buildings. Seven of India's 29 states have made the code mandatory as of June 2014, and 15 more plan to follow. India also has a program called Perform, Achieve, and Trade (PAT) to encourage energy-intensive industries in India, such as thermal coal power plants and cement and steel manufacturing, to become global efficiency leaders. India also has a strong standards and labeling program for key appliances, such as lighting, fans, and air-conditioners.
- *Coal tax to fund renewables*. To support the accelerated growth of renewables, India has quadrupled an innovative coal tax to Rs. 200 (approximately $3.20) per metric ton to fund a National Clean Energy Fund.

C. Question: Can you please discuss the importance of U.S. leadership in addressing climate change and the impact of a strong U.S. pledge on the commitments of other countries?
Answer: The U.S. is the world's largest economy, a global leader on a range of issues, and historically the biggest barrier to an international agreement on climate change. So what the U.S. does on climate change sends a powerful signal to other countries and markets. For example, the U.S. Climate Action Plan and the strategies that have been implemented pursuant to that plan have given the U.S. a lot more credibility as it encourages other countries to cut their emissions. It is unlikely that the U.S.-China agreement would have occurred if the Chinese didn't believe that the U.S. was prepared to act aggressively at home to reduce emissions.

D. Question: Can you also comment on the need to maintain U.S. commitments over the long-term and concerns about sustaining progress over future Administrations?
Answer: Strong and sustained U.S. climate action is essential in efforts to address climate change given the scope of U.S. emissions, the leadership role we play, and focus that other countries have on what the world's largest economy does. Ensuring that these actions continue over the course of decades – spanning several subsequent Administrations – will be essentially to staving off the worst impacts of climate change. Countries often wonder if the U.S. can continue to implement those actions even when Administrations change. When meeting with other countries I'm often asked: "can the U.S. keep implementing these measures when the current Administration leaves office?". If the U.S. weakens its domestic implementation it could have a ripple effect on other countries as it will signal that we aren't serious. Luckily, countries are more clearly recognizing that domestic climate action leads to reduced air pollution, poverty alleviation, and reduced stress on the economy from climate impacts. So they have much stronger domestic motivation to take action than they did a decade ago.

2. During the course of the hearing, some Members and witnesses seemed to suggest that the scientific community is uncertain about the contribution of humans to climate change and that since the science of climate change is largely "unsettled", actions to reduce carbon emissions are unwarranted. Despite any remaining uncertainties surrounding the science of climate change, many would argue that enacting climate policies is comparable to taking out a "climate insurance" policy and protecting ourselves from the most severe consequences of climate change.

A. Question: Can you please discuss the importance of taking steps now to mitigate the impacts of potentially severe climate consequences?
Answer: A recent report from the President's Council of Economic Advisors, *The Cost of Delaying Action to Stem Climate Change,* points out that each year of delay makes it harder to meet a given "safe" climate stabilization level.[6] As the report highlighted: "each year of delay means more CO2 emissions, so it becomes increasingly difficult, or even infeasible, to hit a

---

[6] See:
https://www.whitehouse.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf

climate target that is likely to yield only moderate temperature increases". Part of the need for urgent action is also clear by what is often referred to as "lock-in". Many of the investments by companies, countries, and individuals in buildings, power plants, infrastructure etc. last for decades. What kind of climate impact those investments will have, therefore, are much larger than the simple act of building them. If we "lock-in" infrastructure that has significant climate impacts then those emissions will continue to build for many decades into the future. Typically it is cheaper over the life of those investments to ensure that they lead to lower energy-use and climate impacts than it is to prematurely shut them down and re-build them at a later stage with a lower energy-use.

B. Question: What are the potential consequences, including economic consequences, of inaction or delayed action? Studies of climate action have consistently found that early action reduces the cost of action and the potential damages of not address climate change. A recent report from the President's Council of Economic Advisors, *The Cost of Delaying Action to Stem Climate Change*, detailed these findings. As the study found: "Based on a leading aggregate damage estimate in the climate economics literature, a delay that results in warming of 3° Celsius above preindustrial levels, instead of 2°, could increase economic damages by approximately 0.9 percent of global output...Moreover, these costs are not onetime, but are rather incurred year after year because of the permanent damage caused by increased climate change resulting from the delay."[7]

3. Mr. Schmidt, last month, John Conger, the Deputy Under Secretary of Defense for Installations and Environment, testified before the Senate Armed Services Committee and addressed the impact of climate change on the Department of Defense and our national security. He stated that, "Our warfighters cannot do their jobs without bases from which to fight, on which to train, or in which to live when they are not deployed. When climate effects make our critical facilities unusable, that is an unacceptable impact."

   A. Question: Can you please comment on the importance of addressing climate change as it relates to our security and the stability of other countries?
   Answer: The national security community typically refers to climate change as a "threat multiplier". The Quadrennial Defense Review (QDR) 2014 – a study by the U.S. Department of Defense that analyzes strategic objectives and potential military threats – highlighted climate change in a number of parts of its assessment [8]. As the QDR states: "As greenhouse gas emissions increase, sea levels are rising, average global temperatures are increasing, and severe weather patterns are accelerating. These changes, coupled with other global dynamics, including growing, urbanizing, more affluent populations, and substantial economic growth in India, China, Brazil, and other nations, will devastate homes, land, and infrastructure. Climate change may exacerbate water scarcity and lead to sharp increases in food costs. The pressures

---

[7] See: https://www.whitehouse.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf

[8] See: http://www.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf

caused by climate change will influence resource competition while placing additional burdens on economies, societies, and governance institutions around the world. These effects are threat multipliers that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions – conditions that can enable terrorist activity and other forms of violence".

The Center for Climate and Security outlines several reasons why the national security is concerned about climate change.[9] As they point out the national security community is concerned about climate change leading to "indirect threats in regions of the world that are either of strategic interest to the United States, or whose instability could ultimately lead to direct threats to the United States". The impacts of climate change are often around food, water, access to resources, and other factors that regularly lead to destabilization of communities and countries. So to the extent that these challenges are exacerbated by climate change – as documented in the Intergovernmental Panel on Climate Change – these climate impacts can have devastating impacts on unstable societies. For example, as the Center for Climate and Security paper states: "Climate change may also place stresses on food security by increasing the severity, frequency and variability of crop-damaging events like droughts and floods. Because of the nature of the global food market, this can sometimes result in spikes in world food prices, increasing the likelihood of instability in places that depend on affordable imported food, such as Egypt".

[9] See: Center for Climate and Security, 2014, Climate and Security 101: Why the U.S. National Security Establishment Takes Climate Change Seriously, available at: https://climateandsecurity.files.wordpress.com/2012/04/update_climate-and-security-101_why-the-u-s-national-security-establishment-takes-climate-change-seriously_briefer-232.pdf

Responses by Dr. Margo Thorning

QUESTIONS FOR THE RECORD

The Honorable Lamar Smith (R-TX)

U.S. House Committee on Science, Space, and Technology

The Presidents UN Climate Pledge. Scientifically Justified or a New Tax on Americans?

Monday, May 04, 2015

Questions for Dr. Thorning

1. Question: President Obama has warned that, "for the sake of our children and our future, we must do more to combat climate change." He said we must "choose to believe in the overwhelming judgment on science—and act before it's too late."

A. Is there an overwhelming judgement of science, or any science, that the President's regulatory actions will prevent the threat that he is so concerned about?

Answer: The science about a link between the growth in GHG emissions and a warming of the earth's atmosphere is still unsettled. Experts from international organizations, the U.S. Environmental Protection Agency, academia and energy consulting firms conclude that in order to reduce the growth in GHGs, a global effort is needed, with all the major emitters in developing countries such as China, India, Brazil, Russia, taking commitments to reduce their emissions. If the U.S. adopts unilateral GHG reduction commitments, there will be almost no difference in global GHG concentrations in the atmosphere by 2100. U.S. GHG emissions are predicted to be flat over the next several decades while those in developing countries will grow exponentially, see Figure 1 of my April 15, 2015 testimony before the committee, http://accf.org/wp-content/uploads/2015/04/ACCF-testimony-April-15-2015-FINAL.pdf

Thus, actions taken by the Obama Administration to reduce U.S. GHG emissions will tend to slow both productive investment and GDP growth while doing virtually nothing reduce global concentrations of GHGs in the atmosphere.

2. Question: We have heard a lot of doomsday scenarios about what will happen if we do nothing on climate change. However, there has been less attention to what the results of any actions we take to combat climate might be.

A. Suppose we cut all greenhouse gas emissions in the United States. Would this avert the catastrophic impacts?

B. What could be the impacts to the U.S. economy if we cut all greenhouse gas emissions?

Answer:

A. Reducing U.S. GHG emissions to zero would have almost no impact on the growth in GHGs in the atmosphere due to emission growth in developing countries(see answer to question #1 above). The relationship between GHG emissions and changes in the earth's temperature is still uncertain;

continued research by scientists around the globe is needed to help the U.S. and the international community understand what actions may be need.

B. Reducing U.S. GHGs to zero would shut down the U.S. economy and result in hardship for all Americans. Previous ACCF economic modeling on the impact of cap-and trade bills has shown significant reductions in GDP and employment due to significant increase in energy prices.(see, for example, ACCF analysis of the Kerry/Lieberman bill in 2010 at http://accf.org/wp-content/uploads/2010/07/ACCF-SBEC-K-L-Analysis-7-21-2010-final.pdf)

Trying to substitute renewable energy for fossil fuel in the U.S. would impose very high costs with almost no benefit. More use of nuclear power for electricity generation would be helpful but would not be able to prevent the crushing economic costs of putting the U.S. on a path to achieve zero GHG emissions by 2050, see ACCF testimony at http://accf.org/wp-content/uploads/2012/04/120419-ACCF-Testimony-Final-r.pdf.

3. Question: How can we verify foreign countries compliance with their commitments?

A. For example, Russia is claiming forest offsets. How does that get counted and verified?

B. How can we trust countries that are willing to invade other counties to be honest reporting partners?

C. Are other countries agreeing to drone or satellite surveil lance for monitoring and verification purposes?

Answer: Measuring and verifying carbon sequestration is complex and difficult although satellites can be useful in observing changes in land use and forestry practices. Since countries would receive credits for sequestering carbon through land use measures, there is an incentive to claim as many credits as possible. It would be difficult to trust countries that disregard other countries borders to report their land use changes accurately. If countries are willing to allow drones to survey their forests it would be possible to make accurate estimate of their actual carbon sequestration. It is not clear that any countries which are large emitters are willing to allow drone surveillance by international inspectors.

4. Question: This Administration often takes credit for driving down emissions. Is that a fair assessment?

A. Has it been top-down regulations that have driven our recent emissions reductions or something else?

B. What role do market-driven technologies and innovations play?

C. Is tech-transfer important? Is this in the Administration's commitment?

D. How much additional domestic economic growth might be forthcoming from an acceleration of the LNG permitting process?

Answer:

A. The substitution of natural gas for coal for electricity generation is a major reason for the slowing growth rate in U.S. GHG emissions. From 2000 to 2013, electricity powered by natural gas grew from 16% to 27% of the total; during that same period coal's share fell from 52% to 39 %(see Figure 31 at http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf). The sharp drop in natural gas prices is a major reason for the shift in fuel used for electricity generation. Energy related carbon dioxide (CO_2) emissions in the U.S. are projected to remain below the 2005 level through 2040, according to the U.S. Energy Information Administration.

B. Market driven technology such as hydraulic fracturing for natural gas is the cause of the huge increase in U.S. gas production. In addition, the turnover of the U.S. capital stock tends to reduce emissions intensity per dollar of output as new equipment for electricity production, manufacturing and transportation is usually more energy efficient than the equipment it replaces.

C. Technology transfer to developing countries is important for promoting economic development, increasing energy efficiency and slowing the growth of global GHG emissions. The Obama Administration has focused on curbing the use of fossil fuel, especially coal, at the expense of encouraging cost/effective electricity generation for developing countries.. As my colleague, George Banks noted in a recent ACCF Center for Policy Research study:

"Today, U.S. foreign policy prioritizes climate change mitigation over expanding access to affordable and reliable energy in developing countries—as demonstrated by the Obama Administration's push to eliminate most financing of overseas coal plants. The White House has moved to limit U.S. funds for coal projects, lobbied other developed countries to join its position, and leveraged U.S. influence in multilateral development banks to achieve this goal. These efforts have the indirect effect of imposing a carbon cap on poor countries, despite U.S. recognition, as a party to the United Nations Framework Convention on Climate Change (UNFCCC), that developing countries have the right to increase their greenhouse gas (GHG) emissions to meet social and economic needs" , see http://accf.org/wp-content/uploads/2015/02/ACCF-CPR-Special-Report_Coal-Financing-FINAL.pdf

D. Numerous econometric analyses conclude that accelerating the permitting process for LNG exports would increase U.S. economic and job growth, reduce the trade deficit and put downward pressure on gasoline prices. A 2013 analysis by ICF found that "the net effect on annual U.S. GDP of LNG exports is expected to be positive at about $15.6 to $73.6 billion annually between 2016 and 2035, depending on LNG export case and GDP multiplier effect." The ICF report also shows average net job growth of 73,100 to 452,300 between 2016 and 2035, including all economic multiplier effects, See http://www.api.org/~/media/files/policy/lng-exports/api-lng-export-report-by-icf.pdf

In addition, a 2014 analysis by NERA found that U.S. GDP and economic welfare increased across all levels of LNG exports. In fact, the greater the exports, the greater the positive impact on GDP (see http://www.nera.com/content/dam/nera/publications/archive2/PUB_LNG_Update_0214_FINAL.pdf.

5. Question: In December, Department of Energy, Assistant Secretary Pete Lyons testified before this Committee that "nuclear is going to have to play a strong role as we look forward to reach to the goals that are required."

A. The role of nuclear energy is shockingly absent. Is there any we could ever get to the 80% or more reductions that the Administration talks without nuclear?

B. Why isn't nuclear' in this plan?

C. If we take nuclear of the table, then what's left?

> **Answer:** In the absence of a substantial breakthrough in storage technology, there is no conceivable way to achieve the Administration's long-term reduction goal without a significant expansion of the nation's civil nuclear fleet. In fact, the shutdown of existing units would prevent a number of U.S. states from achieving CO2 reduction goals currently proposed by the EPA. Roughly sixty percent of the nation's emission free generation last year came from the nuclear sector.
>
> In the past, the President has discussed the importance of nuclear power to the nation's climate goals, but we have seen limited action to support the advancement of the technology outside the scope of work of DOE/NE. In fact, the Administration has aggressively pursued policies that actually undermine nuclear's competitiveness. For example, EPA's 111d proposal fails to give the sector proper credit, favoring instead intermittent renewable energy. Clearly, a technology-neutral approach to emissions reductions would greatly benefit civil nuclear energy – and help the United States meet its national security and environmental objectives.

6. Question: When a US manufacturing operation moves overseas are those emissions that were eliminated in the US count toward meeting the US international climate pledge of reducing emissions by 28%?

A. If manufacturing has moved overseas, are emissions actually eliminated or reduced or simply moved?

B. In the US we have some of the strictest pollutions controls, and thereby some of the cleanest air, land and water. What if the country the manufacturing moves to doesn't enforce controls for pollutants that actually kill people? Could off-shoring actually be an environmental problem?

> **Answer:** If manufacturing moves oversees, the U.S. GHG emissions would decline (all other things equal) and the U.S. would get credit for the reduction.
>
> A. In fact, when manufacturing moves overseas, "leakage" of GHG emissions occurs because emission increase in the country where the manufacturer has relocated. Because the new country may have older, less energy efficient equipment that that in the U.S., global emissions may actually increase.
>
> B. Offshoring manufacturing to developing countries may cause products to be produced under less stringent worker protection regulations and looser environmental protection regulations. As a result, the offshoring may contribute to environmental problems including air and water quality in the developing country.

7. Question: You mention something interesting: economic growth drives environmental improvement.

A. That seems like the opposite of this Administration's approach. What does it mean?

> **Answer**: As Professor Bruce Yandle of Clemson University has observed:
>
> "...there is no single EKC (environmental Kuznets Curve) relationship that fits all pollutants for all places and times. There are families of relationships, and in many cases the inverted-U EKC best approximates the link between environmental change and income growth. The indicators for which the EKC relationship seems most plausible are local air pollutants such as oxides of nitrogen, sulfur

dioxide, and particulate matter. By way of contrast, there is no evidence to support the EKC hypothesis for gases such as carbon dioxide, which cause no harm locally but may affect the global climate as they accumulate in the atmosphere. The very nature of the potential harm—impact on global climate—makes unilateral action fruitless. It is impossible for people in a single nation or community to make a difference in upper atmospheric conditions. The EKC evidence for water pollution is mixed. There is evidence of an inverted U-shaped curve for biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates, and some heavy metals (arsenic and cadmium). In most cases, the income threshold for improving water quality is much lower than that for the air pollution improvement threshold. The acceptance of the EKC hypothesis for select pollutants has important policy implications. First, the relationship implies a certain inevitability of environmental degradation along a country's development path, especially during the take-off process of industrialization. Second, the normal EKC suggests that as the development process picks up, when a certain level of per capita income is reached, economic growth helps to undo the damage done in earlier years. If economic growth is good for the environment, policies that stimulate growth (trade liberalization, economic restructuring and price reform) ought to be good for the environment. However, income growth without institutional reform is not likely to be enough. As we have shown, the improvement of the environment with income growth is not automatic but depends on policies and institutions. GDP growth creates the conditions for environmental improvement by raising the demand for improved environmental quality and makes the resources available for supplying it. Whether environmental quality improvements materializes or not, when and how, depends critically on government policies, social institutions and the completeness and functioning of markets. It is for this reason, among others, that Arrow et al. (1995) emphasize the importance of getting the institutions right in rich and poor countries. Along these lines, Torras and Boyce (1998) argue and show empirically that, all else equal, when ordinary people have political power, civil rights as well as economic rights, air and water quality improves in richer and poorer countries" see, http://www.macalester.edu/~wests/econ231/yandleetal.pdf

In addition, Professor Levinson of Georgetown University writes:

"Pollution often appears first to worsen and later to improve as countries' incomes grow. Because of its resemblance to the pattern of inequality and income described by Simon Kuznets, this pattern of pollution and income has been labelled an 'environmental Kuznets curve'. While many pollutants exhibit this pattern, peak pollution levels occur at different income levels for different pollutants, countries and time periods. This link between income and pollution cannot be interpreted causally, and is consistent with either efficient or inefficient growth paths. The evidence does, however, refute the claim that environmental degradation is an inevitable consequence of economic growth." see http://faculty.georgetown.edu/aml6/pdfs&zips/PalgraveEKC.pdf

8. Question: How many countries have announced the expanded use of coal and other fossil fuels?

A. What does this mean for cumulative global totals in comparison with US reduction promises?

Answer:

Dozens of countries have announced the expanded use of coal. While growth rates for coal consumption have slowed, the International Energy Agency (IEA) still projects that global demand will increase roughly 2 percent annually through 2019 – across the developing and developed world.

While Beijing plans to invest less in coal generation in the coming decade, Chinese coal consumption will not peak for another ten years. In fact, China is expected to add the equivalent of the current U.S. coal fleet over the next decade, translating into a new 600-megawatt plant every 10 days.

According to the IEA, India and Southeast Asian countries expect to see "remarkable" growth in coal consumption. Shortly after President Obama's visit to India earlier this year, New Delhi announced that it plans to double its coal output in five years. Before 2020, India will become the world's largest importer of thermal coal and second largest consumer of coal – a position that the United States currently occupies.

Poorer counties, particularly those in Asia and Sub-Saharan Africa, will continue to deploy coal plants to provide basic access to electricity. Moreover, a number of developed countries, including Japan, South Korea, and Turkey, will also invest more in coal consumption.

This planned expansion of coal and the resulting increase in carbon emissions will overwhelm those cuts forecast from the United States and other parts of the developed world. The EIA expects the total CO_2 emissions of the United States, Europe OECD, and Japan to decline by about 1 percent between 2010 and 2030, while global CO_2 emissions will increase by 10,281 million metric tons or 33 percent during the same time period. China's growth in emissions – more than 6,000 million metric tons – is forecast to account for ***60 percent*** of that increase.

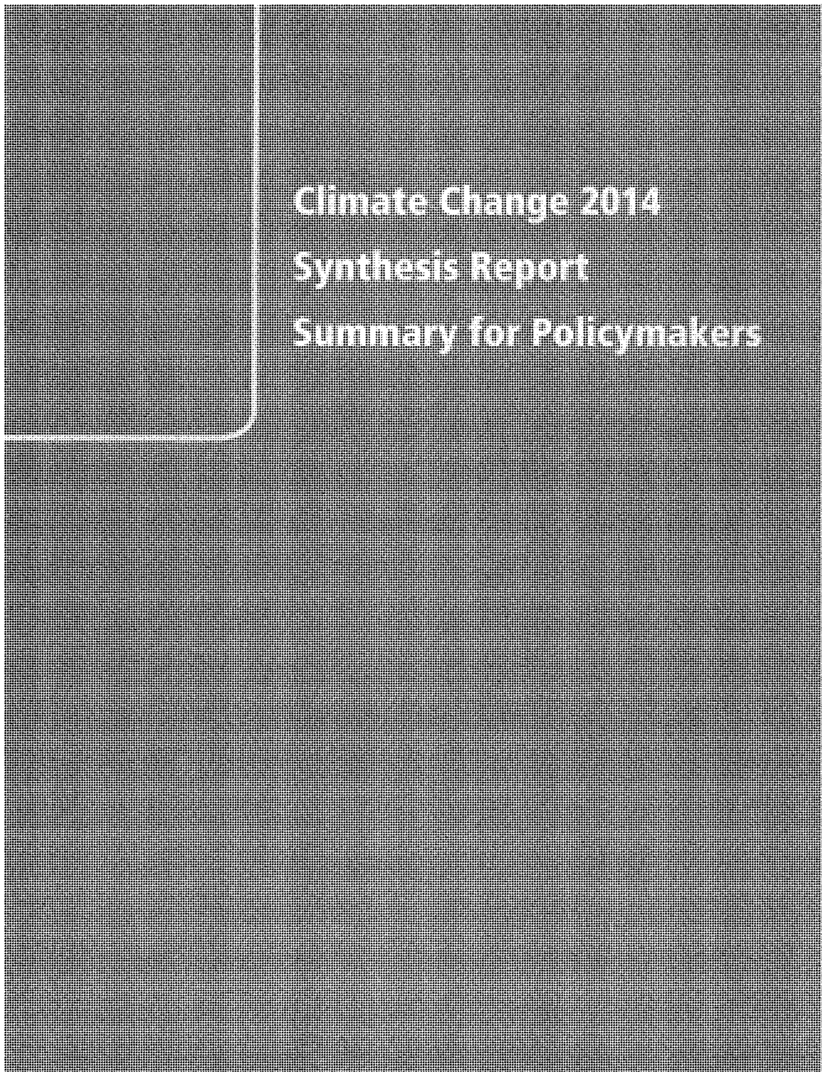
9. Question: If countries that are trade competitors have no legal framework to enforce compliance, how do we protect American businesses and the jobs they provide?

Answer: In the absence of a legal framework to enforce compliance with GHG reductions targets among our trading partners, all energy and energy efficiency regulations should be subject to strict cost/benefit analysis. As is widely recognized, if the U.S. cuts its GHG emissions to zero, there will be almost no impact on global GHG concentrations. Thus, costs of the Administrations climate change agenda exceed the benefits and it should be reevaluated.

Several policies could help strengthen the U.S. economy as well as slowing global CO2 emission growth. Federal tax reform which allows expensing for all new investment would stimulate economic growth and pull through cleaner less emitting technology. Encouraging the export of U.S. LNG and clean coal technology to developing countries would strengthen the economy and slow the growth of global emissions. The consistent use of cost/benefit analysis to review existing regulations and analyze proposed regulations would also strengthen the economy.

Appendix II

Additional Material for the Record


Climate Change 2014
Synthesis Report
Summary for Policymakers

SPM

Introduction

This Synthesis Report is based on the reports of the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC), including relevant Special Reports. It provides an integrated view of climate change as the final part of the IPCC's Fifth Assessment Report (AR5).

This summary follows the structure of the longer report which addresses the following topics: Observed changes and their causes; Future climate change, risks and impacts; Future pathways for adaptation, mitigation and sustainable development; Adaptation and mitigation.

In the Synthesis Report, the certainty in key assessment findings is communicated as in the Working Group Reports and Special Reports. It is based on the author teams' evaluations of underlying scientific understanding and is expressed as a qualitative level of confidence (from *very low* to *very high*) and, when possible, probabilistically with a quantified likelihood (from *exceptionally unlikely* to *virtually certain*)[1]. Where appropriate, findings are also formulated as statements of fact without using uncertainty qualifiers.

This report includes information relevant to Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC).

SPM 1. Observed Changes and their Causes

Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems. *{1}*

SPM 1.1 Observed changes in the climate system

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen. *{1.1}*

Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was *likely* the warmest 30-year period of the last 1400 years in the Northern Hemisphere, where such assessment is possible (*medium confidence*). The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85 [0.65 to 1.06] °C[2] over the period 1880 to 2012, when multiple independently produced datasets exist (Figure SPM.1a). *{1.1.1, Figure 1.1}*

In addition to robust multi-decadal warming, the globally averaged surface temperature exhibits substantial decadal and interannual variability (Figure SPM.1a). Due to this natural variability, trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long-term climate trends. As one example, the rate of warming over

---

1 Each finding is grounded in an evaluation of underlying evidence and agreement. In many cases, a synthesis of evidence and agreement supports an assignment of confidence. The summary terms for evidence are: limited, medium or robust. For agreement, they are low, medium or high. A level of confidence is expressed using five qualifiers: very low, low, medium, high and very high, and typeset in italics, e.g., *medium confidence*. The following terms have been used to indicate the assessed likelihood of an outcome or a result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely 95–100%, more likely than not >50–100%, more unlikely than likely 0–<50%, extremely unlikely 0–5%) may also be used when appropriate. Assessed likelihood is typeset in italics, e.g., *very likely*. See for more details: Mastrandrea, M.D., C.B. Field, T.F. Stocker, O. Edenhofer, K.L. Ebi, D.J. Frame, H. Held, E. Kriegler, K.J. Mach, P.R. Matschoss, G.-K. Plattner, G.W. Yohe and F.W. Zwiers, 2010: Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties, Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland, 4 pp.

2 Ranges in square brackets or following '±' are expected to have a 90% likelihood of including the value that is being estimated, unless otherwise stated.

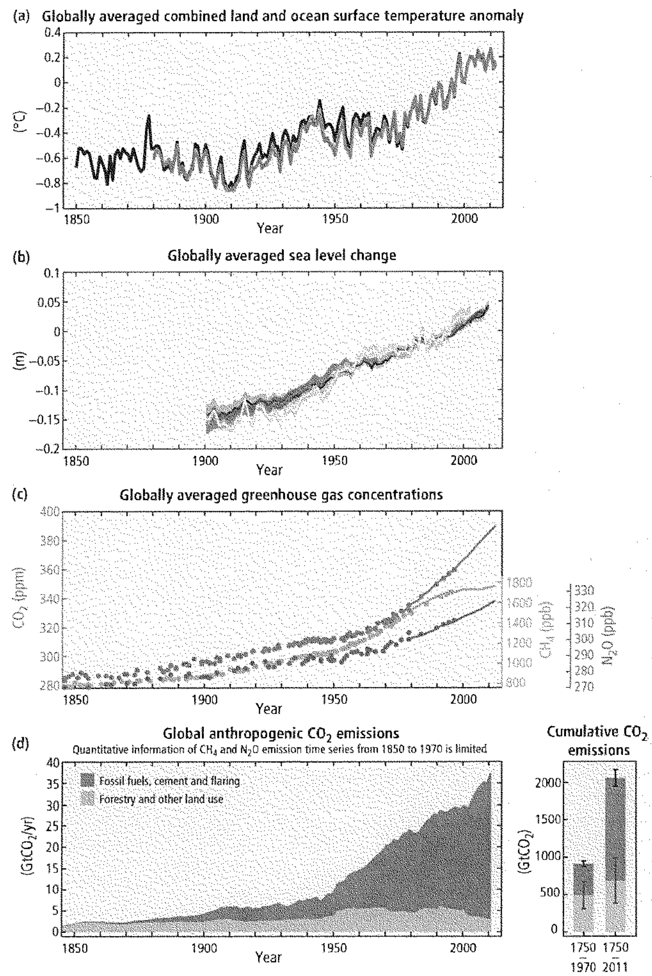


Figure SPM.1 | The complex relationship between the observations (panels a, b, c, yellow background) and the emissions (panel d, light blue background) is addressed in Section 1.2 and Topic 1. Observations and other indicators of a changing global climate system. Observations: **(a)** Annually and globally averaged combined land and ocean surface temperature anomalies relative to the average over the period 1986 to 2005. Colours indicate different data sets. **(b)** Annually and globally averaged sea level change relative to the average over the period 1986 to 2005 in the longest-running dataset. Colours indicate different data sets. All datasets are aligned to have the same value in 1993, the first year of satellite altimetry data (red). Where assessed, uncertainties are indicated by coloured shading. **(c)** Atmospheric concentrations of the greenhouse gases carbon dioxide (CO_2, green), methane (CH_4, orange) and nitrous oxide (N_2O, red) determined from ice core data (dots) and from direct atmospheric measurements (lines). Indicators: **(d)** Global anthropogenic CO_2 emissions from forestry and other land use as well as from burning of fossil fuel, cement production and flaring. Cumulative emissions of CO_2 from these sources and their uncertainties are shown as bars and whiskers, respectively, on the right hand side. The global effects of the accumulation of CH_4 and N_2O emissions are shown in panel c. Greenhouse gas emission data from 1970 to 2010 are shown in Figure SPM.2. *{Figures 1.1, 1.3, 1.5}*

SPM

the past 15 years (1998–2012; 0.05 [–0.05 to 0.15] °C per decade), which begins with a strong El Niño, is smaller than the rate calculated since 1951 (1951–2012; 0.12 [0.08 to 0.14] °C per decade). *{1.1.1, Box 1.1}*

Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (*high confidence*), with only about 1% stored in the atmosphere. On a global scale, the ocean warming is largest near the surface, and the upper 75 m warmed by 0.11 [0.09 to 0.13] °C per decade over the period 1971 to 2010. It is *virtually certain* that the upper ocean (0–700 m) warmed from 1971 to 2010, and it *likely* warmed between the 1870s and 1971. *{1.1.2, Figure 1.2}*

Averaged over the mid-latitude land areas of the Northern Hemisphere, precipitation has increased since 1901 (*medium confidence* before and *high confidence* after 1951). For other latitudes, area-averaged long-term positive or negative trends have *low confidence*. Observations of changes in ocean surface salinity also provide indirect evidence for changes in the global water cycle over the ocean (*medium confidence*). It is *very likely* that regions of high salinity, where evaporation dominates, have become more saline, while regions of low salinity, where precipitation dominates, have become fresher since the 1950s. *{1.1.1, 1.1.2}*

Since the beginning of the industrial era, oceanic uptake of CO_2 has resulted in acidification of the ocean; the pH of ocean surface water has decreased by 0.1 (*high confidence*), corresponding to a 26% increase in acidity, measured as hydrogen ion concentration. *{1.1.2}*

Over the period 1992 to 2011, the Greenland and Antarctic ice sheets have been losing mass (*high confidence*), *likely* at a larger rate over 2002 to 2011. Glaciers have continued to shrink almost worldwide (*high confidence*). Northern Hemisphere spring snow cover has continued to decrease in extent (*high confidence*). There is *high confidence* that permafrost temperatures have increased in most regions since the early 1980s in response to increased surface temperature and changing snow cover. *{1.1.3}*

The annual mean Arctic sea-ice extent decreased over the period 1979 to 2012, with a rate that was *very likely* in the range 3.5 to 4.1% per decade. Arctic sea-ice extent has decreased in every season and in every successive decade since 1979, with the most rapid decrease in decadal mean extent in summer (*high confidence*). It is *very likely* that the annual mean Antarctic sea-ice extent increased in the range of 1.2 to 1.8% per decade between 1979 and 2012. However, there is *high confidence* that there are strong regional differences in Antarctica, with extent increasing in some regions and decreasing in others. *{1.1.3, Figure 1.1}*

Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m (Figure SPM.1b). The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (*high confidence*). *{1.1.4, Figure 1.1}*

SPM 1.2 Causes of climate change

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are *extremely likely* to have been the dominant cause of the observed warming since the mid-20th century. *{1.2, 1.3.1}*

Anthropogenic greenhouse gas (GHG) emissions since the pre-industrial era have driven large increases in the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Figure SPM.1c). Between 1750 and 2011, cumulative anthropogenic CO_2 emissions to the atmosphere were 2040 ± 310 $GtCO_2$. About 40% of these emissions have remained in the atmosphere (880 ± 35 $GtCO_2$); the rest was removed from the atmosphere and stored on land (in plants and soils) and in the ocean. The ocean has absorbed about 30% of the emitted anthropogenic CO_2, causing ocean acidification. About half of the anthropogenic CO_2 emissions between 1750 and 2011 have occurred in the last 40 years (*high confidence*) (Figure SPM.1d). *{1.2.1, 1.2.2}*

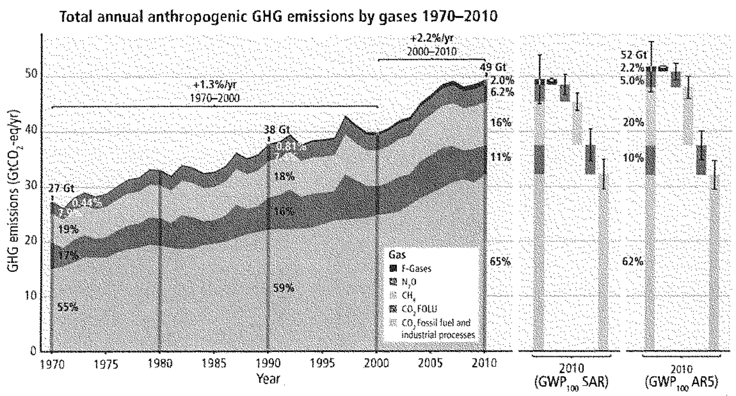


Figure SPM.2 | Total annual anthropogenic greenhouse gas (GHG) emissions (gigatonne of CO_2-equivalent per year, $GtCO_2$-eq/yr) for the period 1970 to 2010 by gases: CO_2 from fossil fuel combustion and industrial processes; CO_2 from Forestry and Other Land Use (FOLU); methane (CH_4); nitrous oxide (N_2O); fluorinated gases covered under the Kyoto Protocol (F-gases). Right hand side shows 2010 emissions, using alternatively CO_2-equivalent emission weightings based on IPCC Second Assessment Report (SAR) and AR5 values. Unless otherwise stated, CO_2-equivalent emissions in this report include the basket of Kyoto gases (CO_2, CH_4, N_2O as well as F-gases) calculated based on 100-year Global Warming Potential (GWP_{100}) values from the SAR (see Glossary). Using the most recent GWP_{100} values from the AR5 (right-hand bars) would result in higher total annual GHG emissions (52 $GtCO_2$-eq/yr) from an increased contribution of methane, but does not change the long-term trend significantly. *{Figure 1.6, Box 3.2}*

Total anthropogenic GHG emissions have continued to increase over 1970 to 2010 with larger absolute increases between 2000 and 2010, despite a growing number of climate change mitigation policies. Anthropogenic GHG emissions in 2010 have reached 49 ± 4.5 $GtCO_2$-eq/yr [3]. Emissions of CO_2 from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emissions increase from 1970 to 2010, with a similar percentage contribution for the increase during the period 2000 to 2010 (*high confidence*) (Figure SPM.2). Globally, economic and population growth continued to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion. The contribution of population growth between 2000 and 2010 remained roughly identical to the previous three decades, while the contribution of economic growth has risen sharply. Increased use of coal has reversed the long-standing trend of gradual decarbonization (i.e., reducing the carbon intensity of energy) of the world's energy supply (*high confidence*). *{1.2.2}*

The evidence for human influence on the climate system has grown since the IPCC Fourth Assessment Report (AR4). It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in GHG concentrations and other anthropogenic forcings together. The best estimate of the human-induced contribution to warming is similar to the observed warming over this period (Figure SPM.3). Anthropogenic forcings have *likely* made a substantial contribution to surface temperature increases since the mid-20th century over every continental region except Antarctica[4]. Anthropogenic influences have *likely* affected the global water cycle since 1960 and contributed to the retreat of glaciers since the 1960s and to the increased surface melting of the Greenland ice sheet since 1993. Anthropogenic influences have *very likely* contributed to Arctic sea-ice loss since 1979 and have *very likely* made a substantial contribution to increases in global upper ocean heat content (0–700 m) and to global mean sea level rise observed since the 1970s. *{1.3, Figure 1.10}*

---

3 Greenhouse gas emissions are quantified as CO_2-equivalent ($GtCO_2$-eq) emissions using weightings based on the 100-year Global Warming Potentials, using IPCC Second Assessment Report values unless otherwise stated. *{Box 3.2}*

4 For Antarctica, large observational uncertainties result in *low confidence* that anthropogenic forcings have contributed to the observed warming averaged over available stations.

SPM

Contributions to observed surface temperature change over the period 1951–2010

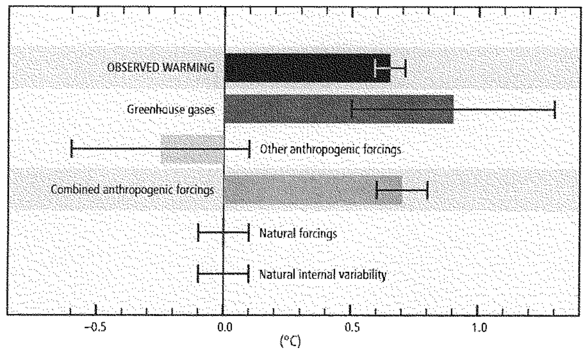


Figure SPM.3 | Assessed *likely* ranges (whiskers) and their mid-points (bars) for warming trends over the 1951–2010 period from well-mixed greenhouse gases, other anthropogenic forcings (including the cooling effect of aerosols and the effect of land use change), combined anthropogenic forcings, natural forcings and natural internal climate variability (which is the element of climate variability that arises spontaneously within the climate system even in the absence of forcings). The observed surface temperature change is shown in black, with the 5 to 95% uncertainty range due to observational uncertainty. The attributed warming ranges (colours) are based on observations combined with climate model simulations, in order to estimate the contribution of an individual external forcing to the observed warming. The contribution from the combined anthropogenic forcings can be estimated with less uncertainty than the contributions from greenhouse gases and from other anthropogenic forcings separately. This is because these two contributions partially compensate, resulting in a combined signal that is better constrained by observations. *{Figure 1.9}*

SPM 1.3 Impacts of climate change

In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate. *{1.3.2}*

Evidence of observed climate change impacts is strongest and most comprehensive for natural systems. In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality (*medium confidence*). Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances and species interactions in response to ongoing climate change (*high confidence*). Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influences (Figure SPM.4). Assessment of many studies covering a wide range of regions and crops shows that negative impacts of climate change on crop yields have been more common than positive impacts (*high confidence*). Some impacts of ocean acidification on marine organisms have been attributed to human influence (*medium confidence*). *{1.3.2}*

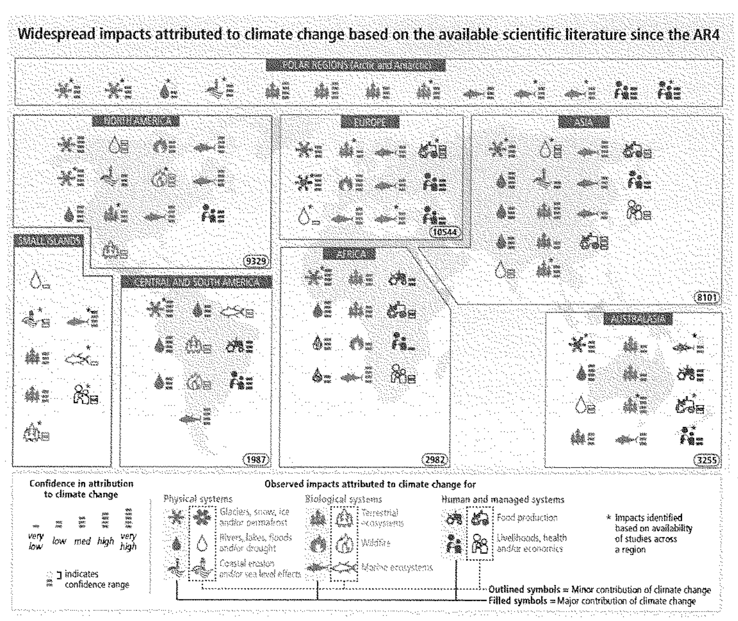


Figure SPM.4 | Based on the available scientific literature since the IPCC Fourth Assessment Report (AR4), there are substantially more impacts in recent decades now attributed to climate change. Attribution requires defined scientific evidence on the role of climate change. Absence from the map of additional impacts attributed to climate change does not imply that such impacts have not occurred. The publications supporting attributed impacts reflect a growing knowledge base, but publications are still limited for many regions, systems and processes, highlighting gaps in data and studies. Symbols indicate categories of attributed impacts, the relative contribution of climate change (major or minor) to the observed impact and confidence in attribution. Each symbol refers to one or more entries in WGII Table SPM.A1, grouping related regional-scale impacts. Numbers in ovals indicate regional totals of climate change publications from 2001 to 2010, based on the Scopus bibliographic database for publications in English with individual countries mentioned in title, abstract or key words (as of July 2011). These numbers provide an overall measure of the available scientific literature on climate change across regions; they do not indicate the number of publications supporting attribution of climate change impacts in each region. Studies for polar regions and small islands are grouped with neighbouring continental regions. The inclusion of publications for assessment of attribution followed IPCC scientific evidence criteria defined in WGII Chapter 18. Publications considered in the attribution analyses come from a broader range of literature assessed in the WGII AR5. See WGII Table SPM.A1 for descriptions of the attributed impacts. *{Figure 1.11}*

SPM 1.4 Extreme events

Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions. *{1.4}*

It is *very likely* that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale. It is *likely* that the frequency of heat waves has increased in large parts of Europe, Asia and Australia. It is *very likely* that human influence has contributed to the observed global scale changes in the frequency and intensity of daily temperature extremes since the mid-20th century. It is *likely* that human influence has more than doubled the probability of occurrence of heat waves in some locations. There is *medium confidence* that the observed warming has increased heat-related human mortality and decreased cold-related human mortality in some regions. *{1.4}*

There are *likely* more land regions where the number of heavy precipitation events has increased than where it has decreased. Recent detection of increasing trends in extreme precipitation and discharge in some catchments implies greater risks of flooding at regional scale (*medium confidence*). It is *likely* that extreme sea levels (for example, as experienced in storm surges) have increased since 1970, being mainly a result of rising mean sea level. *{1.4}*

Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability (*very high confidence*). *{1.4}*

SPM 2. Future Climate Changes, Risks and Impacts

Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks. *{2}*

SPM 2.1 Key drivers of future climate

Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a wide range, depending on both socio-economic development and climate policy. *{2.1}*

Anthropogenic GHG emissions are mainly driven by population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy. The Representative Concentration Pathways (RCPs), which are used for making projections based on these factors, describe four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use. The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5). Scenarios without additional efforts to constrain emissions ('baseline scenarios') lead to pathways ranging between RCP6.0 and RCP8.5 (Figure SPM.5a). RCP2.6 is representative of a scenario that aims to keep global warming *likely* below 2°C above pre-industrial temperatures. The RCPs are consistent with the wide range of scenarios in the literature as assessed by WGIII[5]. *{2.1, Box 2.2, 4.3}*

Multiple lines of evidence indicate a strong, consistent, almost linear relationship between cumulative CO_2 emissions and projected global temperature change to the year 2100 in both the RCPs and the wider set of mitigation scenarios analysed in WGIII (Figure SPM.5b). Any given level of warming is associated with a range of cumulative CO_2 emissions[6], and therefore, e.g., higher emissions in earlier decades imply lower emissions later. *{2.2.5, Table 2.2}*

[5] Roughly 300 baseline scenarios and 900 mitigation scenarios are categorized by CO_2-equivalent concentration (CO_2-eq) by 2100. The CO_2-eq includes the forcing due to all GHGs (including halogenated gases and tropospheric ozone), aerosols and albedo change.

[6] Quantification of this range of CO_2 emissions requires taking into account non-CO_2 drivers.

SPM

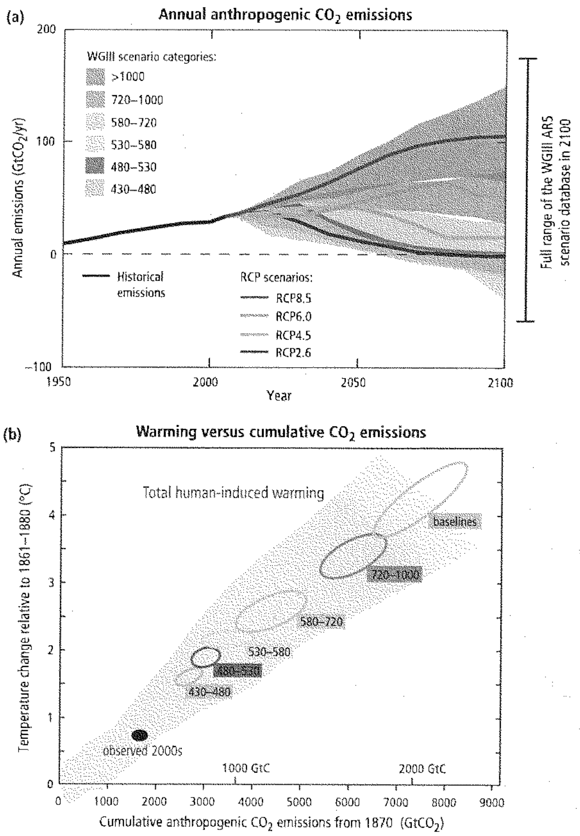


Figure SPM.5 | **(a)** Emissions of carbon dioxide (CO_2) alone in the Representative Concentration Pathways (RCPs) (lines) and the associated scenario categories used in WGIII (coloured areas show 5 to 95% range). The WGIII scenario categories summarize the wide range of emission scenarios published in the scientific literature and are defined on the basis of CO_2-eq concentration levels (in ppm) in 2100. The time series of other greenhouse gas emissions are shown in Box 2.2, Figure 1. **(b)** Global mean surface temperature increase at the time global CO_2 emissions reach a given net cumulative total, plotted as a function of that total, from various lines of evidence. Coloured plume shows the spread of past and future projections from a hierarchy of climate-carbon cycle models driven by historical emissions and the four RCPs over all times out to 2100, and fades with the decreasing number of available models. Ellipses show total anthropogenic warming in 2100 versus cumulative CO_2 emissions from 1870 to 2100 from a simple climate model (median climate response) under the scenario categories used in WGIII. The width of the ellipses in terms of temperature is caused by the impact of different scenarios for non-CO_2 climate drivers. The filled black ellipse shows observed emissions to 2005 and observed temperatures in the decade 2000–2009 with associated uncertainties. *{Box 2.2, Figure 1; Figure 2.3}*

Multi-model results show that limiting total human-induced warming to less than 2°C relative to the period 1861–1880 with a probability of >66%[7] would require cumulative CO_2 emissions from all anthropogenic sources since 1870 to remain below about 2900 $GtCO_2$ (with a range of 2550 to 3150 $GtCO_2$ depending on non-CO_2 drivers). About 1900 $GtCO_2$[8] had already been emitted by 2011. For additional context see Table 2.2. *{2.2.5}*

SPM 2.2 Projected changes in the climate system

Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is *very likely* that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise. *{2.2}*

The projected changes in Section SPM 2.2 are for 2081–2100 relative to 1986–2005, unless otherwise indicated.

Future climate will depend on committed warming caused by past anthropogenic emissions, as well as future anthropogenic emissions and natural climate variability. The global mean surface temperature change for the period 2016–2035 relative to 1986–2005 is similar for the four RCPs and will *likely* be in the range 0.3°C to 0.7°C (*medium confidence*). This assumes that there will be no major volcanic eruptions or changes in some natural sources (e.g., CH_4 and N_2O), or unexpected changes in total solar irradiance. By mid-21st century, the magnitude of the projected climate change is substantially affected by the choice of emissions scenario. *{2.2.1, Table 2.1}*

Relative to 1850–1900, global surface temperature change for the end of the 21st century (2081–2100) is projected to *likely* exceed 1.5°C for RCP4.5, RCP6.0 and RCP8.5 (*high confidence*). Warming is *likely* to exceed 2°C for RCP6.0 and RCP8.5 (*high confidence*), *more likely than not* to exceed 2°C for RCP4.5 (*medium confidence*), but *unlikely* to exceed 2°C for RCP2.6 (*medium confidence*). *{2.2.1}*

The increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to 1986–2005 is *likely* to be 0.3°C to 1.7°C under RCP2.6, 1.1°C to 2.6°C under RCP4.5, 1.4°C to 3.1°C under RCP6.0 and 2.6°C to 4.8°C under RCP8.5[9]. The Arctic region will continue to warm more rapidly than the global mean (Figure SPM.6a, Figure SPM.7a). *{2.2.1, Figure 2.1, Figure 2.2, Table 2.1}*

It is *virtually certain* that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales, as global mean surface temperature increases. It is *very likely* that heat waves will occur with a higher frequency and longer duration. Occasional cold winter extremes will continue to occur. *{2.2.1}*

---

[7] Corresponding figures for limiting warming to 2°C with a probability of >50% and >33% are 3000 $GtCO_2$ (range of 2900 to 3200 $GtCO_2$) and 3300 $GtCO_2$ (range of 2950 to 3800 $GtCO_2$) respectively. Higher or lower temperature limits would imply larger or lower cumulative emissions respectively.

[8] This corresponds to about two thirds of the 2900 $GtCO_2$ that would limit warming to less than 2°C with a probability of >66%; to about 63% of the total amount of 3000 $GtCO_2$ that would limit warming to less than 2°C with a probability of >50%; and to about 58% of the total amount of 3300 $GtCO_2$ that would limit warming to less than 2°C with a probability of >33%.

[9] The period 1986–2005 is approximately 0.61 [0.55 to 0.67] °C warmer than 1850–1900. *{2.2.1}*

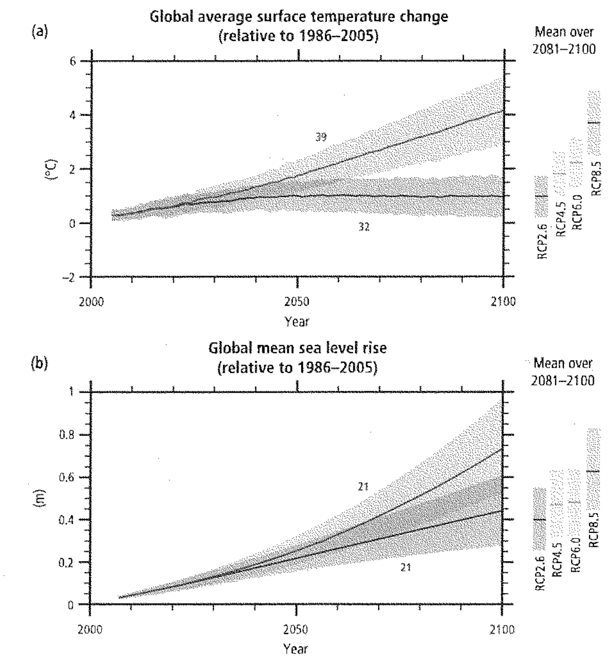


Figure SPM.6 | Global average surface temperature change **(a)** and global mean sea level rise[10] **(b)** from 2006 to 2100 as determined by multi-model simulations. All changes are relative to 1986–2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP2.6 (blue) and RCP8.5 (red). The mean and associated uncertainties averaged over 2081–2100 are given for all RCP scenarios as coloured vertical bars at the right hand side of each panel. The number of Coupled Model Intercomparison Project Phase 5 (CMIP5) models used to calculate the multi-model mean is indicated. *{2.2, Figure 2.1}*

Changes in precipitation will not be uniform. The high latitudes and the equatorial Pacific are *likely* to experience an increase in annual mean precipitation under the RCP8.5 scenario. In many mid-latitude and subtropical dry regions, mean precipitation will *likely* decrease, while in many mid-latitude wet regions, mean precipitation will *likely* increase under the RCP8.5 scenario (Figure SPM.7b). Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will *very likely* become more intense and more frequent. *{2.2.2, Figure 2.2}*

The global ocean will continue to warm during the 21st century, with the strongest warming projected for the surface in tropical and Northern Hemisphere subtropical regions (Figure SPM.7a). *{2.2.3, Figure 2.2}*

---

[10] Based on current understanding (from observations, physical understanding and modelling), only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the *likely* range during the 21st century. There is *medium confidence* that this additional contribution would not exceed several tenths of a meter of sea level rise during the 21st century.

SPM

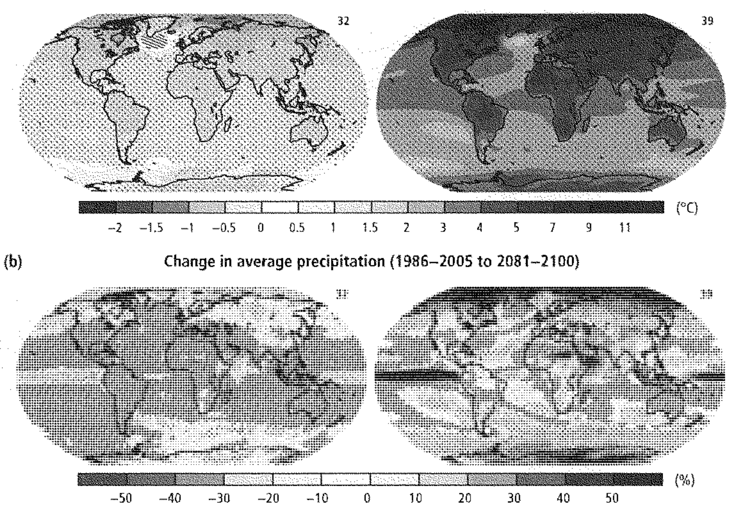


Figure SPM.7 | Change in average surface temperature **(a)** and change in average precipitation **(b)** based on multi-model mean projections for 2081–2100 relative to 1986–2005 under the RCP2.6 (left) and RCP8.5 (right) scenarios. The number of models used to calculate the multi-model mean is indicated in the upper right corner of each panel. Stippling (i.e., dots) shows regions where the projected change is large compared to natural internal variability and where at least 90% of models agree on the sign of change. Hatching (i.e., diagonal lines) shows regions where the projected change is less than one standard deviation of the natural internal variability. *{2.2, Figure 2.2}*

Earth System Models project a global increase in ocean acidification for all RCP scenarios by the end of the 21st century, with a slow recovery after mid-century under RCP2.6. The decrease in surface ocean pH is in the range of 0.06 to 0.07 (15 to 17% increase in acidity) for RCP2.6, 0.14 to 0.15 (38 to 41%) for RCP4.5, 0.20 to 0.21 (58 to 62%) for RCP6.0 and 0.30 to 0.32 (100 to 109%) for RCP8.5. *{2.2.4, Figure 2.1}*

Year-round reductions in Arctic sea ice are projected for all RCP scenarios. A nearly ice-free[11] Arctic Ocean in the summer sea-ice minimum in September before mid-century is *likely* for RCP8.5[12] (*medium confidence*). *{2.2.3, Figure 2.1}*

It is *virtually certain* that near-surface permafrost extent at high northern latitudes will be reduced as global mean surface temperature increases, with the area of permafrost near the surface (upper 3.5 m) projected to decrease by 37% (RCP2.6) to 81% (RCP8.5) for the multi-model average (*medium confidence*). *{2.2.3}*

The global glacier volume, excluding glaciers on the periphery of Antarctica (and excluding the Greenland and Antarctic ice sheets), is projected to decrease by 15 to 55% for RCP2.6 and by 35 to 85% for RCP8.5 (*medium confidence*). *{2.2.3}*

[11] When sea-ice extent is less than one million km^2 for at least five consecutive years.

[12] Based on an assessment of the subset of models that most closely reproduce the climatological mean state and 1979–2012 trend of the Arctic sea-ice extent.

There has been significant improvement in understanding and projection of sea level change since the AR4. Global mean sea level rise will continue during the 21st century, *very likely* at a faster rate than observed from 1971 to 2010. For the period 2081–2100 relative to 1986–2005, the rise will *likely* be in the ranges of 0.26 to 0.55 m for RCP2.6, and of 0.45 to 0.82 m for RCP8.5 (*medium confidence*)[10] (Figure SPM.6b). Sea level rise will not be uniform across regions. By the end of the 21st century, it is *very likely* that sea level will rise in more than about 95% of the ocean area. About 70% of the coastlines worldwide are projected to experience a sea level change within ±20% of the global mean. *{2.2.3}*

SPM 2.3 Future risks and impacts caused by a changing climate

Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development. *{2.3}*

Risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems, including their ability to adapt. Rising rates and magnitudes of warming and other changes in the climate system, accompanied by ocean acidification, increase the risk of severe, pervasive and in some cases irreversible detrimental impacts. Some risks are particularly relevant for individual regions (Figure SPM.8), while others are global. The overall risks of future climate change impacts can be reduced by limiting the rate and magnitude of climate change, including ocean acidification. The precise levels of climate change sufficient to trigger abrupt and irreversible change remain uncertain, but the risk associated with crossing such thresholds increases with rising temperature (*medium confidence*). For risk assessment, it is important to evaluate the widest possible range of impacts, including low-probability outcomes with large consequences. *{1.5, 2.3, 2.4, 3.3, Box Introduction.1, Box 2.3, Box 2.4}*

A large fraction of species faces increased extinction risk due to climate change during and beyond the 21st century, especially as climate change interacts with other stressors (*high confidence*). Most plant species cannot naturally shift their geographical ranges sufficiently fast to keep up with current and high projected rates of climate change in most landscapes; most small mammals and freshwater molluscs will not be able to keep up at the rates projected under RCP4.5 and above in flat landscapes in this century (*high confidence*). Future risk is indicated to be high by the observation that natural global climate change at rates lower than current anthropogenic climate change caused significant ecosystem shifts and species extinctions during the past millions of years. Marine organisms will face progressively lower oxygen levels and high rates and magnitudes of ocean acidification (*high confidence*), with associated risks exacerbated by rising ocean temperature extremes (*medium confidence*). Coral reefs and polar ecosystems are highly vulnerable. Coastal systems and low-lying areas are at risk from sea level rise, which will continue for centuries even if the global mean temperature is stabilized (*high confidence*). *{2.3, 2.4, Figure 2.5}*

Climate change is projected to undermine food security (Figure SPM.9). Due to projected climate change by the mid-21st century and beyond, global marine species redistribution and marine biodiversity reduction in sensitive regions will challenge the sustained provision of fisheries productivity and other ecosystem services (*high confidence*). For wheat, rice and maize in tropical and temperate regions, climate change without adaptation is projected to negatively impact production for local temperature increases of 2°C or more above late 20th century levels, although individual locations may benefit (*medium confidence*). Global temperature increases of ~4°C or more[13] above late 20th century levels, combined with increasing food demand, would pose large risks to food security globally (*high confidence*). Climate change is projected to reduce renewable surface water and groundwater resources in most dry subtropical regions (*robust evidence, high agreement*), intensifying competition for water among sectors (*limited evidence, medium agreement*). *{2.3.1, 2.3.2}*

[13] Projected warming averaged over land is larger than global average warming for all RCP scenarios for the period 2081–2100 relative to 1986–2005. For regional projections, see Figure SPM.7. *{2.2}*

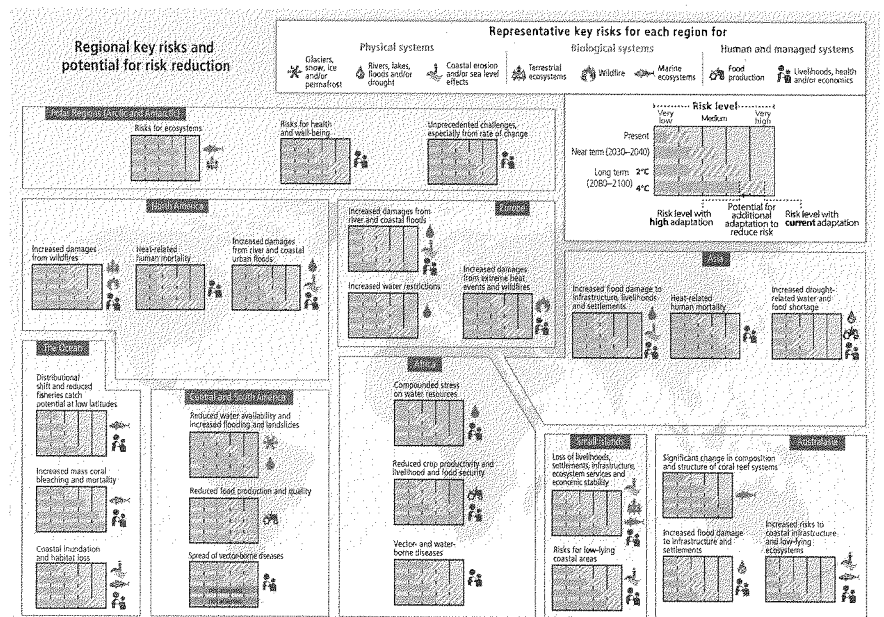


Figure SPM.8 | Representative key risks[14] for each region, including the potential for risk reduction through adaptation and mitigation, as well as limits to adaptation. Each key risk is assessed as very low, low, medium, high or very high. Risk levels are presented for three time frames: present, near term (here, for 2030–2040) and long term (here, for 2080–2100). In the near term, projected levels of global mean temperature increase do not diverge substantially across different emission scenarios. For the long term, risk levels are presented for two possible futures (2°C and 4°C global mean temperature increase above pre-industrial levels). For each timeframe, risk levels are indicated for a continuation of current adaptation and assuming high levels of current or future adaptation. Risk levels are not necessarily comparable, especially across regions. *[Figure 2.4]*

[14] Identification of key risks was based on expert judgment using the following specific criteria: large magnitude, high probability or irreversibility of impacts; timing of impacts; persistent vulnerability or exposure contributing to risks; or limited potential to reduce risks through adaptation or mitigation.

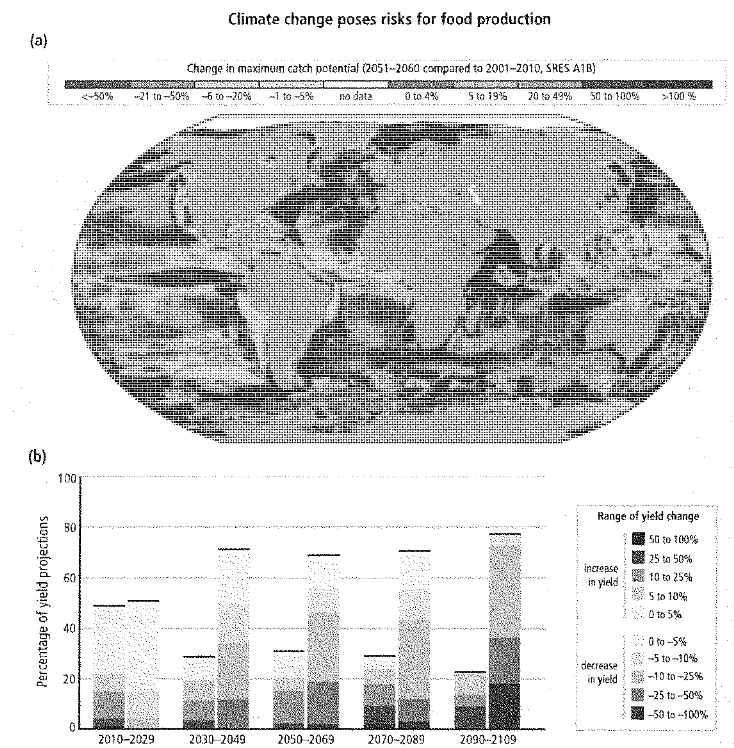


Figure SPM.9 | **(a)** Projected global redistribution of maximum catch potential of ~1000 exploited marine fish and invertebrate species. Projections compare the 10-year averages 2001–2010 and 2051–2060 using ocean conditions based on a single climate model under a moderate to high warming scenario, without analysis of potential impacts of overfishing or ocean acidification. **(b)** Summary of projected changes in crop yields (mostly wheat, maize, rice and soy), due to climate change over the 21st century. Data for each timeframe sum to 100%, indicating the percentage of projections showing yield increases versus decreases. The figure includes projections (based on 1090 data points) for different emission scenarios, for tropical and temperate regions and for adaptation and no-adaptation cases combined. Changes in crop yields are relative to late 20th century levels. *{Figure 2.6a, Figure 2.7}*

Until mid-century, projected climate change will impact human health mainly by exacerbating health problems that already exist (*very high confidence*). Throughout the 21st century, climate change is expected to lead to increases in ill-health in many regions and especially in developing countries with low income, as compared to a baseline without climate change (*high confidence*). By 2100 for RCP8.5, the combination of high temperature and humidity in some areas for parts of the year is expected to compromise common human activities, including growing food and working outdoors (*high confidence*). *{2.3.2}*

In urban areas climate change is projected to increase risks for people, assets, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges (*very high confidence*). These risks are amplified for those lacking essential infrastructure and services or living in exposed areas. *{2.3.2}*

Rural areas are expected to experience major impacts on water availability and supply, food security, infrastructure and agricultural incomes, including shifts in the production areas of food and non-food crops around the world (*high confidence*). {2.3.2}

Aggregate economic losses accelerate with increasing temperature (*limited evidence, high agreement*), but global economic impacts from climate change are currently difficult to estimate. From a poverty perspective, climate change impacts are projected to slow down economic growth, make poverty reduction more difficult, further erode food security and prolong existing and create new poverty traps, the latter particularly in urban areas and emerging hotspots of hunger (*medium confidence*). International dimensions such as trade and relations among states are also important for understanding the risks of climate change at regional scales. {2.3.2}

Climate change is projected to increase displacement of people (*medium evidence, high agreement*). Populations that lack the resources for planned migration experience higher exposure to extreme weather events, particularly in developing countries with low income. Climate change can indirectly increase risks of violent conflicts by amplifying well-documented drivers of these conflicts such as poverty and economic shocks (*medium confidence*). {2.3.2}

SPM 2.4 Climate change beyond 2100, irreversibility and abrupt changes

Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. The risks of abrupt or irreversible changes increase as the magnitude of the warming increases. {2.4}

Warming will continue beyond 2100 under all RCP scenarios except RCP2.6. Surface temperatures will remain approximately constant at elevated levels for many centuries after a complete cessation of net anthropogenic CO_2 emissions. A large fraction of anthropogenic climate change resulting from CO_2 emissions is irreversible on a multi-century to millennial timescale, except in the case of a large net removal of CO_2 from the atmosphere over a sustained period. {2.4, *Figure 2.8*}

Stabilization of global average surface temperature does not imply stabilization for all aspects of the climate system. Shifting biomes, soil carbon, ice sheets, ocean temperatures and associated sea level rise all have their own intrinsic long timescales which will result in changes lasting hundreds to thousands of years after global surface temperature is stabilized. {2.1, 2.4}

There is *high confidence* that ocean acidification will increase for centuries if CO_2 emissions continue, and will strongly affect marine ecosystems. {2.4}

It is *virtually certain* that global mean sea level rise will continue for many centuries beyond 2100, with the amount of rise dependent on future emissions. The threshold for the loss of the Greenland ice sheet over a millennium or more, and an associated sea level rise of up to 7 m, is greater than about 1°C (*low confidence*) but less than about 4°C (*medium confidence*) of global warming with respect to pre-industrial temperatures. Abrupt and irreversible ice loss from the Antarctic ice sheet is possible, but current evidence and understanding is insufficient to make a quantitative assessment. {2.4}

Magnitudes and rates of climate change associated with medium- to high-emission scenarios pose an increased risk of abrupt and irreversible regional-scale change in the composition, structure and function of marine, terrestrial and freshwater ecosystems, including wetlands (*medium confidence*). A reduction in permafrost extent is *virtually certain* with continued rise in global temperatures. {2.4}

SPM 3. Future Pathways for Adaptation, Mitigation and Sustainable Development

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development. *{3.2, 3.3, 3.4}*

SPM

SPM 3.1 Foundations of decision-making about climate change

Effective decision-making to limit climate change and its effects can be informed by a wide range of analytical approaches for evaluating expected risks and benefits, recognizing the importance of governance, ethical dimensions, equity, value judgments, economic assessments and diverse perceptions and responses to risk and uncertainty. *{3.1}*

Sustainable development and equity provide a basis for assessing climate policies. Limiting the effects of climate change is necessary to achieve sustainable development and equity, including poverty eradication. Countries' past and future contributions to the accumulation of GHGs in the atmosphere are different, and countries also face varying challenges and circumstances and have different capacities to address mitigation and adaptation. Mitigation and adaptation raise issues of equity, justice and fairness. Many of those most vulnerable to climate change have contributed and contribute little to GHG emissions. Delaying mitigation shifts burdens from the present to the future, and insufficient adaptation responses to emerging impacts are already eroding the basis for sustainable development. Comprehensive strategies in response to climate change that are consistent with sustainable development take into account the co-benefits, adverse side effects and risks that may arise from both adaptation and mitigation options. *{3.1, 3.5, Box 3.4}*

The design of climate policy is influenced by how individuals and organizations perceive risks and uncertainties and take them into account. Methods of valuation from economic, social and ethical analysis are available to assist decision-making. These methods can take account of a wide range of possible impacts, including low-probability outcomes with large consequences. But they cannot identify a single best balance between mitigation, adaptation and residual climate impacts. *{3.1}*

Climate change has the characteristics of a collective action problem at the global scale, because most GHGs accumulate over time and mix globally, and emissions by any agent (e.g., individual, community, company, country) affect other agents. Effective mitigation will not be achieved if individual agents advance their own interests independently. Cooperative responses, including international cooperation, are therefore required to effectively mitigate GHG emissions and address other climate change issues. The effectiveness of adaptation can be enhanced through complementary actions across levels, including international cooperation. The evidence suggests that outcomes seen as equitable can lead to more effective cooperation. *{3.1}*

SPM 3.2 Climate change risks reduced by mitigation and adaptation

Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (*high confidence*). Mitigation involves some level of co-benefits and of risks due to adverse side effects, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change, increasing the benefits from near-term mitigation efforts. *{3.2, 3.4}*

Mitigation and adaptation are complementary approaches for reducing risks of climate change impacts over different timescales (*high confidence*). Mitigation, in the near term and through the century, can substantially reduce climate change

SPM

impacts in the latter decades of the 21st century and beyond. Benefits from adaptation can already be realized in addressing current risks, and can be realized in the future for addressing emerging risks. *{3.2, 4.5}*

Five Reasons For Concern (RFCs) aggregate climate change risks and illustrate the implications of warming and of adaptation limits for people, economies and ecosystems across sectors and regions. The five RFCs are associated with: (1) Unique and threatened systems, (2) Extreme weather events, (3) Distribution of impacts, (4) Global aggregate impacts, and (5) Large-scale singular events. In this report, the RFCs provide information relevant to Article 2 of UNFCCC. *{Box 2.4}*

Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (*high confidence*) (Figure SPM.10). In most scenarios without additional mitigation efforts (those with 2100 atmospheric concentrations

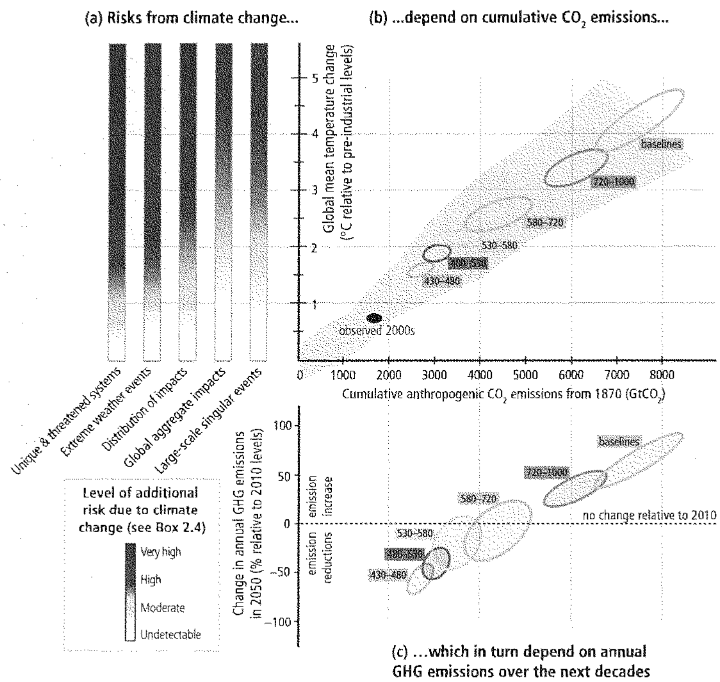


Figure SPM.10 | The relationship between risks from climate change, temperature change, cumulative carbon dioxide (CO_2) emissions and changes in annual greenhouse gas (GHG) emissions by 2050. Limiting risks across Reasons For Concern **(a)** would imply a limit for cumulative emissions of CO_2 **(b)** which would constrain annual GHG emissions over the next few decades **(c)**. **Panel a** reproduces the five Reasons For Concern *{Box 2.4}*. **Panel b** links temperature changes to cumulative CO_2 emissions (in $GtCO_2$) from 1870. They are based on Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations (pink plume) and on a simple climate model (median climate response in 2100), for the baselines and five mitigation scenario categories (six ellipses). Details are provided in Figure SPM.5. **Panel c** shows the relationship between the cumulative CO_2 emissions (in $GtCO_2$) of the scenario categories and their associated change in annual GHG emissions by 2050, expressed in percentage change (in percent $GtCO_2$-eq per year) relative to 2010. The ellipses correspond to the same scenario categories as in Panel b, and are built with a similar method (see details in Figure SPM.5). *{Figure 3.1}*

SPM

>1000 ppm CO_2-eq), warming is *more likely than not* to exceed 4°C above pre-industrial levels by 2100 (Table SPM.1). The risks associated with temperatures at or above 4°C include substantial species extinction, global and regional food insecurity, consequential constraints on common human activities and limited potential for adaptation in some cases (*high confidence*). Some risks of climate change, such as risks to unique and threatened systems and risks associated with extreme weather events, are moderate to high at temperatures 1°C to 2°C above pre-industrial levels. *{2.3, Figure 2.5, 3.2, 3.4, Box 2.4, Table SPM.1}*

Substantial cuts in GHG emissions over the next few decades can substantially reduce risks of climate change by limiting warming in the second half of the 21st century and beyond. Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. Limiting risks across RFCs would imply a limit for cumulative emissions of CO_2. Such a limit would require that global net emissions of CO_2 eventually decrease to zero and would constrain annual emissions over the next few decades (Figure SPM.10) (*high confidence*). But some risks from climate damages are unavoidable, even with mitigation and adaptation. *{2.2.5, 3.2, 3.4}*

Mitigation involves some level of co-benefits and risks, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change. Inertia in the economic and climate system and the possibility of irreversible impacts from climate change increase the benefits from near-term mitigation efforts (*high confidence*). Delays in additional mitigation or constraints on technological options increase the longer-term mitigation costs to hold climate change risks at a given level (Table SPM.2). *{3.2, 3.4}*

SPM 3.3 Characteristics of adaptation pathways

Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer-term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness. *{3.3}*

Adaptation can contribute to the well-being of populations, the security of assets and the maintenance of ecosystem goods, functions and services now and in the future. Adaptation is place- and context-specific (*high confidence*). A first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability (*high confidence*). Integration of adaptation into planning, including policy design, and decision-making can promote synergies with development and disaster risk reduction. Building adaptive capacity is crucial for effective selection and implementation of adaptation options (*robust evidence, high agreement*). *{3.3}*

Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments (*high confidence*). National governments can coordinate adaptation efforts of local and sub-national governments, for example by protecting vulnerable groups, by supporting economic diversification and by providing information, policy and legal frameworks and financial support (*robust evidence, high agreement*). Local government and the private sector are increasingly recognized as critical to progress in adaptation, given their roles in scaling up adaptation of communities, households and civil society and in managing risk information and financing (*medium evidence, high agreement*). *{3.3}*

Adaptation planning and implementation at all levels of governance are contingent on societal values, objectives and risk perceptions (*high confidence*). Recognition of diverse interests, circumstances, social-cultural contexts and expectations can benefit decision-making processes. Indigenous, local and traditional knowledge systems and practices, including indigenous peoples' holistic view of community and environment, are a major resource for adapting to climate change, but these have not been used consistently in existing adaptation efforts. Integrating such forms of knowledge with existing practices increases the effectiveness of adaptation. *{3.3}*

Constraints can interact to impede adaptation planning and implementation (*high confidence*). Common constraints on implementation arise from the following: limited financial and human resources; limited integration or coordination of governance; uncertainties about projected impacts; different perceptions of risks; competing values; absence of key adaptation leaders and advocates; and limited tools to monitor adaptation effectiveness. Another constraint includes insufficient research, monitoring, and observation and the finance to maintain them. *{3.3}*

Greater rates and magnitude of climate change increase the likelihood of exceeding adaptation limits (*high confidence*). Limits to adaptation emerge from the interaction among climate change and biophysical and/or socio-economic constraints. Further, poor planning or implementation, overemphasizing short-term outcomes or failing to sufficiently anticipate consequences can result in maladaptation, increasing the vulnerability or exposure of the target group in the future or the vulnerability of other people, places or sectors (*medium evidence, high agreement*). Underestimating the complexity of adaptation as a social process can create unrealistic expectations about achieving intended adaptation outcomes. *{3.3}*

Significant co-benefits, synergies and trade-offs exist between mitigation and adaptation and among different adaptation responses; interactions occur both within and across regions (*very high confidence*). Increasing efforts to mitigate and adapt to climate change imply an increasing complexity of interactions, particularly at the intersections among water, energy, land use and biodiversity, but tools to understand and manage these interactions remain limited. Examples of actions with co-benefits include (i) improved energy efficiency and cleaner energy sources, leading to reduced emissions of health-damaging, climate-altering air pollutants; (ii) reduced energy and water consumption in urban areas through greening cities and recycling water; (iii) sustainable agriculture and forestry; and (iv) protection of ecosystems for carbon storage and other ecosystem services. *{3.3}*

Transformations in economic, social, technological and political decisions and actions can enhance adaptation and promote sustainable development (*high confidence*). At the national level, transformation is considered most effective when it reflects a country's own visions and approaches to achieving sustainable development in accordance with its national circumstances and priorities. Restricting adaptation responses to incremental changes to existing systems and structures, without considering transformational change, may increase costs and losses and miss opportunities. Planning and implementation of transformational adaptation could reflect strengthened, altered or aligned paradigms and may place new and increased demands on governance structures to reconcile different goals and visions for the future and to address possible equity and ethical implications. Adaptation pathways are enhanced by iterative learning, deliberative processes and innovation. *{3.3}*

SPM 3.4 Characteristics of mitigation pathways

There are multiple mitigation pathways that are *likely* to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero emissions of CO_2 and other long-lived greenhouse gases by the end of the century. Implementing such reductions poses substantial technological, economic, social and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges but on different timescales. *{3.4}*

Without additional efforts to reduce GHG emissions beyond those in place today, global emissions growth is expected to persist, driven by growth in global population and economic activities. Global mean surface temperature increases in 2100 in baseline scenarios—those without additional mitigation—range from 3.7°C to 4.8°C above the average for 1850–1900 for a median climate response. They range from 2.5°C to 7.8°C when including climate uncertainty (5th to 95th percentile range) (*high confidence*). *{3.4}*

Emissions scenarios leading to CO_2-equivalent concentrations in 2100 of about 450 ppm or lower are *likely* to maintain warming below 2°C over the 21st century relative to pre-industrial levels[15]. These scenarios are characterized by 40 to 70% global anthropogenic GHG emissions reductions by 2050 compared to 2010[16], and emissions levels near zero or below in 2100. Mitigation scenarios reaching concentration levels of about 500 ppm CO_2-eq by 2100 are *more likely than not* to limit temperature change to less than 2°C, unless they temporarily overshoot concentration levels of roughly 530 ppm CO_2-eq

[15] For comparison, the CO_2-eq concentration in 2011 is estimated to be 430 ppm (uncertainty range 340 to 520 ppm)

[16] This range differs from the range provided for a similar concentration category in the AR4 (50 to 85% lower than 2000 for CO_2 only). Reasons for this difference include that this report has assessed a substantially larger number of scenarios than in the AR4 and looks at all GHGs. In addition, a large proportion of the new scenarios include Carbon Dioxide Removal (CDR) technologies (see below). Other factors include the use of 2100 concentration levels instead of stabilization levels and the shift in reference year from 2000 to 2010.

SPM

before 2100, in which case they are *about as likely as not* to achieve that goal. In these 500 ppm CO_2-eq scenarios, global 2050 emissions levels are 25 to 55% lower than in 2010. Scenarios with higher emissions in 2050 are characterized by a greater reliance on Carbon Dioxide Removal (CDR) technologies beyond mid-century (and vice versa). Trajectories that are *likely* to limit warming to 3°C relative to pre-industrial levels reduce emissions less rapidly than those limiting warming to 2°C. A limited number of studies provide scenarios that are *more likely than not* to limit warming to 1.5°C by 2100; these scenarios are characterized by concentrations below 430 ppm CO_2-eq by 2100 and 2050 emission reduction between 70% and 95% below 2010. For a comprehensive overview of the characteristics of emissions scenarios, their CO_2-equivalent concentrations and their likelihood to keep warming to below a range of temperature levels, see Figure SPM.11 and Table SPM.1. *{3.4}*

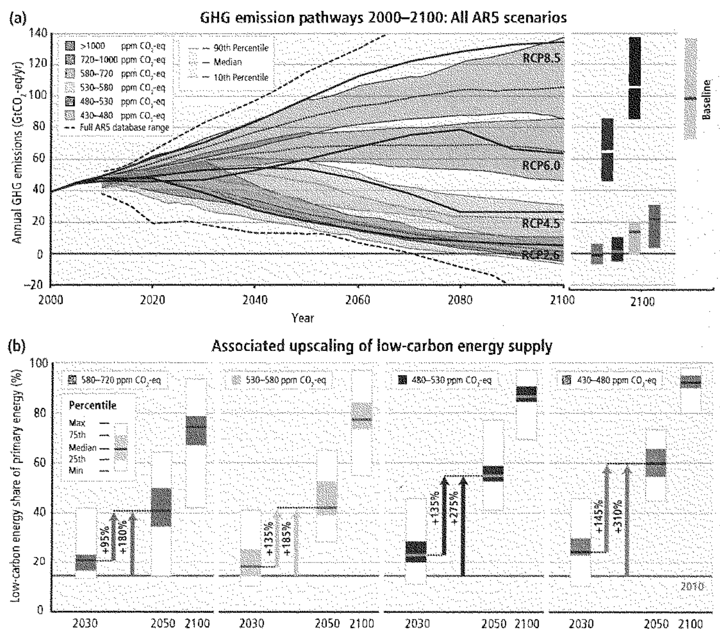


Figure SPM.11 | Global greenhouse gas emissions (gigatonne of CO_2-equivalent per year, $GtCO_2$-eq/yr) in baseline and mitigation scenarios for different long-term concentration levels **(a)** and associated upscaling requirements of low-carbon energy (% of primary energy) for 2030, 2050 and 2100 compared to 2010 levels in mitigation scenarios **(b)**. *{Figure 3.2}*

Table SPM.1 | Key characteristics of the scenarios collected and assessed for WGIII AR5. For all parameters the 10th to 90th percentile of the scenarios is shown [a]. *{Table 3.1}*

<table>
<tr><th rowspan="2">CO_2-eq Concentrations in 2100 (ppm CO_2-eq) [f]
Category label (conc. range)</th><th rowspan="2">Subcategories</th><th rowspan="2">Relative position of the RCPs [d]</th><th colspan="2">Change in CO_2-eq emissions compared to 2010 (in %) [c]</th><th colspan="4">Likelihood of staying below a specific temperature level over the 21st century (relative to 1850–1900) [d, e]</th></tr>
<tr><th>2050</th><th>2100</th><th>1.5°C</th><th>2°C</th><th>3°C</th><th>4°C</th></tr>
<tr><td><430</td><td colspan="8">Only a limited number of individual model studies have explored levels below 430 ppm CO_2-eq [j]</td></tr>
<tr><td>450
(430 to 480)</td><td>Total range [a, g]</td><td>RCP2.6</td><td>−72 to −41</td><td>−118 to −78</td><td>More unlikely than likely</td><td>Likely</td><td rowspan="6">Likely</td><td rowspan="8">Likely</td></tr>
<tr><td rowspan="2">500
(480 to 530)</td><td>No overshoot of 530 ppm CO_2-eq</td><td></td><td>−57 to −42</td><td>−107 to −73</td><td rowspan="6">Unlikely</td><td>More likely than not</td></tr>
<tr><td>Overshoot of 530 ppm CO_2-eq</td><td></td><td>−55 to −25</td><td>−114 to −90</td><td>About as likely as not</td></tr>
<tr><td rowspan="2">550
(530 to 580)</td><td>No overshoot of 580 ppm CO_2-eq</td><td></td><td>−47 to −19</td><td>−81 to −59</td><td rowspan="3">More unlikely than likely [i]</td></tr>
<tr><td>Overshoot of 580 ppm CO_2-eq</td><td></td><td>−16 to 7</td><td>−183 to −86</td></tr>
<tr><td>(580 to 650)</td><td>Total range</td><td rowspan="2">RCP4.5</td><td>−38 to 24</td><td>−134 to −50</td></tr>
<tr><td>(650 to 720)</td><td>Total range</td><td>−11 to 17</td><td>−54 to −21</td><td rowspan="2">Unlikely</td><td>More likely than not</td></tr>
<tr><td>(720 to 1000) [b]</td><td>Total range</td><td>RCP6.0</td><td>18 to 54</td><td>−7 to 72</td><td rowspan="2">Unlikely [h]</td><td>More unlikely than likely</td></tr>
<tr><td>>1000 [b]</td><td>Total range</td><td>RCP8.5</td><td>52 to 95</td><td>74 to 178</td><td>Unlikely [h]</td><td>Unlikely</td><td>More unlikely than likely</td></tr>
</table>

Notes:

[a] The 'total range' for the 430 to 480 ppm CO_2-eq concentrations scenarios corresponds to the range of the 10th to 90th percentile of the subcategory of these scenarios shown in Table 6.3 of the Working Group III Report.

[b] Baseline scenarios fall into the >1000 and 720 to 1000 ppm CO_2-eq categories. The latter category also includes mitigation scenarios. The baseline scenarios in the latter category reach a temperature change of 2.5°C to 5.8°C above the average for 1850–1900 in 2100. Together with the baseline scenarios in the >1000 ppm CO_2-eq category, this leads to an overall 2100 temperature range of 2.5°C to 7.8°C (range based on median climate response: 3.7°C to 4.8°C) for baseline scenarios across both concentration categories.

[c] The global 2010 emissions are 31% above the 1990 emissions (consistent with the historic greenhouse gas emission estimates presented in this report). CO_2-eq emissions include the basket of Kyoto gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) as well as fluorinated gases).

[d] The assessment here involves a large number of scenarios published in the scientific literature and is thus not limited to the Representative Concentration Pathways (RCPs). To evaluate the CO_2-eq concentration and climate implications of these scenarios, the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC) was used in a probabilistic mode. For a comparison between MAGICC model results and the outcomes of the models used in WGI, see WGI 12.4.1.2, 12.4.8 and WGIII 6.3.2.6.

[e] The assessment in this table is based on the probabilities calculated for the full ensemble of scenarios in WGIII AR5 using MAGICC and the assessment in WGI of the uncertainty of the temperature projections not covered by climate models. The statements are therefore consistent with the statements in WGI, which are based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) runs of the RCPs and the assessed uncertainties. Hence, the likelihood statements reflect different lines of evidence from both WGs. This WGI method was also applied for scenarios with intermediate concentration levels where no CMIP5 runs are available. The likelihood statements are indicative only *{WGIII 6.3}* and follow broadly the terms used by the WGI SPM for temperature projections: likely 66–100%, more likely than not >50–100%, about as likely as not 33–66%, and unlikely 0–33%. In addition the term more unlikely than likely 0–<50% is used.

[f] The CO_2-equivalent concentration (see Glossary) is calculated on the basis of the total forcing from a simple carbon cycle/climate model, MAGICC. The CO_2-equivalent concentration in 2011 is estimated to be 430 ppm (uncertainty range 340 to 520 ppm). This is based on the assessment of total anthropogenic radiative forcing for 2011 relative to 1750 in WGI, i.e., 2.3 W/m^2, uncertainty range 1.1 to 3.3 W/m^2.

[g] The vast majority of scenarios in this category overshoot the category boundary of 480 ppm CO_2-eq concentration.

[h] For scenarios in this category, no CMIP5 run or MAGICC realization stays below the respective temperature level. Still, an *unlikely* assignment is given to reflect uncertainties that may not be reflected by the current climate models.

[i] Scenarios in the 580 to 650 ppm CO_2-eq category include both overshoot scenarios and scenarios that do not exceed the concentration level at the high end of the category (e.g., RCP4.5). The latter type of scenarios, in general, have an assessed probability of *more unlikely than likely* to stay below the 2°C temperature level, while the former are mostly assessed to have an *unlikely* probability of staying below this level.

[j] In these scenarios, global CO_2-eq emissions in 2050 are between 70 to 95% below 2010 emissions, and they are between 110 to 120% below 2010 emissions in 2100.

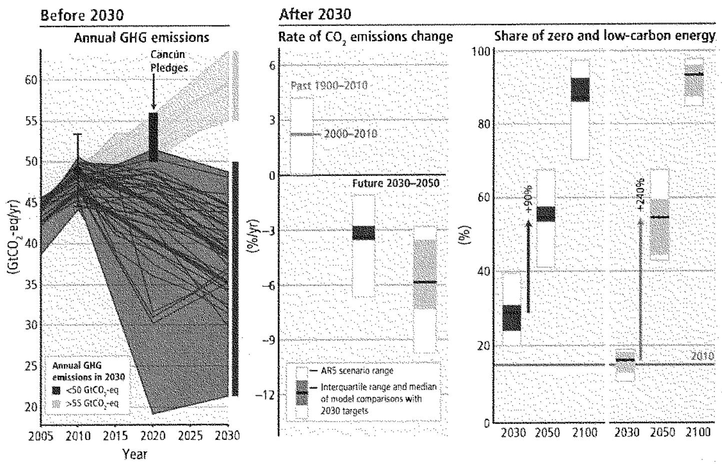


Figure SPM.12 | The implications of different 2030 greenhouse gas (GHG) emissions levels for the rate of carbon dioxide (CO_2) emissions reductions and low-carbon energy upscaling in mitigation scenarios that are at least *about as likely as not* to keep warming throughout the 21st century below 2°C relative to pre-industrial levels (2100 CO_2-equivalent concentrations of 430 to 530 ppm). The scenarios are grouped according to different emissions levels by 2030 (coloured in different shades of green). The left panel shows the pathways of GHG emissions (gigatonne of CO_2-equivalent per year, $GtCO_2$-eq/yr) leading to these 2030 levels. The black dot with whiskers gives historic GHG emission levels and associated uncertainties in 2010 as reported in Figure SPM.2. The black bar shows the estimated uncertainty range of GHG emissions implied by the Cancún Pledges. The middle panel denotes the average annual CO_2 emissions reduction rates for the period 2030–2050. It compares the median and interquartile range across scenarios from recent inter-model comparisons with explicit 2030 interim goals to the range of scenarios in the Scenario Database for WGIII AR5. Annual rates of historical emissions change (sustained over a period of 20 years) and the average annual CO_2 emission change between 2000 and 2010 are shown as well. The arrows in the right panel show the magnitude of zero and low-carbon energy supply upscaling from 2030 to 2050 subject to different 2030 GHG emissions levels. Zero- and low-carbon energy supply includes renewables, nuclear energy and fossil energy with carbon dioxide capture and storage (CCS) or bioenergy with CCS (BECCS). [Note: Only scenarios that apply the full, unconstrained mitigation technology portfolio of the underlying models (default technology assumption) are shown. Scenarios with large net negative global emissions (>20 $GtCO_2$-eq/yr), scenarios with exogenous carbon price assumptions and scenarios with 2010 emissions significantly outside the historical range are excluded.] *{Figure 3.3}*

Mitigation scenarios reaching about 450 ppm CO_2-eq in 2100 (consistent with a *likely* chance to keep warming below 2°C relative to pre-industrial levels) typically involve temporary overshoot[17] of atmospheric concentrations, as do many scenarios reaching about 500 ppm CO_2-eq to about 550 ppm CO_2-eq in 2100 (Table SPM.1). Depending on the level of overshoot, overshoot scenarios typically rely on the availability and widespread deployment of bioenergy with carbon dioxide capture and storage (BECCS) and afforestation in the second half of the century. The availability and scale of these and other CDR technologies and methods are uncertain and CDR technologies are, to varying degrees, associated with challenges and risks[18]. CDR is also prevalent in many scenarios without overshoot to compensate for residual emissions from sectors where mitigation is more expensive (*high confidence*). *{3.4, Box 3.3}*

Reducing emissions of non-CO_2 agents can be an important element of mitigation strategies. All current GHG emissions and other forcing agents affect the rate and magnitude of climate change over the next few decades, although long-term warming is mainly driven by CO_2 emissions. Emissions of non-CO_2 forcers are often expressed as 'CO_2-equivalent emissions', but the choice of metric to calculate these emissions, and the implications for the emphasis and timing of abatement of the various climate forcers, depends on application and policy context and contains value judgments. *{3.4, Box 3.2}*

[17] In concentration 'overshoot' scenarios, concentrations peak during the century and then decline.

[18] CDR methods have biogeochemical and technological limitations to their potential on the global scale. There is insufficient knowledge to quantify how much CO_2 emissions could be partially offset by CDR on a century timescale. CDR methods may carry side effects and long-term consequences on a global scale.

SPM

Global mitigation costs and consumption growth in baseline scenarios

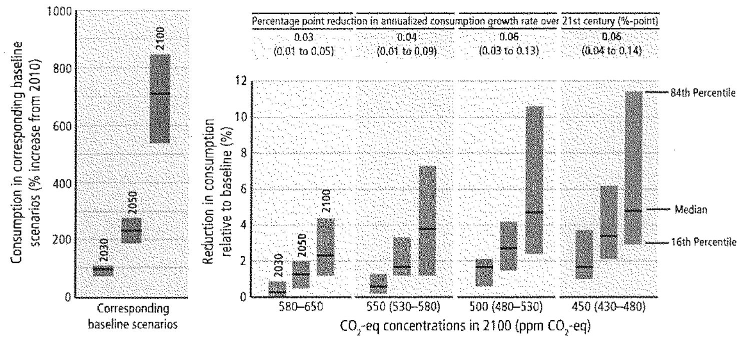


Figure SPM.13 | Global mitigation costs in cost-effective scenarios at different atmospheric concentrations levels in 2100. Cost-effective scenarios assume immediate mitigation in all countries and a single global carbon price, and impose no additional limitations on technology relative to the models' default technology assumptions. Consumption losses are shown relative to a baseline development without climate policy (left panel). The table at the top shows percentage points of annualized consumption growth reductions relative to consumption growth in the baseline of 1.6 to 3% per year (e.g., if the reduction is 0.06 percentage points per year due to mitigation, and baseline growth is 2.0% per year, then the growth rate with mitigation would be 1.94% per year). Cost estimates shown in this table do not consider the benefits of reduced climate change or co-benefits and adverse side effects of mitigation. Estimates at the high end of these cost ranges are from models that are relatively inflexible to achieve the deep emissions reductions required in the long run to meet these goals and/or include assumptions about market imperfections that would raise costs. *{Figure 3.4}*

Delaying additional mitigation to 2030 will substantially increase the challenges associated with limiting warming over the 21st century to below 2°C relative to pre-industrial levels. It will require substantially higher rates of emissions reductions from 2030 to 2050; a much more rapid scale-up of low-carbon energy over this period; a larger reliance on CDR in the long term; and higher transitional and long-term economic impacts. Estimated global emissions levels in 2020 based on the Cancún Pledges are not consistent with cost-effective mitigation trajectories that are at least *about as likely as not* to limit warming to below 2°C relative to pre-industrial levels, but they do not preclude the option to meet this goal (*high confidence*) (Figure SPM.12, Table SPM.2). *{3.4}*

Estimates of the aggregate economic costs of mitigation vary widely depending on methodologies and assumptions, but increase with the stringency of mitigation. Scenarios in which all countries of the world begin mitigation immediately, in which there is a single global carbon price, and in which all key technologies are available have been used as a cost-effective benchmark for estimating macro-economic mitigation costs (Figure SPM.13). Under these assumptions mitigation scenarios that are *likely* to limit warming to below 2°C through the 21st century relative to pre-industrial levels entail losses in global consumption—not including benefits of reduced climate change as well as co-benefits and adverse side effects of mitigation—of 1 to 4% (median: 1.7%) in 2030, 2 to 6% (median: 3.4%) in 2050 and 3 to 11% (median: 4.8%) in 2100 relative to consumption in baseline scenarios that grows anywhere from 300% to more than 900% over the century (Figure SPM.13). These numbers correspond to an annualized reduction of consumption growth by 0.04 to 0.14 (median: 0.06) percentage points over the century relative to annualized consumption growth in the baseline that is between 1.6 and 3% per year (*high confidence*). *{3.4}*

In the absence or under limited availability of mitigation technologies (such as bioenergy, CCS and their combination BECCS, nuclear, wind/solar), mitigation costs can increase substantially depending on the technology considered. Delaying additional mitigation increases mitigation costs in the medium to long term. Many models could not limit *likely* warming to below 2°C over the 21st century relative to pre-industrial levels if additional mitigation is considerably delayed. Many models could not limit *likely* warming to below 2°C if bioenergy, CCS and their combination (BECCS) are limited (*high confidence*) (Table SPM.2). *{3.4}*

Table SPM.2 | Increase in global mitigation costs due to either limited availability of specific technologies or delays in additional mitigation [a] relative to cost-effective scenarios [b]. The increase in costs is given for the median estimate and the 16th to 84th percentile range of the scenarios (in parentheses) [c]. In addition, the sample size of each scenario set is provided in the coloured symbols. The colours of the symbols indicate the fraction of models from systematic model comparison exercises that could successfully reach the targeted concentration level. *{Table 3.2}*

	Mitigation cost increases in scenarios with limited availability of technologies [d] *[% increase in total discounted [e] mitigation costs (2015–2100) relative to default technology assumptions]*				Mitigation cost increases due to delayed additional mitigation until 2030 *[% increase in mitigation costs relative to immediate mitigation]*	
2100 concentrations (ppm CO_2-eq)	no CCS	nuclear phase out	limited solar/wind	limited bioenergy	medium term costs (2030–2050)	long term costs (2050–2100)
450 (430 to 480)	138% (29 to 297%) 4	7% (4 to 18%) 8	6% (2 to 29%) 8	64% (44 to 78%) 8	44% (2 to 78%) 29	37% (16 to 82%) 29
500 (480 to 530)	not available (n.a.)	n.a.	n.a.	n.a.		
550 (530 to 580)	39% (18 to 78%) 11	13% (2 to 23%) 10	8% (5 to 15%) 10	18% (4 to 66%) 12	15% (3 to 32%)	16% (5 to 24%)
580 to 650	n.a.	n.a.	n.a.	n.a.		

Symbol legend—fraction of models successful in producing scenarios (numbers indicate the number of successful models)

: all models successful

: between 80 and 100% of models successful

: between 50 and 80% of models successful

: less than 50% of models successful

Notes:

[a] Delayed mitigation scenarios are associated with greenhouse gas emission of more than 55 $GtCO_2$-eq in 2030, and the increase in mitigation costs is measured relative to cost-effective mitigation scenarios for the same long-term concentration level.

[b] Cost-effective scenarios assume immediate mitigation in all countries and a single global carbon price, and impose no additional limitations on technology relative to the models' default technology assumptions.

[c] The range is determined by the central scenarios encompassing the 16th to 84th percentile range of the scenario set. Only scenarios with a time horizon until 2100 are included. Some models that are included in the cost ranges for concentration levels above 530 ppm CO_2-eq in 2100 could not produce associated scenarios for concentration levels below 530 ppm CO_2-eq in 2100 with assumptions about limited availability of technologies and/or delayed additional mitigation.

[d] No CCS: carbon dioxide capture and storage is not included in these scenarios. Nuclear phase out: no addition of nuclear power plants beyond those under construction, and operation of existing plants until the end of their lifetime. Limited Solar/Wind: a maximum of 20% global electricity generation from solar and wind power in any year of these scenarios. Limited Bioenergy: a maximum of 100 EJ/yr modern bioenergy supply globally (modern bioenergy used for heat, power, combinations and industry was around 18 EJ/yr in 2008). EJ = Exajoule = 10^{18} Joule.

[e] Percentage increase of net present value of consumption losses in percent of baseline consumption (for scenarios from general equilibrium models) and abatement costs in percent of baseline gross domestic product (GDP, for scenarios from partial equilibrium models) for the period 2015–2100, discounted at 5% per year.

Mitigation scenarios reaching about 450 or 500 ppm CO_2-eq by 2100 show reduced costs for achieving air quality and energy security objectives, with significant co-benefits for human health, ecosystem impacts and sufficiency of resources and resilience of the energy system. *{4.4.2.2}*

Mitigation policy could devalue fossil fuel assets and reduce revenues for fossil fuel exporters, but differences between regions and fuels exist (*high confidence*). Most mitigation scenarios are associated with reduced revenues from coal and oil trade for major exporters (*high confidence*). The availability of CCS would reduce the adverse effects of mitigation on the value of fossil fuel assets (*medium confidence*). *{4.4.2.2}*

Solar Radiation Management (SRM) involves large-scale methods that seek to reduce the amount of absorbed solar energy in the climate system. SRM is untested and is not included in any of the mitigation scenarios. If it were deployed, SRM would

SPM

entail numerous uncertainties, side effects, risks and shortcomings and has particular governance and ethical implications. SRM would not reduce ocean acidification. If it were terminated, there is *high confidence* that surface temperatures would rise very rapidly impacting ecosystems susceptible to rapid rates of change. *{Box 3.3}*

SPM 4. Adaptation and Mitigation

Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives. *{4}*

SPM 4.1 Common enabling factors and constraints for adaptation and mitigation responses

Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioural and lifestyle choices. *{4.1}*

Inertia in many aspects of the socio-economic system constrains adaptation and mitigation options (*medium evidence, high agreement*). Innovation and investments in environmentally sound infrastructure and technologies can reduce GHG emissions and enhance resilience to climate change (*very high confidence*). *{4.1}*

Vulnerability to climate change, GHG emissions and the capacity for adaptation and mitigation are strongly influenced by livelihoods, lifestyles, behaviour and culture (*medium evidence, medium agreement*). Also, the social acceptability and/or effectiveness of climate policies are influenced by the extent to which they incentivize or depend on regionally appropriate changes in lifestyles or behaviours. *{4.1}*

For many regions and sectors, enhanced capacities to mitigate and adapt are part of the foundation essential for managing climate change risks (*high confidence*). Improving institutions as well as coordination and cooperation in governance can help overcome regional constraints associated with mitigation, adaptation and disaster risk reduction (*very high confidence*). *{4.1}*

SPM 4.2 Response options for adaptation

Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differs across sectors and regions. Some adaptation responses involve significant co-benefits, synergies and trade-offs. Increasing climate change will increase challenges for many adaptation options. *{4.2}*

Adaptation experience is accumulating across regions in the public and private sectors and within communities. There is increasing recognition of the value of social (including local and indigenous), institutional, and ecosystem-based measures and of the extent of constraints to adaptation. Adaptation is becoming embedded in some planning processes, with more limited implementation of responses (*high confidence*). *{1.6, 4.2, 4.4.2.1}*

The need for adaptation along with associated challenges is expected to increase with climate change (*very high confidence*). Adaptation options exist in all sectors and regions, with diverse potential and approaches depending on their context in vulnerability reduction, disaster risk management or proactive adaptation planning (Table SPM.3). Effective strategies and actions consider the potential for co-benefits and opportunities within wider strategic goals and development plans. *{4.2}*

Table SPM.3 | Approaches for managing the risks of climate change through adaptation. These approaches should be considered overlapping rather than discrete, and they are often pursued simultaneously. Examples are presented in no specific order and can be relevant to more than one category. *[Table 4.2]*

Overlapping Approaches	Category	Examples
Vulnerability & Exposure Reduction through development, planning & practices including many low-regrets measures	Human development	Improved access to education, nutrition, health facilities, energy, safe housing & settlement structures, & social support structures; Reduced gender inequality & marginalization in other forms.
	Poverty alleviation	Improved access to & control of local resources; Land tenure; Disaster risk reduction; Social safety nets & social protection; Insurance schemes.
	Livelihood security	Income, asset & livelihood diversification; Improved infrastructure; Access to technology & decision-making fora; Increased decision-making power; Changed cropping, livestock & aquaculture practices; Reliance on social networks.
	Disaster risk management	Early warning systems; Hazard & vulnerability mapping; Diversifying water resources; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements.
	Ecosystem management	Maintaining wetlands & urban green spaces; Coastal afforestation; Watershed & reservoir management; Reduction of other stressors on ecosystems & of habitat fragmentation; Maintenance of genetic diversity; Manipulation of disturbance regimes; Community-based natural resource management.
	Spatial or land-use planning	Provisioning of adequate housing, infrastructure & services; Managing development in flood prone & other high risk areas; Urban planning & upgrading programs; Land zoning laws; Easements; Protected areas.
Adaptation including incremental & transformational adjustments	Structural/physical	***Engineered & built-environment options***: Sea walls & coastal protection structures; Flood levees; Water storage; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements; Floating houses; Power plant & electricity grid adjustments.
		Technological options: New crop & animal varieties; Indigenous, traditional & local knowledge, technologies & methods; Efficient irrigation; Water-saving technologies; Desalinisation; Conservation agriculture; Food storage & preservation facilities; Hazard & vulnerability mapping & monitoring; Early warning systems; Building insulation; Mechanical & passive cooling; Technology development, transfer & diffusion.
		Ecosystem-based options: Ecological restoration; Soil conservation; Afforestation & reforestation; Mangrove conservation & replanting; Green infrastructure (e.g., shade trees, green roofs); Controlling overfishing; Fisheries co-management; Assisted species migration & dispersal; Ecological corridors; Seed banks, gene banks & other *ex situ* conservation; Community-based natural resource management.
		Services: Social safety nets & social protection; Food banks & distribution of food surplus; Municipal services including water & sanitation; Vaccination programs; Essential public health services; Enhanced emergency medical services.
	Institutional	***Economic options***: Financial incentives; Insurance; Catastrophe bonds; Payments for ecosystem services; Pricing water to encourage universal provision and careful use; Microfinance; Disaster contingency funds; Cash transfers; Public-private partnerships.
		Laws & regulations: Land zoning laws; Building standards & practices; Easements; Water regulations & agreements; Laws to support disaster risk reduction; Laws to encourage insurance purchasing; Defined property rights & land tenure security; Protected areas; Fishing quotas; Patent pools & technology transfer.
		National & government policies & programs: National & regional adaptation plans including mainstreaming; Sub-national & local adaptation plans; Economic diversification; Urban upgrading programs; Municipal water management programs; Disaster planning & preparedness; Integrated water resource management; Integrated coastal zone management; Ecosystem-based management; Community-based adaptation.
	Social	***Educational options***: Awareness raising & integrating into education; Gender equity in education; Extension services; Sharing indigenous, traditional & local knowledge; Participatory action research & social learning; Knowledge-sharing & learning platforms.
		Informational options: Hazard & vulnerability mapping; Early warning & response systems; Systematic monitoring & remote sensing; Climate services; Use of indigenous climate observations; Participatory scenario development; Integrated assessments.
		Behavioural options: Household preparation & evacuation planning; Migration; Soil & water conservation; Storm drain clearance; Livelihood diversification; Changed cropping, livestock & aquaculture practices; Reliance on social networks.
Transformation	Spheres of change	***Practical***: Social & technical innovations, behavioural shifts, or institutional & managerial changes that produce substantial shifts in outcomes.
		Political: Political, social, cultural & ecological decisions & actions consistent with reducing vulnerability & risk & supporting adaptation, mitigation & sustainable development.
		Personal: Individual & collective assumptions, beliefs, values & worldviews influencing climate-change responses.

SPM

SPM 4.3 Response options for mitigation

Mitigation options are available in every major sector. Mitigation can be more cost-effective if using an integrated approach that combines measures to reduce energy use and the greenhouse gas intensity of end-use sectors, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors. *{4.3}*

Well-designed systemic and cross-sectoral mitigation strategies are more cost-effective in cutting emissions than a focus on individual technologies and sectors, with efforts in one sector affecting the need for mitigation in others (*medium confidence*). Mitigation measures intersect with other societal goals, creating the possibility of co-benefits or adverse side effects. These intersections, if well-managed, can strengthen the basis for undertaking climate action. *{4.3}*

Emissions ranges for baseline scenarios and mitigation scenarios that limit CO_2-equivalent concentrations to low levels (about 450 ppm CO_2-eq, *likely* to limit warming to 2°C above pre-industrial levels) are shown for different sectors and gases in Figure SPM.14. Key measures to achieve such mitigation goals include decarbonizing (i.e., reducing the carbon intensity of) electricity generation (*medium evidence, high agreement*) as well as efficiency enhancements and behavioural changes, in order to reduce energy demand compared to baseline scenarios without compromising development (*robust evidence, high agreement*). In scenarios reaching 450 ppm CO_2-eq concentrations by 2100, global CO_2 emissions from the energy supply sector are projected to decline over the next decade and are characterized by reductions of 90% or more below 2010 levels between 2040 and 2070. In the majority of low-concentration stabilization scenarios (about 450 to about 500 ppm CO_2-eq, at least *about as likely as not* to limit warming to 2°C above pre-industrial levels), the share of low-carbon electricity supply (comprising renewable energy (RE), nuclear and carbon dioxide capture and storage (CCS) including bioenergy with carbon dioxide capture and storage (BECCS)) increases from the current share of approximately 30% to more than 80% by 2050, and fossil fuel power generation without CCS is phased out almost entirely by 2100. *{4.3}*

Direct CO_2 emissions by major sectors, and non-CO_2 emissions, for baseline and mitigation scenarios

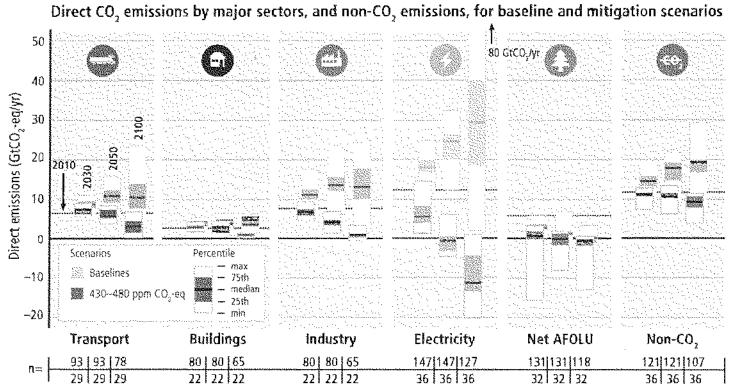


Figure SPM.14 | Carbon dioxide (CO_2) emissions by sector and total non-CO_2 greenhouse gases (Kyoto gases) across sectors in baseline (faded bars) and mitigation scenarios (solid colour bars) that reach about 450 (430 to 480) ppm CO_2-eq concentrations in 2100 (*likely* to limit warming to 2°C above pre-industrial levels). Mitigation in the end-use sectors leads also to indirect emissions reductions in the upstream energy supply sector. Direct emissions of the end-use sectors thus do not include the emission reduction potential at the supply-side due to, for example, reduced electricity demand. The numbers at the bottom of the graphs refer to the number of scenarios included in the range (upper row: baseline scenarios; lower row: mitigation scenarios), which differs across sectors and time due to different sectoral resolution and time horizon of models. Emissions ranges for mitigation scenarios include the full portfolio of mitigation options; many models cannot reach 450 ppm CO_2-eq concentration by 2100 in the absence of carbon dioxide capture and storage (CCS). Negative emissions in the electricity sector are due to the application of bioenergy with carbon dioxide capture and storage (BECCS). 'Net' agriculture, forestry and other land use (AFOLU) emissions consider afforestation, reforestation as well as deforestation activities. *{4.3, Figure 4.1}*

Near-term reductions in energy demand are an important element of cost-effective mitigation strategies, provide more flexibility for reducing carbon intensity in the energy supply sector, hedge against related supply-side risks, avoid lock-in to carbon-intensive infrastructures, and are associated with important co-benefits. The most cost-effective mitigation options in forestry are afforestation, sustainable forest management and reducing deforestation, with large differences in their relative importance across regions; and in agriculture, cropland management, grazing land management and restoration of organic soils (*medium evidence, high agreement*). *{4.3, Figures 4.1, 4.2, Table 4.3}*

Behaviour, lifestyle and culture have a considerable influence on energy use and associated emissions, with high mitigation potential in some sectors, in particular when complementing technological and structural change (*medium evidence, medium agreement*). Emissions can be substantially lowered through changes in consumption patterns, adoption of energy savings measures, dietary change and reduction in food wastes. *{4.1, 4.3}*

SPM 4.4 Policy approaches for adaptation and mitigation, technology and finance

Effective adaptation and mitigation responses will depend on policies and measures across multiple scales: international, regional, national and sub-national. Policies across all scales supporting technology development, diffusion and transfer, as well as finance for responses to climate change, can complement and enhance the effectiveness of policies that directly promote adaptation and mitigation. *{4.4}*

International cooperation is critical for effective mitigation, even though mitigation can also have local co-benefits. Adaptation focuses primarily on local to national scale outcomes, but its effectiveness can be enhanced through coordination across governance scales, including international cooperation: *{3.1, 4.4.1}*

- The United Nations Framework Convention on Climate Change (UNFCCC) is the main multilateral forum focused on addressing climate change, with nearly universal participation. Other institutions organized at different levels of governance have resulted in diversifying international climate change cooperation. *{4.4.1}*
- The Kyoto Protocol offers lessons towards achieving the ultimate objective of the UNFCCC, particularly with respect to participation, implementation, flexibility mechanisms and environmental effectiveness (*medium evidence, low agreement*). *{4.4.1}*
- Policy linkages among regional, national and sub-national climate policies offer potential climate change mitigation benefits (*medium evidence, medium agreement*). Potential advantages include lower mitigation costs, decreased emission leakage and increased market liquidity. *{4.4.1}*
- International cooperation for supporting adaptation planning and implementation has received less attention historically than mitigation but is increasing and has assisted in the creation of adaptation strategies, plans and actions at the national, sub-national and local level (*high confidence*). *{4.4.1}*

There has been a considerable increase in national and sub-national plans and strategies on both adaptation and mitigation since the AR4, with an increased focus on policies designed to integrate multiple objectives, increase co-benefits and reduce adverse side effects (*high confidence*): *{4.4.2.1, 4.4.2.2}*

- National governments play key roles in adaptation planning and implementation (*robust evidence, high agreement*) through coordinating actions and providing frameworks and support. While local government and the private sector have different functions, which vary regionally, they are increasingly recognized as critical to progress in adaptation, given their roles in scaling up adaptation of communities, households and civil society and in managing risk information and financing (*medium evidence, high agreement*). *{4.4.2.1}*
- Institutional dimensions of adaptation governance, including the integration of adaptation into planning and decision-making, play a key role in promoting the transition from planning to implementation of adaptation (*robust evidence,*

SPM

high agreement). Examples of institutional approaches to adaptation involving multiple actors include economic options (e.g., insurance, public-private partnerships), laws and regulations (e.g., land-zoning laws) and national and government policies and programmes (e.g., economic diversification). *{4.2, 4.4.2.1, Table SPM.3}*

- In principle, mechanisms that set a carbon price, including cap and trade systems and carbon taxes, can achieve mitigation in a cost-effective way but have been implemented with diverse effects due in part to national circumstances as well as policy design. The short-run effects of cap and trade systems have been limited as a result of loose caps or caps that have not proved to be constraining (*limited evidence, medium agreement*). In some countries, tax-based policies specifically aimed at reducing GHG emissions—alongside technology and other policies—have helped to weaken the link between GHG emissions and GDP (*high confidence*). In addition, in a large group of countries, fuel taxes (although not necessarily designed for the purpose of mitigation) have had effects that are akin to sectoral carbon taxes. *{4.4.2.2}*

- Regulatory approaches and information measures are widely used and are often environmentally effective (*medium evidence, medium agreement*). Examples of regulatory approaches include energy efficiency standards; examples of information programmes include labelling programmes that can help consumers make better-informed decisions. *{4.4.2.2}*

- Sector-specific mitigation policies have been more widely used than economy-wide policies (*medium evidence, high agreement*). Sector-specific policies may be better suited to address sector-specific barriers or market failures and may be bundled in packages of complementary policies. Although theoretically more cost-effective, administrative and political barriers may make economy-wide policies harder to implement. Interactions between or among mitigation policies may be synergistic or may have no additive effect on reducing emissions. *{4.4.2.2}*

- Economic instruments in the form of subsidies may be applied across sectors, and include a variety of policy designs, such as tax rebates or exemptions, grants, loans and credit lines. An increasing number and variety of renewable energy (RE) policies including subsidies—motivated by many factors—have driven escalated growth of RE technologies in recent years. At the same time, reducing subsidies for GHG-related activities in various sectors can achieve emission reductions, depending on the social and economic context (*high confidence*). *{4.4.2.2}*

Co-benefits and adverse side effects of mitigation could affect achievement of other objectives such as those related to human health, food security, biodiversity, local environmental quality, energy access, livelihoods and equitable sustainable development. The potential for co-benefits for energy end-use measures outweighs the potential for adverse side effects whereas the evidence suggests this may not be the case for all energy supply and agriculture, forestry and other land use (AFOLU) measures. Some mitigation policies raise the prices for some energy services and could hamper the ability of societies to expand access to modern energy services to underserved populations (*low confidence*). These potential adverse side effects on energy access can be avoided with the adoption of complementary policies such as income tax rebates or other benefit transfer mechanisms (*medium confidence*). Whether or not side effects materialize, and to what extent side effects materialize, will be case- and site-specific, and depend on local circumstances and the scale, scope and pace of implementation. Many co-benefits and adverse side effects have not been well-quantified. *{4.3, 4.4.2.2, Box 3.4}*

Technology policy (development, diffusion and transfer) complements other mitigation policies across all scales, from international to sub-national; many adaptation efforts also critically rely on diffusion and transfer of technologies and management practices (*high confidence*). Policies exist to address market failures in R&D, but the effective use of technologies can also depend on capacities to adopt technologies appropriate to local circumstances. *{4.4.3}*

Substantial reductions in emissions would require large changes in investment patterns (*high confidence*). For mitigation scenarios that stabilize concentrations (without overshoot) in the range of 430 to 530 ppm CO_2-eq by 2100[19], annual investments in low carbon electricity supply and energy efficiency in key sectors (transport, industry and buildings) are projected in the scenarios to rise by several hundred billion dollars per year before 2030. Within appropriate enabling environments, the private sector, along with the public sector, can play important roles in financing mitigation and adaptation (*medium evidence, high agreement*). *{4.4.4}*

---

[19] This range comprises scenarios that reach 430 to 480 ppm CO_2-eq by 2100 (*likely* to limit warming to 2°C above pre-industrial levels) and scenarios that reach 480 to 530 ppm CO_2-eq by 2100 (without overshoot: *more likely than* not to limit warming to 2°C above pre-industrial levels).

Financial resources for adaptation have become available more slowly than for mitigation in both developed and developing countries. Limited evidence indicates that there is a gap between global adaptation needs and the funds available for adaptation (*medium confidence*). There is a need for better assessment of global adaptation costs, funding and investment. Potential synergies between international finance for disaster risk management and adaptation have not yet been fully realized (*high confidence*). *{4.4.4}*

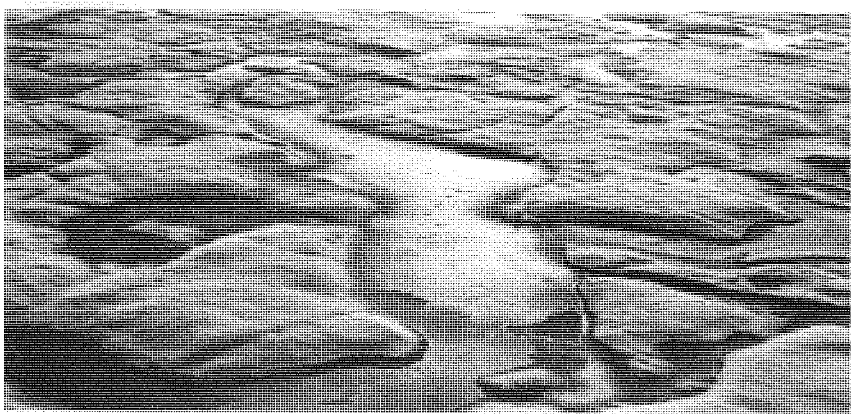
SPM 4.5 Trade-offs, synergies and interactions with sustainable development

Climate change is a threat to sustainable development. Nonetheless, there are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses (*high confidence*). Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond (*medium confidence*). *{3.5, 4.5}*

Climate change exacerbates other threats to social and natural systems, placing additional burdens particularly on the poor (*high confidence*). Aligning climate policy with sustainable development requires attention to both adaptation and mitigation (*high confidence*). Delaying global mitigation actions may reduce options for climate-resilient pathways and adaptation in the future. Opportunities to take advantage of positive synergies between adaptation and mitigation may decrease with time, particularly if limits to adaptation are exceeded. Increasing efforts to mitigate and adapt to climate change imply an increasing complexity of interactions, encompassing connections among human health, water, energy, land use and biodiversity (*medium evidence, high agreement*). *{3.1, 3.5, 4.5}*

Strategies and actions can be pursued now which will move towards climate-resilient pathways for sustainable development, while at the same time helping to improve livelihoods, social and economic well-being and effective environmental management. In some cases, economic diversification can be an important element of such strategies. The effectiveness of integrated responses can be enhanced by relevant tools, suitable governance structures and adequate institutional and human capacity (*medium confidence*). Integrated responses are especially relevant to energy planning and implementation; interactions among water, food, energy and biological carbon sequestration; and urban planning, which provides substantial opportunities for enhanced resilience, reduced emissions and more sustainable development (*medium confidence*). *{3.5, 4.4, 4.5}*

CLIMATE CHANGE
EVIDENCE & CAUSES



An overview from the Royal Society and the US National Academy of Sciences

NATIONAL ACADEMY OF SCIENCES

THE ROYAL SOCIETY

FOREWORD

CLIMATE CHANGE IS ONE OF THE DEFINING ISSUES OF OUR TIME. It is now more certain than ever, based on many lines of evidence, that humans are changing Earth's climate. The atmosphere and oceans have warmed, accompanied by sea-level rise, a strong decline in Arctic sea ice, and other climate-related changes.

The evidence is clear. However, due to the nature of science, not every single detail is ever totally settled or completely certain. Nor has every pertinent question yet been answered. Scientific evidence continues to be gathered around the world, and assumptions and findings about climate change are continually analysed and tested. Some areas of active debate and ongoing research include the link between ocean heat content and the rate of warming, estimates of how much warming to expect in the future, and the connections between climate change and extreme weather events.

The Royal Society and the US National Academy of Sciences, with their similar missions to promote the use of science to benefit society and to inform critical policy debates, offer this new publication as a key reference document for decision makers, policy makers, educators, and other individuals seeking authoritative answers about the current state of climate-change science. The publication makes clear what is well established, where consensus is growing, and where there is still uncertainty. It is written and reviewed by a UK-US team of leading climate scientists. It echoes and builds upon the long history of climate-related work from both national science academies, as well as the newest climate-change assessment from the United Nations' Intergovernmental Panel on Climate Change.

Scientific information is a vital component of the evidence required for societies to make sensible policy decisions. Climate-change science will continue to help society make informed decisions about how to reduce the magnitude of climate change and to adapt to its impacts. The Royal Society and the US National Academy of Sciences will continue to support the use of robust science toward these critical goals.

In 2008 Raymond and Beverly Sackler established the USA-UK Scientific Forum to help the scientists of the United Kingdom and the United States forge an enduring partnership on topics of worldwide scientific concern. As Presidents of the Royal Society and National Academy of Sciences, we are pleased to introduce the latest piece of work supported by the Sacklers' inspired generosity.

Dr. Ralph J. Cicerone
President, National Academy of Sciences

Sir Paul Nurse
President, Royal Society

CONTENTS

SUMMARY

GREENHOUSE GASES such as carbon dioxide (CO_2) absorb heat (infrared radiation) emitted from Earth's surface. Increases in the atmospheric concentrations of these gases cause Earth to warm by trapping more of this heat. Human activities—especially the burning of fossil fuels since the start of the Industrial Revolution—have increased atmospheric CO_2 concentrations by about 40%, with more than half the increase occurring since 1970. Since 1900, the global average surface temperature has increased by about 0.8 °C (1.4 °F). This has been accompanied by warming of the ocean, a rise in sea level, a strong decline in Arctic sea ice, and many other associated climate effects. Much of this warming has occurred in the last four decades. Detailed analyses have shown that the warming during this period is mainly a result of the increased concentrations of CO_2 and other greenhouse gases. Continued emissions of these gases will cause further climate change, including substantial increases in global average surface temperature and important changes in regional climate. The magnitude and timing of these changes will depend on many factors, and slowdowns and accelerations in warming lasting a decade or more will continue to occur. However, long-term climate change over many decades will depend mainly on the total amount of CO_2 and other greenhouse gases emitted as a result of human activities.

Q&A

1 Is the Climate Warming?

Yes. Earth's average surface air temperature has increased by about 0.8 °C (1.4 °F) since 1900, with much of this increase taking place since the mid-1970s (FIGURE 1A). A wide range of other observations (such as reduced Arctic sea ice extent and increased ocean heat content) and indications from the natural world (such as poleward shifts of temperature-sensitive species of fish, mammals, insects, etc.) together provide incontrovertible evidence of planetary-scale warming.

The clearest evidence for surface warming comes from widespread thermometer records. In some places, these records extend back to the late 19th century. Today, temperatures are monitored at many thousands of locations, over both the land and ocean surface. Indirect estimates of temperature change from such sources as tree rings and ice cores help to place recent temperature changes in the context of the past. In terms of the average surface temperature of Earth, these indirect estimates show that 1983 to 2012 was probably the warmest 30-year period in more than 800 years.

A wide range of other observations provides a more comprehensive picture of warming throughout the climate system. For example, the lower atmosphere and the upper layers of the ocean have also warmed, snow and ice cover are decreasing in the Northern Hemisphere, the Greenland ice sheet is shrinking, and sea level is rising [FIGURE 1B]. These measurements are made with a variety of monitoring systems, which gives added confidence in the reality that Earth's climate is warming.

FIGURE 1A. Earth's global average surface temperature has risen as shown in this plot of combined land and ocean measurements from 1850 to 2012, derived from three independent analyses of the available data sets. The temperature changes are relative to the global average surface temperature of 1961–1990. *Source: IPCC AR5, data from the HadCRUT4 dataset (black), UK Met Office Hadley Centre, the NCDC MLOST dataset (orange), US National Oceanic and Atmospheric Administration, and the NASA GISS dataset (blue), US National Aeronautics and Space Administration.*

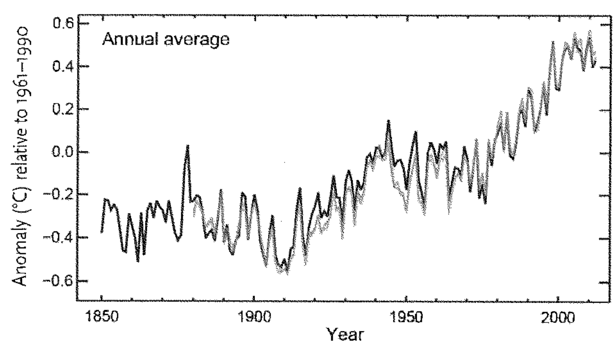
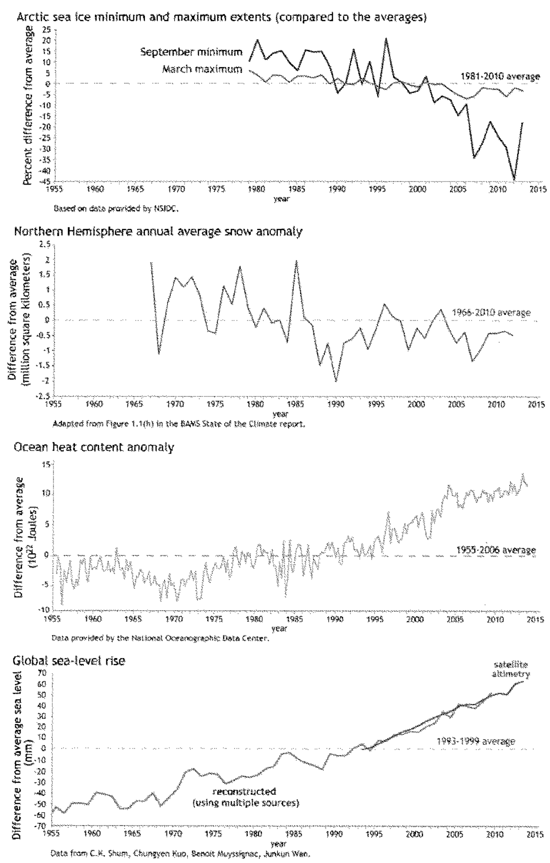


FIGURE 1B. A large amount of observational evidence besides the temperature records shows that Earth's climate is changing. For example, additional evidence of a warming trend can be found in the dramatic decrease in the extent of Arctic sea ice at its summer minimum (which occurs in September), decrease in spring snow cover in the Northern Hemisphere, increases in the global average upper ocean (upper 700 m or 2300 feet) heat content (shown relative to the 1955–2006 average), and in sea-level rise.
Source: NOAA climate.gov



2 How do scientists know that recent climate change is largely caused by human activities?

Scientists know that recent climate change is largely caused by human activities from an understanding of basic physics, comparing observations with models, and fingerprinting the detailed patterns of climate change caused by different human and natural influences.

Since the mid-1800s, scientists have known that CO_2 is one of the main greenhouse gases of importance to Earth's energy balance. Direct measurements of CO_2 in the atmosphere and in air trapped in ice show that atmospheric CO_2 increased by about 40% from 1800 to 2012. Measurements of different forms of carbon (isotopes, see Question 3) reveal that this increase is due to human activities. Other greenhouse gases (notably methane and nitrous oxide) are also increasing as a consequence of human activities. The observed global surface temperature rise since 1900 is consistent with detailed calculations of the impacts of the observed increase in atmospheric CO_2 (and other human-induced changes) on Earth's energy balance.

Different influences on climate have different signatures in climate records. These unique fingerprints are easier to see by probing beyond a single number (such as the average temperature of Earth's surface), and looking instead at the geographical and seasonal patterns of climate change. The observed patterns of surface warming, temperature changes through the atmosphere, increases in ocean heat content, increases in atmospheric moisture, sea level rise, and increased melting of land and sea ice also match the patterns scientists expect to see due to rising levels of CO_2 and other human-induced changes (see Question 5).

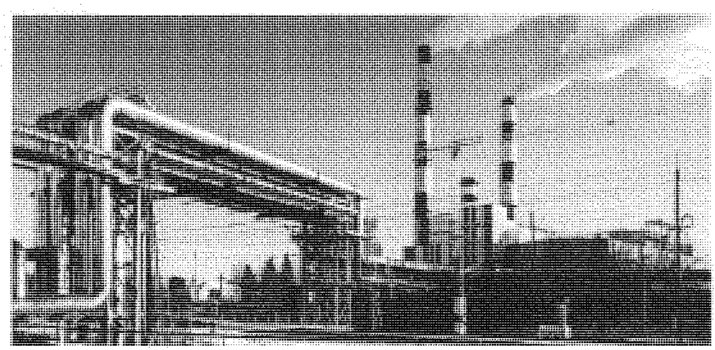
The expected changes in climate are based on our understanding of how greenhouse gases trap heat. Both this fundamental understanding of the physics of greenhouse gases and fingerprint studies show that natural causes alone are inadequate to explain the recent observed changes in climate. Natural causes include variations in the Sun's output and in Earth's orbit around the Sun, volcanic eruptions, and internal fluctuations in the climate system (such as El Niño and La Niña). Calculations using climate models (see infobox, p.20) have been used to simulate what would have happened to global temperatures if only natural factors were influencing the climate system. These simulations yield little warming, or even a slight cooling, over the 20th century. Only when models include human influences on the composition of the atmosphere are the resulting temperature changes consistent with observed changes.

3 CO_2 IS ALREADY IN THE ATMOSPHERE NATURALLY, SO WHY ARE EMISSIONS FROM HUMAN ACTIVITY SIGNIFICANT?

Human activities have significantly disturbed the natural carbon cycle by extracting long-buried fossil fuels and burning them for energy, thus releasing CO_2 to the atmosphere.

In nature, CO_2 is exchanged continually between the atmosphere, plants and animals through photosynthesis, respiration, and decomposition, and between the atmosphere and ocean through gas exchange. A very small amount of CO_2 (roughly 1% of the emission rate from fossil fuel combustion) is also emitted in volcanic eruptions. This is balanced by an equivalent amount that is removed by chemical weathering of rocks.

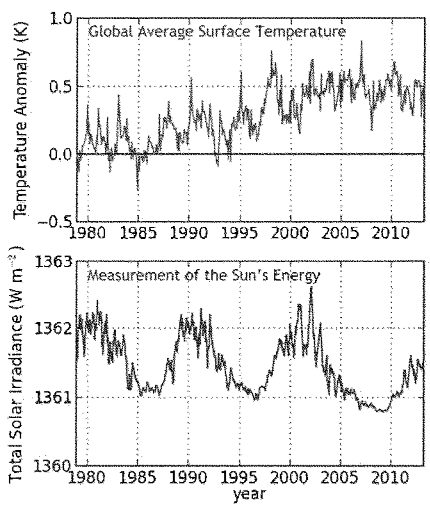
The CO_2 level in 2012 was about 40% higher than it was in the nineteenth century. Most of this CO_2 increase has taken place since 1970, about the time when global energy consumption accelerated. Measured decreases in the fraction of other forms of carbon (the isotopes ^{14}C and ^{13}C) and a small decrease in atmospheric oxygen concentration (observations of which have been available since 1990) show that the rise in CO_2 is largely from combustion of fossil fuels (which have low ^{13}C fractions and no ^{14}C). Deforestation and other land use changes have also released carbon from the biosphere (living world) where it normally resides for decades to centuries. The additional CO_2 from fossil fuel burning and deforestation has disturbed the balance of the carbon cycle, because the natural processes that could restore the balance are too slow compared to the rates at which human activities are adding CO_2 to the atmosphere. As a result, a substantial fraction of the CO_2 emitted from human activities accumulates in the atmosphere, where some of it will remain not just for decades or centuries, but for thousands of years. Comparison with the CO_2 levels measured in air extracted from ice cores indicates that the current concentrations are higher than they have been in at least 800,000 years (see Question 6).



4 WHAT ROLE HAS THE SUN PLAYED IN CLIMATE CHANGE IN RECENT DECADES?

The Sun provides the primary source of energy driving Earth's climate system, but its variations have played very little role in the climate changes observed in recent decades. Direct satellite measurements since the late 1970s show no net increase in the Sun's output, while at the same time global surface temperatures have increased [FIGURE 2].

For earlier periods, solar changes are less certain because they are inferred from indirect sources—including the number of sunspots and the abundance of certain forms (isotopes) of carbon or beryllium atoms, whose production rates in Earth's atmosphere are influenced by variations in the Sun. There is evidence that the 11 year solar cycle, during which the Sun's energy output varies by roughly 0.1%, can influence ozone concentrations, temperatures, and winds in the stratosphere (the layer in the atmosphere above the troposphere, typically from 12 to 50 km, depending on latitude and season). These stratospheric changes may have a small effect on surface climate over the 11 year cycle. However, the available evidence does not indicate pronounced long-term changes in the Sun's output over the past century, during which time human-induced increases in CO_2 concentrations have been the dominant influence on the long-term global surface temperature increase. Further evidence that current warming is not a result of solar changes can be found in the temperature trends at different altitudes in the atmosphere (see Question 5).



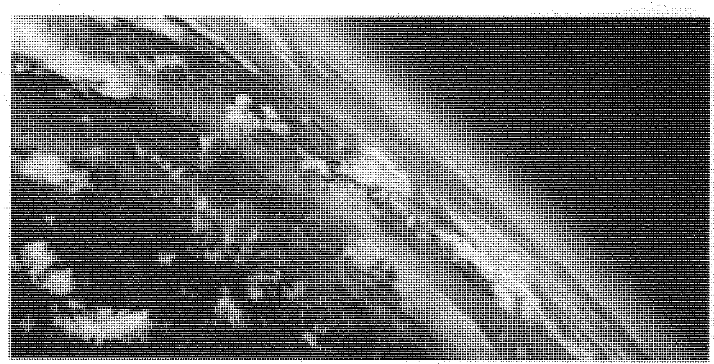
IGURE 2. Measurements of the iun's energy incident on Earth how no net increase in solar orcing during the past 30 years, nd therefore this cannot be esponsible for warming during hat period. The data show only mall periodic amplitude variations ssociated with the Sun's 11-year ycle. Figure by Keith Shine.
ource: TSI data from Physikalisch-Meteorologisches Observatorium Davos, Switzerland, adjusted down y 4.46 W m⁻² to agree with the 2008 olar minimum data from Kopp and ean, 2011; temperature data from the HadCRUT4 dataset, UK Met Office, ladley Centre

5 WHAT DO CHANGES IN THE VERTICAL STRUCTURE OF ATMOSPHERIC TEMPERATURE —FROM THE SURFACE UP TO THE STRATOSPHERE—TELL US ABOUT THE CAUSES OF RECENT CLIMATE CHANGE?

The observed warming in the lower atmosphere and cooling in the upper atmosphere provide us with key insights into the underlying causes of climate change and reveal that natural factors alone cannot explain the observed changes.

In the early 1960s, results from mathematical/physical models of the climate system first showed that human-induced increases in CO_2 would be expected to lead to gradual warming of the lower atmosphere (the troposphere) and cooling of higher levels of the atmosphere (the stratosphere). In contrast, increases in the Sun's output would warm both the troposphere and the full vertical extent of the stratosphere. At that time, there was insufficient observational data to test this prediction, but temperature measurements from weather balloons and satellites have since confirmed these early forecasts. It is now known that the observed pattern of tropospheric warming and stratospheric cooling over the past 30 to 40 years is broadly consistent with computer model simulations that include increases in CO_2 and decreases in stratospheric ozone, each caused by human activities. The observed pattern is not consistent with purely natural changes in the Sun's energy output, volcanic activity, or natural climate variations such as El Niño and La Niña.

Despite this agreement between the global-scale patterns of modelled and observed atmospheric temperature change, there are still some differences. The most noticeable differences are in the tropical troposphere, where models currently show more warming than has been observed, and in the Arctic, where the observed warming of the troposphere is greater than in most models.



6 CLIMATE IS ALWAYS CHANGING. WHY IS CLIMATE CHANGE OF CONCERN NOW?

All major climate changes, including natural ones, are disruptive. Past climate changes led to extinction of many species, population migrations, and pronounced changes in the land surface and ocean circulation. The speed of the current climate change is faster than most of the past events, making it more difficult for human societies and the natural world to adapt.

The largest global-scale climate variations in Earth's recent geological past are the ice age cycles (see infobox, p.B4), which are cold glacial periods followed by shorter warm periods [FIGURE 3]. The last few of these natural cycles have recurred roughly every 100,000 years. They are mainly paced by slow changes in Earth's orbit which alter the way the Sun's energy is distributed with latitude and by season on Earth. These changes alone are not sufficient to cause the observed magnitude of change in temperature, nor to act on the whole Earth. Instead they lead to changes in the extent of ice sheets and in the abundance of CO_2 and other greenhouse gases which amplify the initial temperature change and complete the global transition from warm to cold or vice versa.

Recent estimates of the increase in global average temperature since the end of the last ice age are 4 to 5 °C (7 to 9 °F). That change occurred over a period of about 7,000 years, starting 18,000 years ago. CO_2 has risen by 40% in just the past 200 years, contributing to human alteration of the planet's energy budget that has so far warmed Earth by about 0.8 °C (1.4 °F). If the rise in CO_2 continues unchecked, warming of the same magnitude as the increase out of the ice age can be expected by the end of this century or soon after. This speed of warming is more than ten times that at the end of an ice age, the fastest known natural sustained change on a global scale.

7 IS THE CURRENT LEVEL OF ATMOSPHERIC CO_2 CONCENTRATION UNPRECEDENTED IN EARTH'S HISTORY?

The present level of atmospheric CO_2 concentration is almost certainly unprecedented in the past million years, during which time modern humans evolved and societies developed. The atmospheric CO_2 concentration was however higher in Earth's more distant past (many millions of years ago), at which time palaeoclimatic and geological data indicate that temperatures and sea levels were also higher than they are today.

Measurements of air in ice cores show that for the past 800,000 years up until the 20th century, the atmospheric CO_2 concentration stayed within the range 170 to 300 parts per million (ppm), making the recent rapid rise to nearly 400 ppm over 200 years particularly remarkable [FIGURE 3]. During the glacial cycles of the past 800,000 years both CO_2 and methane have acted as important amplifiers of the climate changes triggered by variations in Earth's orbit around the Sun. As Earth warmed from the last ice age, temperature

continued

and CO_2 started to rise at approximately the same time and continued to rise in tandem from about 18,000 to 11,000 years ago. Changes in ocean temperature, circulation, chemistry and biology caused CO_2 to be released to the atmosphere, which combined with other feedbacks to push Earth into an even warmer state.

For earlier geological times, CO_2 concentrations and temperatures have been inferred from less direct methods. Those suggest that the concentration of CO_2 last approached 400 ppm about 3 to 5 million years ago, a period when global average surface temperature is estimated to have been about 2 to 3.5°C higher than in the pre-industrial period. At 50 million years ago, CO_2 may have reached 1000 ppm, and global average temperature was probably about 10°C warmer than today. Under those conditions, Earth had little ice, and sea level was at least 60 metres higher than current levels.

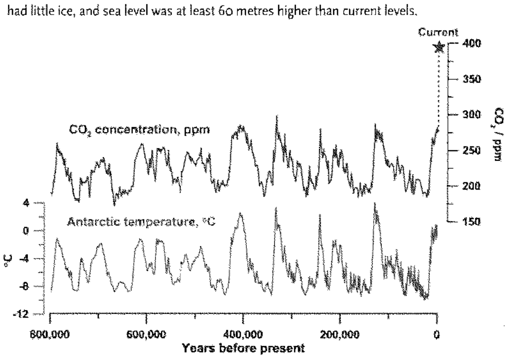


FIGURE 3. Data from ice cores have been used to reconstruct Antarctic temperatures and atmospheric CO_2 concentrations over the past 800,000 years. Temperature is based on measurements of the isotopic content of water in the Dome C ice core. CO_2 is measured in air trapped in ice, and is a composite of the Dome C and Vostok ice core. The current CO_2 concentration (blue star) is from atmospheric measurements. The cyclical pattern of temperature variations constitutes the ice age/ interglacial cycles. During these cycles, changes in CO_2 concentrations (in blue) track closely with changes in temperature (in red). As the record shows, the recent increase in atmospheric CO_2 concentration is unprecedented in the past 800,000 years. *Source: Figure by Jeremy Shakun, data from Lüthi et al., 2008 and Jouzel et al., 2007.*

8 IS THERE A POINT AT WHICH ADDING MORE CO_2 WILL NOT CAUSE FURTHER WARMING?

No. Adding more CO_2 to the atmosphere will cause surface temperatures to continue to increase. As the atmospheric concentrations of CO_2 increase, the addition of extra CO_2 becomes progressively less effective at trapping Earth's energy, but surface temperature will still rise.

Our understanding of the physics by which CO_2 affects Earth's energy balance is confirmed by laboratory measurements, as well as by detailed satellite and surface observations of the emission and absorption of infrared energy by the atmosphere. Greenhouse gases absorb some of the infrared energy that Earth emits in so-called bands of stronger absorption that occur at certain wavelengths. Different gases absorb energy at different wavelengths. CO_2 has its strongest heat-trapping band centred at a wavelength of 15 micrometres (millionths of a metre), with wings that spread out a few micrometres on either side. There are also many weaker absorption bands. As CO_2 concentrations increase, the absorption at the centre of the strong band is already so intense that it plays little role in causing additional warming. However, more energy is absorbed in the weaker bands and in the wings of the strong band, causing the surface and lower atmosphere to warm further.

9 DOES THE RATE OF WARMING VARY FROM ONE DECADE TO ANOTHER?

Yes. The observed warming rate has varied from year to year, decade to decade, and place to place, as is expected from our understanding of the climate system. These shorter-term variations are mostly due to natural causes, and do not contradict our fundamental understanding that the long-term warming trend is primarily due to human-induced changes in the atmospheric levels of CO_2 and other greenhouse gases.

Even as CO_2 is rising steadily in the atmosphere, leading to gradual warming of Earth's surface, many natural factors are modulating this long-term warming. Large volcanic eruptions increase the number of small particles in the stratosphere that reflect sunlight, leading to short-term surface cooling lasting typically two to three years, followed by a slow recovery. Ocean circulation and mixing vary naturally on many time scales, causing variations in sea surface temperatures as well as changes in the rate at which heat is transported to greater depths. For example, the tropical Pacific swings between warm El Niño and cooler La Niña events on timescales of two to seven years. Scientists know of and study many different types of climate variations, such as those on decadal and multi-decadal timescales in the Pacific and North Atlantic Oceans, each with its own unique characteristics. These oceanic variations are associated with significant regional and global shifts in temperature and rainfall patterns that are evident in the observations.

Warming from decade to decade can also be affected by human factors such as variations in the emissions, from coal-fired power plants and other pollution sources, of greenhouse gases and of aerosols (airborne particles that can have both warming and cooling effects).

These variations in the temperature trend are clearly evident in the observed temperature record [FIGURE 4]. Short-term natural climate variations could also affect the long-term human-induced climate change signal and vice-versa, because climate variations on different space and timescales can interact with one another. It is partly for this reason that climate change projections are made using climate models (*see infobox, p.20*) that can account for many different types of climate variations and their interactions. Reliable inferences about human-induced climate change must be made with a longer view, using records that cover many decades.

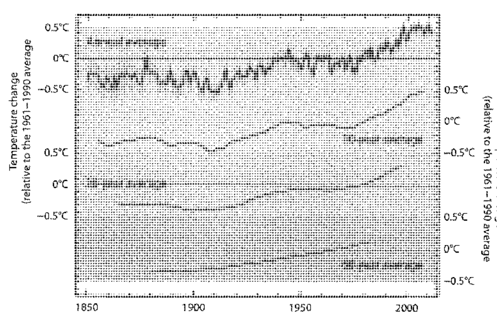


FIGURE 4. As the climate system varies naturally from year to year and from decade to decade, reliable inferences about human-induced climate change must be made with a longer view, using multi-decadal and longer records. Calculating a 'running average' over these longer timescales allows one to more easily see long-term trends. For the global average temperature for the period 1850-2012 (using the data from the UK Met Office Hadley Centre relative to the 1961-90 average) the plots show: (top) the average and range of uncertainty for annually averaged data; (2nd plot) the temperature given for any date is the average for the ten years about that date; (3rd plot) the equivalent picture for 30-year; and (4th plot) the 60-year averages. *Source: Met Office, based on the HadCRUT4 dataset from the Met Office and Climatic Research Unit (Morice et al., 2012).*

10 Does the recent slowdown of warming mean that climate change is no longer happening?

No. Since the very warm year 1998 that followed the strong 1997-98 El Niño, the increase in average surface temperature has slowed relative to the previous decade of rapid temperature increases. Despite the slower rate of warming the 2000s were warmer than the 1990s. A short-term slowdown in the warming of Earth's surface does not invalidate our understanding of long-term changes in global temperature arising from human-induced changes in greenhouse gases.

Decades of slow warming as well as decades of accelerated warming occur naturally in the climate system. Decades that are cold or warm compared to the long-term trend are seen in the observations of the past 150 years and also captured by climate models. Because the atmosphere stores very little heat, surface temperatures can be rapidly affected by heat uptake elsewhere in the climate system and by changes in external influences on climate (such as particles formed from material lofted high into the atmosphere from volcanic eruptions). More than 90% of the heat added to Earth is absorbed by the oceans and penetrates only slowly into deep water. A faster rate of heat penetration into the deeper ocean will slow the warming seen at the surface and in the atmosphere, but by itself will not change the long-term warming that will occur from a given amount of CO_2. For example, recent studies show that some heat comes out of the ocean into the atmosphere during warm El Niño events, and more heat penetrates to ocean depths in cold La Niñas. Such changes occur repeatedly over timescales of decades and longer. An example is the major El Niño event in 1997–98 when the globally averaged air temperature soared to the highest level in the 20th century as the ocean lost heat to the atmosphere, mainly by evaporation.

Recent studies have also pointed to a number of other small cooling influences over the past decade or so. These include a relatively quiet period of solar activity and a measured increase in the amount of aerosols (reflective particles) in the atmosphere due to the cumulative effects of a succession of small volcanic eruptions. The combination of these factors, both the interaction between the ocean and the atmosphere and the forcing from the Sun and aerosols, is thought likely to be responsible for the recent slowdown in surface warming.

Despite the decadal slowdown in the rise of average surface temperature, a longer-term warming trend is still evident (see Figure 4). Each of the last three decades was warmer than any other decade since widespread thermometer measurements were introduced in the 1850s. Record heatwaves have occurred in Australia (January 2013), USA (July 2012), in Russia (summer 2010), and in Europe (summer 2003). The continuing effects of the warming climate are also seen in the increasing trends in ocean heat content and sea level, as well as in the continued melting of Arctic sea ice, glaciers and the Greenland ice sheet.

11 If the world is warming, why are some winters and summers still very cold?

Global warming is a long-term trend, but that does not mean that every year will be warmer than the previous one. Day to day and year to year changes in weather patterns will continue to produce some unusually cold days and nights, and winters and summers, even as the climate warms.

Climate change means not only changes in globally averaged surface temperature, but also changes in atmospheric circulation, in the size and patterns of natural climate variations, and in local weather. La Niña events shift weather patterns so that some regions are made wetter, and wet summers are generally cooler. Stronger winds from polar regions can contribute to an occasional colder winter. In a similar way, the persistence of one phase of an atmospheric circulation pattern known as the North Atlantic Oscillation has contributed to several recent cold winters in Europe, eastern North America, and northern Asia.

Atmospheric and ocean circulation patterns will evolve as Earth warms and will influence storm tracks and many other aspects of the weather. Global warming tilts the odds in favour of more warm days and seasons and fewer cold days and seasons. For example, across the continental United States in the 1960s there were more daily record low temperatures than record highs, but in the 2000s there were more than twice as many record highs as record lows. Another important example of tilting the odds is that over recent decades heatwaves have increased in frequency in large parts of Europe, Asia and Australia.

12 WHY IS ARCTIC SEA ICE DECREASING WHILE ANTARCTIC SEA ICE IS NOT?

Sea ice extent is affected by winds and ocean currents as well as temperature. Sea ice in the partly-enclosed Arctic Ocean seems to be responding directly to warming, while changes in winds and in the ocean seem to be dominating the patterns of climate and sea ice change in the ocean around Antarctica.

Sea ice in the Arctic has decreased dramatically since the late 1970s, particularly in summer and autumn. Since the satellite record began in 1978 (providing for the first time a complete and continuous areal coverage of the Arctic), the yearly minimum Arctic sea ice extent (which occurs in early to mid-September) has decreased by more than 40% [FIGURE 5]. Ice cover expands again each Arctic winter but the ice is thinner than it used to be. Estimates of past sea ice extent suggest that this decline may be unprecedented in at least the past 1,450 years. The total volume of ice, the product of ice thickness and area, has decreased faster than ice extent over the past decades. Because sea ice is highly reflective, warming is amplified as the ice decreases and more sunshine is absorbed by the darker underlying ocean surface.

Sea ice in the Antarctic has shown a slight increase in extent since 1979 overall, although some areas, such as that to the west of the Antarctic Peninsula, have experienced a decrease. Changes in surface wind patterns around the continent have contributed to the Antarctic pattern of sea ice change while ocean factors such as the addition of cool fresh water from melting ice shelves may also have played a role. The wind changes include a recent strengthening of westerly winds, which reduces the amount of warm air from low latitudes penetrating into the southern high latitudes and alters the way in which ice moves away from the continent. The change in winds may result in part from the effects of stratospheric ozone depletion over Antarctica (i.e., the ozone hole, a phenomenon that is distinct from the human-driven changes in long-lived greenhouse gases discussed in this document). However, short-term trends in the Southern Ocean, such as those observed, can readily occur from natural variability of the atmosphere, ocean and sea ice system.

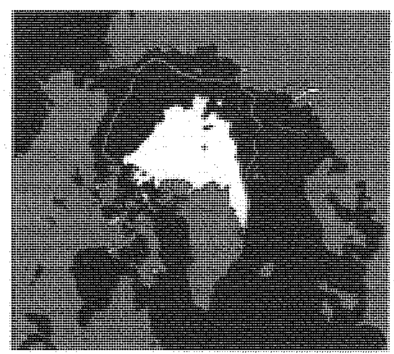


FIGURE 5. The Arctic summer sea ice extent in 2012, (measured in September) was a record low, shown (in white) compared to the median summer sea ice extent for 1979 to 2000 (in orange outline). In 2013, Arctic summer sea ice extent rebounded somewhat, but was still the sixth smallest extent on record. *Source: National Snow and Ice Data Center*

13 HOW DOES CLIMATE CHANGE AFFECT THE STRENGTH AND FREQUENCY OF FLOODS, DROUGHTS, HURRICANES, AND TORNADOES?

Earth's lower atmosphere is becoming warmer and moister as a result of human-emitted greenhouse gases. This gives the potential for more energy for storms and certain severe weather events. Consistent with theoretical expectations, heavy rainfall and snowfall events (which increase the risk of flooding) and heatwaves are generally becoming more frequent. Trends in extreme rainfall vary from region to region: the most pronounced changes are evident in North America and parts of Europe, especially in winter.

Attributing extreme weather events to climate change is challenging because these events are by definition rare and therefore hard to evaluate reliably, and are affected by patterns of natural climate variability. For instance, the biggest cause of droughts and floods around the world is the shifting of climate patterns between El Niño and La Niña events. On land, El Niño events favour drought in many tropical and subtropical areas, while La Niña events promote wetter conditions in many places, as has happened in recent years. These short-term and regional variations are expected to become more extreme in a warming climate.

There is considerable uncertainty about how hurricanes are changing because of the large natural variability and the incomplete observational record. The impact of climate change on hurricane frequency remains a subject of ongoing studies. While changes in hurricane frequency remain uncertain, basic physical understanding and model results suggest that the strongest hurricanes (when they occur) are likely to become more intense and possibly larger in a warmer, moister atmosphere over the oceans. This is supported by available observational evidence in the North Atlantic. Some conditions favourable for strong thunderstorms that spawn tornadoes are expected to increase with warming, but uncertainty exists in other factors that affect tornado formation, such as changes in the vertical and horizontal variations of winds.

14 HOW FAST IS SEA LEVEL RISING?

Long-term measurements of tide gauges and recent satellite data show that global sea level is rising, with best estimates of the global-average rise over the last two decades centred on 3.2 mm per year (0.12 inches per year). The overall observed rise since 1901 is about 20 cm (8 inches) [FIGURE 6].

This sea-level rise has been driven by (in order of importance): expansion of water volume as the ocean warms, melting of mountain glaciers in most regions of the world, and losses from the Greenland and Antarctic ice sheets. All of these result from a warming climate. Fluctuations in sea level also occur due to changes in the amounts of water stored on land. The amount of sea level change experienced at any given location also depends on a variety of other factors, including whether regional geological processes and rebound of the land weighted down by previous ice sheets are causing the land itself to rise or sink, and whether changes in winds and currents are piling ocean water against some coasts or moving water away.

The effects of rising sea level are felt most acutely in the increased frequency and intensity of occasional storm surges. If CO_2 and other greenhouse gases continue to increase on their current trajectories, it is projected that sea level may rise by a further 0.5 to 1 m (1.5 to 3 feet) by 2100. But rising sea levels will not stop in 2100; sea levels will be much higher in the following centuries as the sea continues to take up heat and glaciers continue to retreat. It remains difficult to predict the details of how the Greenland and Antarctic Ice Sheets will respond to continued warming, but it is thought that Greenland and perhaps West Antarctica will continue to lose mass, whereas the colder parts of Antarctica could start to gain mass as they receive more snowfall from warmer air that contains more moisture. Sea level in the last interglacial (warm) period around 125,000 years ago peaked at probably 5 to 10 m above the present level. During this period, the polar regions were warmer than they are today. This suggests that, over millennia, long periods of increased warmth will lead to very significant loss of parts of the Greenland and Antarctic Ice Sheets and to consequent sea level rise.

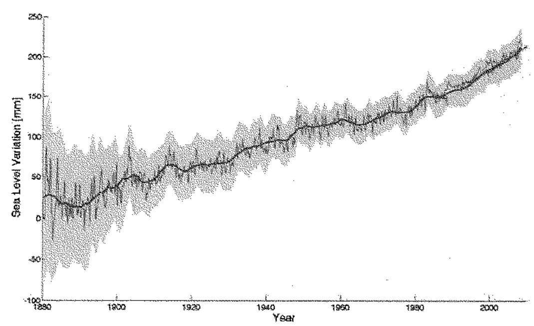


FIGURE 6. Observations show that the global average sea level has risen by about 20 cm (8 inches) since the late 19th century. Sea level is rising faster in recent decades; measurements from tide gauges (blue) and satellites (red) indicate that the best estimate for the average sea level rise over the last two decades is centred on 3.2 mm per year (0.12 inches per year). The shaded area represents the sea level uncertainty, which has decreased as the number of gauge sites used in the global averages and the number of data points have increased.
Source: Shum and Kuo (2011)

15 WHAT IS OCEAN ACIDIFICATION AND WHY DOES IT MATTER?

Direct observations of ocean chemistry have shown that the chemical balance of seawater has shifted to a more acidic state (lower pH) [FIGURE 7]. Some marine organisms (such as corals and some shellfish) have shells composed of calcium carbonate which dissolves more readily in acid. As the acidity of sea water increases, it becomes more difficult for them to form or maintain their shells.

CO_2 dissolves in water to form a weak acid, and the oceans have absorbed about a third of the CO_2 resulting from human activities, leading to a steady decrease in ocean pH levels. With increasing atmospheric CO_2, the chemical balance will change even more during the next century. Laboratory and other experiments show that under high CO_2 and in more acidic waters, some marine species have misshapen shells and lower growth rates, although the effect varies among species. Acidification also alters the cycling of nutrients and many other elements and compounds in the ocean, and it is likely to shift the competitive advantage among species, with as-yet-to-be-determined impacts on marine ecosystems and the food web.

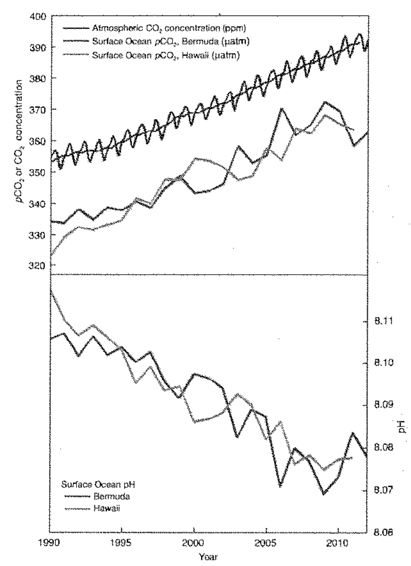
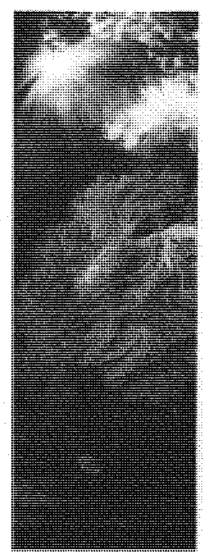


FIGURE 7. As CO_2 in the air has increased, there has been an increase in the CO_2 content of the surface ocean (upper box), and a decrease in the seawater pH (lower box). *Source: adapted from Dore et al. (2009) and Bates et al. (2012).*



16 How confident are scientists that Earth will warm further over the coming century?

Very confident. If emissions continue on their present trajectory, without either technological or regulatory abatement, then warming of 2.6 to 4.8 °C (4.7 to 8.6 °F) in addition to that which has already occurred would be expected by the end of the 21st century.

Warming due to the addition of large amounts of greenhouse gases to the atmosphere can be understood in terms of very basic properties of greenhouse gases. It will in turn lead to many changes in natural climate processes, with a net effect of amplifying the warming. The size of the warming that will be experienced depends largely on the amount of greenhouse gases accumulating in the atmosphere and hence on the trajectory of emissions [FIGURE 8]. If the total cumulative emissions since 1870 are kept below about 1 trillion (million million) tonnes of carbon, then there is a two-thirds chance of keeping the rise in global average temperature since the pre-industrial period below 2 °C (3.6 °F). However, over half this amount has already been emitted.

Based just on the established physics of the amount of heat CO_2 absorbs and emits, a doubling of atmospheric CO_2 concentration from pre-industrial levels (up to about 560 ppm) would by itself, without amplification by any other effects, cause a global average temperature increase of about 1 °C (1.8 °F). However, the total amount of warming from a given amount of emissions depends on chains of effects (feedbacks) that can individually either amplify or diminish the initial warming.

The most important amplifying feedback is caused by water vapour, which is a potent greenhouse gas in the atmosphere as warmer air can hold more moisture. Also, as Arctic sea ice and glaciers melt, more sunlight is absorbed into the darker underlying land and ocean surfaces causing further warming and further melting of ice and snow. The biggest uncertain factor in our knowledge of feedbacks is in how the properties of clouds will change in response to climate change. Other feedbacks involve the carbon cycle. Currently the land and oceans together absorb about half of the CO_2 emitted from human activities, but the capacities of land and ocean to store additional carbon are expected to decrease with additional warming, leading to faster increases in atmospheric CO_2 and faster warming. Models vary in their projections of how much additional warming to expect, but all such models agree that the overall net effect of feedbacks is to amplify the CO_2-only warming by a factor of 1.5 to 4.5.

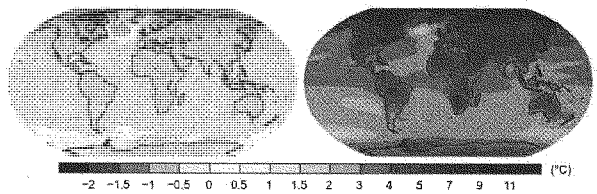


FIGURE 8. If emissions continue on their present trajectory, without either technological or regulatory abatement, then the best estimate is that global average temperature will warm a further 2.6 to 4.8 °C (4.7 to 8.6 °F) by the end of the century (right). The figure on left shows projected warming with very aggressive emissions reductions. The figures represent multi-model estimates of temperature averages for 2081-2100 compared to 1986–2005. *Source: IPCC AR5*

17 Are climate changes of a few degrees a cause for concern?

Yes. Even though an increase of a few degrees in global average temperature does not sound like much, global average temperature during the last ice age was only about 4 to 5 °C (7 to 9 °F) colder than now. Global warming of just a few degrees will be associated with widespread changes in regional and local temperature and precipitation as well as with increases in some types of extreme weather events. These and other changes (such as sea level rise and storm surge) will have serious impacts on human societies and the natural world.

Both theory and direct observations have confirmed that global warming is associated with greater warming over land than oceans, moistening of the atmosphere, shifts in regional precipitation patterns and increases in extreme weather events, ocean acidification, melting glaciers, and rising sea levels (which increases the risk of coastal inundation and storm surge). Already, record high temperatures are on average significantly outpacing record low temperatures, wet areas are becoming wetter as dry areas are becoming drier, heavy rainstorms have become heavier, and snowpacks (an important source of freshwater for many regions) are decreasing.

These impacts are expected to increase with greater warming and will threaten food production, freshwater supplies, coastal infrastructure, and especially the welfare of the huge population currently living in low-lying areas. Even though certain regions may realise some local benefit from the warming, the long-term consequences overall will be disruptive.

18 What are scientists doing to address key uncertainties in our understanding of the climate system?

Science is a continual process of observation, understanding, modelling, testing and prediction. The prediction of a long-term trend in global warming from increasing greenhouse gases is robust and has been confirmed by a growing body of evidence. Nevertheless, understanding (for example, of cloud dynamics, and of climate variations on centennial and decadal timescales and on regional-to-local spatial scales) remains incomplete. All of these are areas of active research.

Comparisons of model predictions with observations identify what is well-understood and, at the same time, reveal uncertainties or gaps in our understanding. This helps to set priorities for new research. Vigilant monitoring of the entire climate system—the atmosphere, oceans, land, and ice—is therefore critical, as the climate system may be full of surprises.

continued

Together, field and laboratory data and theoretical understanding are used to advance models of Earth's climate system and to improve representation of key processes in them, especially those associated with clouds, aerosols, and transport of heat into the oceans. This is critical for accurately simulating climate change and associated changes in severe weather, especially at the regional and local scales important for policy decisions.

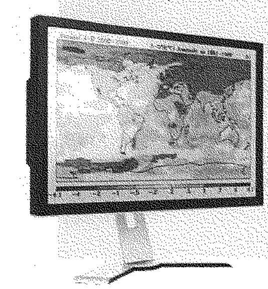
Simulating how clouds will change with warming and in turn may themselves affect warming, remains one of the major challenges for global climate models, in part because many cloud processes occur on scales smaller than the current models can resolve. Greater computer power may enable some of these processes to be resolved in future-generation models.

Dozens of groups and research institutions work on climate models, and scientists are now able to analyse results from essentially all of the world's major Earth-System Models and compare them with each other and with observations. Such opportunities are of tremendous benefit in bringing out the strengths and weaknesses of various models and diagnosing the causes of differences among models, so that research can focus on the relevant processes. The differences among models allow estimates to be made of the uncertainties in projections of future climate change, and in understanding which aspects of these projections are robust.

Studying how climate responded to major changes in the past is another way of checking that we understand how different processes work and that models are capable of performing under a wide range of conditions.

Why are computer models used to study climate change?

The future evolution of Earth's climate as it responds to the present rapid rate of increasing atmospheric CO_2 has no precise analogues in the past, nor can it be properly understood through laboratory experiments. As we are also unable to carry out deliberate controlled experiments on Earth itself, computer models are among the most important tools used to study Earth's climate system.



Climate models are based on mathematical equations that represent the best understanding of the basic laws of physics, chemistry, and biology that govern the behaviour of the atmosphere, ocean, land surface, ice, and other parts of the climate system, as well as the interactions among them. The most comprehensive climate models, Earth-System Models, are designed to simulate Earth's climate system with as much detail as is permitted by our understanding and by available supercomputers.

The capability of climate models has improved steadily since the 1960s. Using physics-based equations, the models can be tested and are successful in simulating a broad range of weather and climate variations, for example from individual storms, jet stream meanders, El Niño events, and the climate of the last century. Their projections of the most prominent features of the long-term human-induced climate change signal have remained robust, as generations of increasingly complex models yield richer details of the change. They are also used to perform experiments to isolate specific causes of climate change and to explore the consequences of different scenarios of future greenhouse gas emissions and other influences on climate.

19 ARE DISASTER SCENARIOS ABOUT TIPPING POINTS LIKE 'TURNING OFF THE GULF STREAM' AND RELEASE OF METHANE FROM THE ARCTIC A CAUSE FOR CONCERN?

Results from the best available climate models do not predict abrupt changes in such systems (often referred to as tipping points) in the near future. However, as warming increases, the possibilities of major abrupt change cannot be ruled out.

The composition of the atmosphere is changing towards conditions that have not been experienced for millions of years, so we are headed for unknown territory, and uncertainty is large. The climate system involves many competing processes that could switch the climate into a different state once a threshold has been exceeded.

A well-known example is the south-north ocean overturning circulation, which is maintained by cold salty water sinking in the North Atlantic and which involves the transport of extra heat to the North Atlantic via the Gulf Stream. During the last ice age, pulses of freshwater from the ice sheet over North America led to slowing down of this overturning circulation and to widespread changes in climate around the Northern Hemisphere. Freshening of the North Atlantic from the melting of the Greenland ice sheet is however, much less intense and hence is not expected to cause abrupt changes. As another example, Arctic warming could destabilise methane (a greenhouse gas) trapped in ocean sediments and permafrost, potentially leading to a rapid release of a large amount of methane. If such a rapid release occurred, then major, fast climate changes would ensue.

Such high-risk changes are considered unlikely in this century, but are by definition hard to predict. Scientists are therefore continuing to study the possibility of such tipping points beyond which we risk large and abrupt changes.

20 If emissions of greenhouse gases were stopped, would the climate return to the conditions of 200 years ago?

No. Even if emissions of greenhouse gases were to suddenly stop, Earth's surface temperature would not cool and return to the level in the pre-industrial era for thousands of years.

If emissions of CO_2 stopped altogether, it would take many thousands of years for atmospheric CO_2 to return to 'pre-industrial' levels due to its very slow transfer to the deep ocean and ultimate burial in ocean sediments. Surface temperatures would stay elevated for at least a thousand years, implying extremely long-term commitment to a warmer planet due to past and current emissions, and sea level would likely continue to rise for many centuries even after temperature stopped increasing [FIGURE 9]. Significant cooling would be required to reverse melting of glaciers and the Greenland ice sheet, which formed during past cold climates. The current CO_2-induced warming of Earth is therefore essentially irreversible on human timescales. The amount and rate of further warming will depend almost entirely on how much more CO_2 humankind emits.

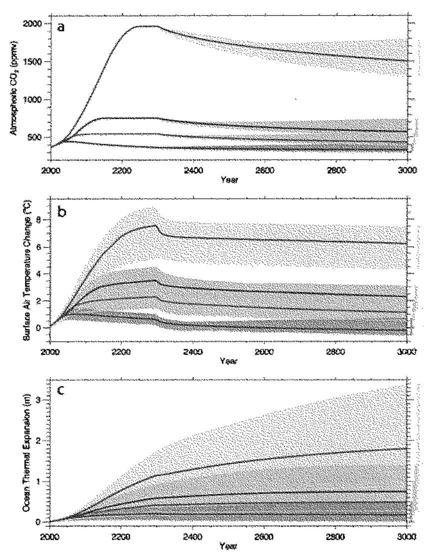


FIGURE 9: If global emissions were to suddenly stop, it would take a long time for surface air temperatures and the ocean to begin to cool, because the excess CO_2 in the atmosphere would remain there for a long time and would continue to exert a warming effect. Model projections show how atmospheric CO_2 concentration (a), surface air temperature (b), and ocean thermal expansion (c) would respond following a scenario of business-as-usual emissions ceasing in 2300 (red), a scenario of aggressive emission reductions, falling close to zero 50 years from now (orange), and two intermediate emissions scenarios (green and blue). The small downward tick in temperature at 2300 is caused by the elimination of emissions of short-lived greenhouse gases, including methane. *Source: Zickfeld et al., 2013*

The Basics of Climate Change

Greenhouse gases affect Earth's energy balance and climate

The Sun serves as the primary energy source for Earth's climate. Some of the incoming sunlight is reflected directly back into space, especially by bright surfaces such as ice and clouds, and the rest is absorbed by the surface and the atmosphere. Much of this absorbed solar energy is re-emitted as heat (longwave or infrared radiation). The atmosphere in turn absorbs and re-radiates heat, some of which escapes to space. Any disturbance to this balance of incoming and outgoing energy will affect the climate. For example, small changes in the output of energy from the Sun will affect this balance directly.

If all heat energy emitted from the surface passed through the atmosphere directly into space, Earth's average surface temperature would be tens of degrees colder than today. Greenhouse gases in the atmosphere, including water vapour, carbon dioxide, methane, and nitrous oxide, act to make the surface much warmer than this, because they absorb and emit heat energy in all directions (including downwards), keeping Earth's surface and lower atmosphere warm (Figure B1). Without this greenhouse effect, life as we know it could not have evolved on our planet. Adding more greenhouse gases to the atmosphere makes it even more effective at preventing heat from escaping into space. When the energy leaving is less than the energy entering, Earth warms until a new balance is established.

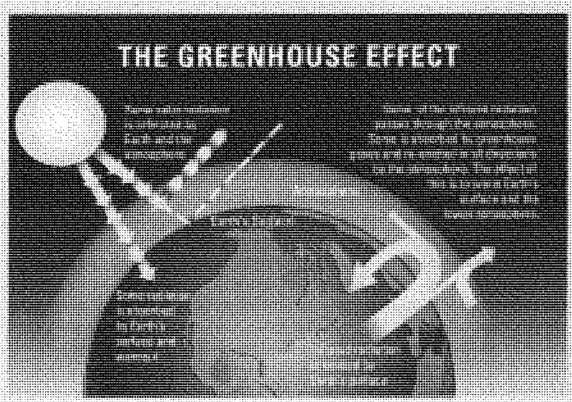


Figure B1. Greenhouse gases in the atmosphere, including water vapour, carbon dioxide, methane, and nitrous oxide, absorb heat energy and emit it in all directions (including downwards), keeping Earth's surface and lower atmosphere warm. Adding more greenhouse gases to the atmosphere enhances the effect, making Earth's surface and lower atmosphere even warmer. Image based on a figure from US EPA.

Greenhouse gases emitted by human activities alter Earth's energy balance and thus its climate. Humans also affect climate by changing the nature of the land surfaces (for example by clearing forests for farming) and through the emission of pollutants that affect the amount and type of particles in the atmosphere.

Scientists have determined that, when all human and natural factors are considered, Earth's climate balance has been altered towards warming, with the biggest contributor being increases in CO_2.

Human activities have added greenhouse gases to the atmosphere

The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased significantly since the Industrial Revolution began. In the case of carbon dioxide, the average concentration measured at the Mauna Loa Observatory in Hawaii has risen from 316 parts per million (ppm)[1] in 1959 (the first full year of data available) to 396 ppm in 2013 [FIGURE B2]. The same rates of increase have since been recorded at numerous other stations worldwide. Since pre-industrial times, the atmospheric concentration of CO_2 has increased by 40%, methane has increased by about 150%, and nitrous oxide has increased by roughly 20%. More than half of the increase in CO_2 has occurred since 1970. Increases in all three gases contribute to warming of Earth, with the increase in CO_2 playing the largest role. See page B3 to learn about the sources of human emitted greenhouse gases.

Scientists have examined greenhouse gases in the context of the past. Analysis of air trapped inside ice that has been accumulating over time in Antarctica shows that the CO_2

1 *that is, for every million molecules in the air, 316 of them were CO_2*

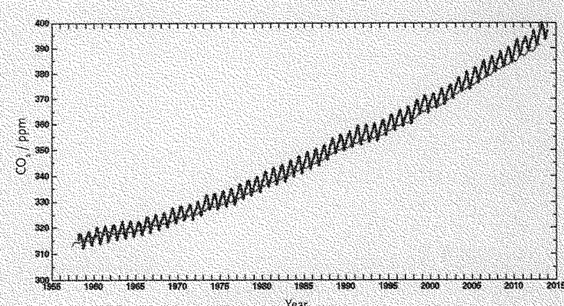


FIGURE B2. Measurements of atmospheric CO_2 since 1958 from the Mauna Loa Observatory in Hawaii (black) and from the South Pole (red) show a steady annual increase in atmospheric CO_2 concentration. (The measurements are made at remote places like those because they are not greatly influenced by local processes, so therefore are representative of the background atmosphere.) The small up and down saw-tooth pattern reflects seasonal changes in the release and uptake of CO_2 by plants. *Source: Scripps CO_2 Program* concentration began to increase significantly in the 19th century [FIGURE B3], after staying in the range of 260 to 280 ppm for the previous 10,000 years. Ice core records extending back 800,000 years show that during that time, CO_2 concentrations remained within the range of 170 to 300 ppm throughout many 'ice age' cycles—see page B4 to learn about the ice ages—and no concentration above 300 ppm is seen in ice core records until the past 200 years.

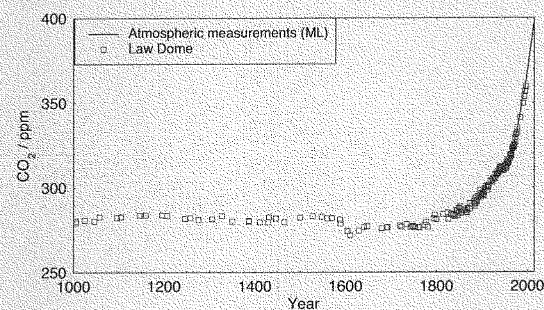


FIGURE B3. CO_2 variations during the past 1,000 years, obtained from analysis of air trapped in an ice core extracted from Antarctica (red squares), show a sharp rise in atmospheric CO_2 starting in the late 19th century. Modern atmospheric measurements from Mauna Loa are superimposed in blue. *Source: figure by Eric Wolff, data from Etheridge et al., 1996; MacFarling Meure et al., 2006.*

Learn about the sources of human-emitted greenhouse gases

- **Carbon dioxide (CO_2)** has both natural and human sources, but CO_2 levels are increasing primarily because of the combustion of fossil fuels, cement production, deforestation (which reduces the CO_2 taken up by trees and increases the CO_2 released by decomposition of the detritus), and other land use changes. Increases in CO_2 are the single largest contributor to global warming.
- **Methane (CH_4)** has both human and natural sources, and levels have risen significantly since pre-industrial times due to human activities such as raising livestock, growing paddy rice, filling landfills, and using natural gas (which is mostly CH_4, some of which may be released when it is extracted, transported, and used).
- **Nitrous oxide (N_2O)** concentrations have risen primarily because of agricultural activities such as the use of nitrogen-based fertilisers and land use changes.
- **Halocarbons**, including chlorofluorocarbons (CFCs), are chemicals used as refrigerants and fire retardants. In addition to being potent greenhouse gases, CFCs also damage the ozone layer. The production of most CFCs has now been banned, so their impact is starting to decline. However, many CFC replacements are also potent greenhouse gases and their concentrations and the concentrations of other halocarbons continue to increase.

Measurements of the forms (isotopes) of carbon in the modern atmosphere show a clear fingerprint of the addition of 'old' carbon (depleted in natural radioactive ^{14}C) coming from the combustion of fossil fuels (as opposed to 'newer' carbon coming from living systems). In addition, it is known that human activities (excluding land-use changes) currently emit an estimated 10 billion tonnes of carbon each year, mostly by burning fossil fuels, which is more than enough to explain the observed increase in concentration.

These and other lines of evidence point conclusively to the fact that the elevated CO_2 concentration in our atmosphere is the result of human activities.

Climate records show a warming trend

Estimating global average surface air temperature increase requires careful analysis of millions of measurements from around the world, including from land stations, ships, and satellites. Despite the many complications of synthesising such data, multiple independent teams have concluded separately and unanimously that global average surface air temperature has risen by about 0.8 °C (1.4 °F) since 1900 [FIGURE B4]. Although the record shows several pauses and accelerations in the increasing trend, each of the last three decades has been warmer than any other decade in the instrumental record since 1850.

Going further back in time before accurate thermometers were widely available, temperatures can be reconstructed using climate-sensitive indicators ('proxies')

Learn about the ice ages

Detailed analyses of ocean sediments, ice cores, and other data show that for at least the last 2.6 million years, Earth has gone through extended periods when temperatures were much lower than today and thick blankets of ice covered large areas of the Northern Hemisphere. These long cold spells, lasting in the most recent cycles for around 100,000 years, were interrupted by shorter warm 'interglacial' periods, including the past 10,000 years.

Through a combination of theory, observations, and modelling, scientists have deduced that the ice ages* are triggered by recurring variations in Earth's orbit that primarily alter the regional and seasonal distribution of solar energy reaching Earth. These relatively small changes in solar energy are reinforced over thousands of years by gradual changes in Earth's ice cover (the cryosphere), especially over the Northern Hemisphere, and in atmospheric composition, eventually leading to large changes in global temperature.

The average global temperature change during an ice-age cycle is estimated as 5 °C ± 1 °C (9 °F ± 2 °F).

**Note that in geological terms Earth has been in an ice age ever since the Antarctic Ice Sheet last formed about 36 million years ago. However, in this document we have used the term in its more colloquial usage indicating the regular occurrence of extensive ice sheets over North America and northern Eurasia.*

in materials such as tree rings, ice cores, and marine sediments. Comparisons of the thermometer record with these proxy measurements suggest that the time since the early 1980s has been the warmest 30-year period in at least eight centuries, and that global temperature is rising towards peak temperatures last seen 5,000 to 10,000 years ago in the warmest part of our current interglacial period.

Many other impacts associated with the warming trend have become evident in recent years. Arctic summer sea ice cover has shrunk dramatically. The heat content of the ocean has increased. Global average sea level has risen by approximately 20 cm (8 inches) since 1901, due both to the expansion of warmer ocean water and to the addition of melt waters from glaciers and ice sheets on land. Warming and precipitation changes are altering the geographical ranges of many plant and animal species and the timing of their life cycles. In addition to the effects on climate, some of the excess CO_2 in the atmosphere is being taken up by the ocean, changing its chemical composition (causing ocean acidification).

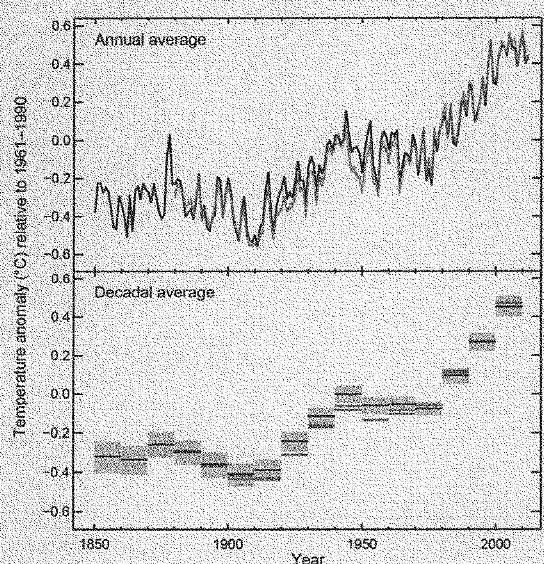
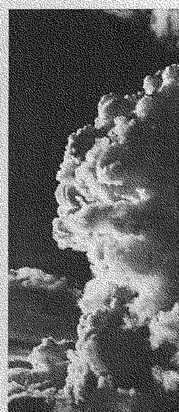


FIGURE B4. Earth's global average surface temperature has risen as shown in this plot of combined land and ocean measurements from 1850 to 2012, derived from three independent analyses of the available data sets. The top panel shows annual average values from the three analyses, and the bottom panel shows decadal average values, including the uncertainty range (grey bars) for the black (HadCRUT4) dataset. The temperature changes are relative to the global average surface temperature, averaged from 1961–1990. *Source: IPCC AR5, data from the HadCRUT4 dataset (black), UK Met Office Hadley Centre, the NCDC MLOST dataset (orange), US National Oceanic and Atmospheric Administration, and the NASA GISS dataset (blue), US National Aeronautics and Space Administration.*



Many complex processes shape our climate

Based just on the physics of the amount of energy that CO_2 absorbs and emits, a doubling of atmospheric CO_2 concentration from pre-industrial levels (up to about 560 ppm) would, by itself, cause a global average temperature increase of about 1 °C (1.8 °F). In the overall climate system, however, things are more complex; warming leads to further effects (feedbacks) that either amplify or diminish the initial warming.

The most important feedbacks involve various forms of water. A warmer atmosphere generally contains more water vapour. Water vapour is a potent greenhouse gas, thus causing more warming; its short lifetime in the atmosphere keeps its increase largely in step with warming. Thus, water vapour is treated as an amplifier, and not a driver, of climate change. Higher temperatures in the polar regions melt sea ice and reduce seasonal snow cover, exposing a darker ocean and land surface that can absorb more heat, causing further warming. Another important but uncertain feedback concerns changes in clouds. Warming and increases in water vapour together may cause cloud cover to increase or decrease which can either amplify or dampen temperature change depending on the changes in the horizontal extent, altitude, and properties of clouds. The latest assessment of the science indicates that the overall net global effect of cloud changes is likely to be to amplify warming.

The ocean moderates climate change. The ocean is a huge heat reservoir, but it is difficult to heat its full depth because warm water tends to stay near the surface. The rate at which heat is transferred to the deep ocean is therefore slow; it varies from year to year and from decade to decade, and helps to determine the pace of warming at the surface. Observations of the sub-surface ocean are limited prior to about 1970, but since then, warming of the upper 700 m (2,300 feet) is readily apparent. There is also evidence of deeper warming.

Surface temperatures and rainfall in most regions vary greatly from the global average because of geographical location, in particular latitude and continental position. Both the average values of temperature, rainfall, and their extremes (which generally have the largest impacts on natural systems and human infrastructure), are also strongly affected by local patterns of winds.

Estimating the effects of feedback processes, the pace of the warming, and regional climate change requires the use of mathematical models of the atmosphere, ocean, land, and ice (the cryosphere) built upon established laws of physics and the latest understanding of the physical, chemical and biological processes affecting climate, and run on powerful computers. Models vary in their projections of how much additional warming to expect (depending on the type of model and on assumptions used in simulating certain climate processes, particularly cloud formation and ocean mixing), but all such models agree that the overall net effect of feedbacks is to amplify warming.

Human activities are changing the climate

Rigorous analysis of all data and lines of evidence shows that most of the observed global warming over the past 50 years or so cannot be explained by natural causes and instead requires a significant role for the influence of human activities.

In order to discern the human influence on climate, scientists must consider many natural variations that affect temperature, precipitation, and other aspects of climate from local to global scale, on timescales from days to decades and longer. One natural variation is the El Niño Southern Oscillation (ENSO), an irregular alternation between warming and cooling (lasting about two to seven years) in the equatorial Pacific Ocean that causes significant year-to-year regional and global shifts in temperature and rainfall patterns. Volcanic eruptions also alter climate, in part increasing the amount of small (aerosol) particles in the stratosphere that reflect or absorb sunlight, leading to a short-term surface cooling lasting typically about two to three years. Over hundreds of thousands of years, slow, recurring variations in Earth's orbit around the Sun, which alter the distribution of solar energy received by Earth, have been enough to trigger the ice age cycles of the past 800,000 years.

Fingerprinting is a powerful way of studying the causes of climate change. Different influences on climate lead to different patterns seen in climate records. This becomes obvious when scientists probe beyond changes in the average temperature of the planet and look more closely at geographical and temporal patterns of climate change. For example, an increase in the Sun's energy output will lead to a very different pattern of temperature change (across Earth's surface and vertically in the atmosphere) compared to that induced by an increase in CO_2 concentration. Observed atmospheric temperature changes show a fingerprint much

Learn more about other human causes of climate change

In addition to emitting greenhouse gases, human activities have also altered Earth's energy balance through, for example:

- **Changes in land use.** Changes in the way people use land — for example, for forests, farms, or cities — can lead to both warming and cooling effects locally by changing the reflectivity of Earth's surfaces (affecting how much sunlight is sent back into space) and by changing how wet a region is.
- **Emissions of pollutants (other than greenhouse gases).** Some industrial and agricultural processes emit pollutants that produce aerosols (small droplets or particles suspended in the atmosphere). Most aerosols cool Earth by reflecting sunlight back to space. Some aerosols also affect the formation of clouds, which can have a warming or cooling effect depending on their type and location. Black carbon particles (or 'soot') produced when fossil fuels or vegetation are burned, generally have a warming effect because they absorb incoming solar radiation.

closer to that of a long-term CO_2 increase than to that of a fluctuating Sun alone. Scientists routinely test whether purely natural changes in the Sun, volcanic activity, or internal climate variability could plausibly explain the patterns of change they have observed in many different aspects of the climate system. These analyses have shown that the observed climate changes of the past several decades cannot be explained just by natural factors.

How will climate change in the future?

Scientists have made major advances in the observations, theory, and modelling of Earth's climate system; and these advances have enabled them to project future climate change with increasing confidence. Nevertheless, several major issues make it impossible to give precise estimates of how global or regional temperature trends will evolve decade by decade into the future. Firstly, we cannot predict how much CO_2 human activities will emit, as this depends on factors such as how the global economy develops and how society's production and consumption of energy changes in the coming decades. Secondly, with current understanding of the complexities of how climate feedbacks operate, there is a range of possible outcomes, even for a particular scenario of CO_2 emissions. Finally, over timescales of a decade or so, natural variability can modulate the effects of an underlying trend in temperature. Taken together, all model projections indicate that Earth will continue to warm considerably more over the next few decades to centuries. If there were no technological or policy changes to reduce emission trends from their current trajectory, then further warming of 2.6 to 4.8 °C (4.7 to 8.6 °F) in addition to that which has already occurred would be expected during the 21st century [FIGURE B5]. Projecting what those ranges will mean for the climate experienced at any particular location is a challenging scientific problem, but estimates are continuing to improve as regional and local-scale models advance.

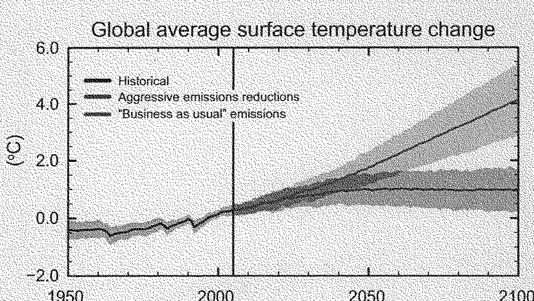


FIGURE B5. The amount and rate of warming expected for the 21st century depends on the total amount of greenhouse gases that humankind emits. Models project the temperature increase for a business-as-usual emissions scenario (in red) and aggressive emission reductions, falling close to zero 50 years from now (in blue). Black is the modelled estimate of past warming. Each solid line represents the average of different model runs using the same emissions scenario, and the shaded areas provide a measure of the spread (one standard deviation) between the temperature changes projected by the different models. All data are relative to a reference period (set to zero) of 1986-2005. *Source: IPCC AR5*

CONCLUSION

This document explains that there are well-understood physical mechanisms by which changes in the amounts of greenhouse gases cause climate changes. It discusses the evidence that the concentrations of these gases in the atmosphere have increased and are still increasing rapidly, that climate change is occurring, and that most of the recent change is almost certainly due to emissions of greenhouse gases caused by human activities. Further climate change is inevitable; if emissions of greenhouse gases continue unabated, future changes will substantially exceed those that have occurred so far. There remains a range of estimates of the magnitude and regional expression of future change, but increases in the extremes of climate that can adversely affect natural ecosystems and human activities and infrastructure are expected.

Citizens and governments can choose among several options (or a mixture of those options) in response to this information: they can change their pattern of energy production and usage in order to limit emissions of greenhouse gases and hence the magnitude of climate changes; they can wait for changes to occur and accept the losses, damage and suffering that arise; they can adapt to actual and expected changes as much as possible; or they can seek as yet unproven 'geoengineering' solutions to counteract some of the climate changes that would otherwise occur. Each of these options has risks, attractions and costs, and what is actually done may be a mixture of these different options. Different nations and communities will vary in their vulnerability and their capacity to adapt. There is an important debate to be had about choices among these options, to decide what is best for each group or nation, and most importantly for the global population as a whole. The options have to be discussed at a global scale, because in many cases those communities that are most vulnerable control few of the emissions, either past or future. Our description of the science of climate change, with both its facts and its uncertainties, is offered as a basis to inform that policy debate.

Acknowledgements

The following individuals served as the primary writing team for this document:

- Eric Wolff FRS (**UK lead**), University of Cambridge
- Inez Fung (NAS, **US lead**), University of California, Berkeley
- Brian Hoskins FRS, Imperial College London and University of Reading
- John Mitchell FRS, UK Met Office
- Tim Palmer FRS, University of Oxford
- Benjamin Santer (NAS), Lawrence Livermore National Laboratory
- John Shepherd FRS, University of Southampton
- Keith Shine FRS, University of Reading
- Susan Solomon (NAS), Massachusetts Institute of Technology
- Kevin Trenberth, National Center for Atmospheric Research
- John Walsh, University of Alaska, Fairbanks
- Don Wuebbles, University of Illinois

This document was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the Royal Society and the National Academy of Sciences. The reviewers provided comments and suggestions, but were not asked to endorse the views of the writing team, nor did they see the final draft before its release. We wish to thank the following individuals for their review of this report:

- Richard Alley (NAS), Department of Geosciences, Pennsylvania State University
- Alec Broers FRS, Diamond Light Source and Bio Nano Consulting (Former President of the Royal Academy of Engineering)
- Harry Elderfield FRS, Department of Earth Sciences, University of Cambridge
- Joanna Haigh FRS, Imperial College London
- Isaac Held (NAS), NOAA Geophysical Fluid Dynamics Laboratory
- John Kutzbach (NAS), Center for Climatic Research, University of Wisconsin
- Jerry Meehl, National Center for Atmospheric Research
- John Pendry FRS, Imperial College London
- John Pyle FRS, Department of Chemistry, University of Cambridge
- Gavin Schmidt, NASA Goddard Space Flight Center
- Emily Shuckburgh, British Antarctic Survey
- Gabrielle Walker, Journalist
- Andrew Watson FRS, University of Exeter

Oversight of the review process was provided by representatives of the Royal Society Council (John Pethica FRS) and the NAS Council (Jeremiah Ostriker, NAS). Staff assistance was provided by Nancy F. Huddleston, Laurie Geller, Sally Tyldesley and Tracey Elliott.

Sincere thanks to the Raymond and Beverly Sackler US-UK Scientific Forum for support of this activity.

FOR FURTHER READING

For more detailed discussion of the topics addressed in this document (including references to the underlying original research), see:

- IPCC 2013, *Climate change 2013: The physical science basis.* Fifth Assessment Report (AR5) Working Group 1.
  visit site
- NRC 2010, *America's climate choices: Advancing the Science of Climate Change.*
  visit site
- NRC 2011, *Climate stabilization targets: Emissions, Concentrations, and Impacts over Decades to Millennia.*
  visit site
- NRC 2013, *Abrupt impacts of climate change: Anticipating Surprises.*
  visit site
- Royal Society 2010, *Climate Change: A Summary of the Science.*
  visit site

Much of the original data underlying the scientific findings discussed here are available at:

- metoffice.gov.uk/hadobs
- www.cru.uea.ac.uk
- cdp.ucar.edu
- climatedataguide.ucar.edu
- iridl.ldeo.columbia.edu
- cdiac.ornl.gov
- ncdc.noaa.gov
- esrl.noaa.gov/gmd/ccgg/trends
- scrippsco2.ucsd.edu
- hahana.soest.hawaii.edu/hot

NATIONAL ACADEMY OF SCIENCES

THE NATIONAL ACADEMY OF SCIENCES (NAS) was established to advise the United States on scientific and technical issues when President Lincoln signed a Congressional charter in 1863. The National Research Council, the operating arm of the National Academy of Sciences and the National Academy of Engineering, has issued numerous reports on the causes of and potential responses to climate change. Climate change resources from the National Research Council are available at nas-sites.org/americasclimatechoices.

THE ROYAL SOCIETY

THE ROYAL SOCIETY is a self-governing Fellowship of many of the world's most distinguished scientists. Its members are drawn from all areas of science, engineering, and medicine. It is the national academy of science in the UK. The Society's fundamental purpose, reflected in its founding Charters of the 1660s, is to recognise, promote, and support excellence in science, and to encourage the development and use of science for the benefit of humanity. More information on the Society's climate change work is available at royalsociety.org/policy/climate-change

FOR FURTHER READING

For more detailed discussion of the topics addressed in this document (including references to the underlying original research), see:

- IPCC 2013, *Climate change 2013: The physical science basis.* Fifth Assessment Report (AR5) Working Group 1.
  visit site
- NRC 2010, *America's climate choices: Advancing the Science of Climate Change.*
  visit site
- NRC 2011, *Climate stabilization targets: Emissions, Concentrations, and Impacts over Decades to Millennia.*
  visit site
- NRC 2013, *Abrupt impacts of climate change: Anticipating Surprises.*
  visit site
- Royal Society 2010, *Climate Change: A Summary of the Science.*
  visit site

Much of the original data underlying the scientific findings discussed here are available at:

- metoffice.gov.uk/hadobs
- www.cru.uea.ac.uk
- cdp.ucar.edu
- climatedataguide.ucar.edu
- iridl.ldeo.columbia.edu
- cdiac.ornl.gov
- ncdc.noaa.gov
- esrl.noaa.gov/gmd/ccgg/trends
- scrippsco2.ucsd.edu
- hahana.soest.hawaii.edu/hot

NATIONAL ACADEMY OF SCIENCES

THE NATIONAL ACADEMY OF SCIENCES (NAS) was established to advise the United States on scientific and technical issues when President Lincoln signed a Congressional charter in 1863. The National Research Council, the operating arm of the National Academy of Sciences and the National Academy of Engineering, has issued numerous reports on the causes of and potential responses to climate change. Climate change resources from the National Research Council are available at nas-sites.org/americasclimatechoices.

THE ROYAL SOCIETY

THE ROYAL SOCIETY is a self-governing Fellowship of many of the world's most distinguished scientists. Its members are drawn from all areas of science, engineering, and medicine. It is the national academy of science in the UK. The Society's fundamental purpose, reflected in its founding Charters of the 1660s, is to recognise, promote, and support excellence in science, and to encourage the development and use of science for the benefit of humanity. More information on the Society's climate change work is available at royalsociety.org/policy/climate-change

Foundation, which **has given millions to NRDC**. Ironically enough, researchers have **uncovered** that Steyer's hedge fund "minted a lot of money off oil and gas investments, among other environmentally destructive business ventures." A profile of environmental groups profiting from the very oil and gas companies they fundamentally oppose by the progressive magazine *The Nation* **confirmed**that "NRDC still holds stocks in mutual funds and mixed assets that do not screen for fossil fuels."

The NRDC also received more than $1.7 million in 2011 from the SeaChange Foundation—a foundation with dubious funders. An **exposé** by the Washington Free Beacon uncovered that Klein Ltd., a company incorporated in Bermuda that exists solely on paper, donated at least $10 million to the SeaChange Foundation. SeaChange then funnels that shadowy money to a number of progressive organizations.

NRDC has received similarly hidden contributions through other "donor-advised" funds, criticized by some watchdogs as "dark money." The Schwab Charitable Fund, a donor-advised fund that donors to other left-environmentalist groups have used to obscure their identities, funneled at least $4.7 million in NRDC donations since 2008.

NRDC also receives considerable funding from more traditional liberal foundations. The George Soros-backed Open Society Institute and Foundation to Support Open Society gave NRDC over $2.2 million since 2008. The William and Flora Hewlett Foundation, one of the largest left-environmentalist foundations in the country, has provided NRDC with over $4.7 million over that same period.

Black Eyes

Concocting Hysteria That's Rotten to the Core

In 1989, the NRDC colluded with Washington PR firm Fenton Communications to create the "Alar-on-apples" food scare.

Following the release of a report called "Intolerable Risk" — which claimed that Alar, a pesticide used by apple farmers, was "the most potent cancer-causing agent in our food supply" and blamed the chemical for "as many as 5,300" childhood cancer cases — Fenton and NRDC went on a five-month media blitz. The campaign kicked off with a CBS 60 Minutes feature seen by over 50 million Americans. Despite the fact that the claims were completely unfounded, hysteria set in. Apples were pulled off of grocery shelves, schools stopped serving them at lunch, and apple growers nationwide lost over $250 million.

The Wall Street Journal printed one of David Fenton's (of Fenton Communications) internal memos, after the Alar-on-apples scandal was publicly debunked. Here's Fenton in his own words:

We designed [the Alar Campaign] so that revenue would flow back to the Natural Resources Defense Council from the public, and we sold this book about pesticides through a 900 number and the Donahue show. And to date there has been $700,000 in net revenue from it.

Henry Miller, the founding director of the FDA's Office of Biotechnology **summed up** the debacle:

Thousands of apple growers suffered substantial losses, some went bankrupt, and the federal government spent almost $10 million to support struggling apple growers. The scare was eventually exposed as a fraud. The source of that chaos, the Natural Resources Defense Council (NRDC), is known for that sort of alarmist junk science.

Fabricating a Swordfish Shortage

In 1998, NRDC joined forces with Fenton Communications again. This time, the plan was to convince the public that swordfish were being over-fished, with claims that America's taste for it "threaten[ed] the livelihood of the species."

The "Give Swordfish a Break!" campaign was operated by a group called SeaWeb, which, conveniently, was created by Fenton specifically for this purpose. Nearly 100% of the funding for this campaign came from pass-through grants solicited by NRDC on behalf of SeaWeb.

As with the Alar scare, these claims were utterly false, ultimately leading the U.S. Fish and Wildlife Service to condemn the campaign as "flawed to the core," while the National Marine Fisheries Institute declared that swordfish were never in any danger of extinction at all. Rebecca Lent, the director of the Highly Migratory

Species Division of the National Marine Fisheries Service (NMFS), which regulates commercial fishing, said "Swordfish are not considered endangered." About SeaWeb's NRDC-backed campaign, Lent said, "I think it will end up having a detrimental effect on our fishermen… I know a lot of [U.S. fishermen] who have lost their jobs already."

Using Questionable Science to Generate Chemical Scares

NRDC is no stranger to overstating environmental risks to generate public outcry and attention. The organization has been especially effective in using a handful of questionable "studies" to scare the public about the safety of chemicals used in millions of everyday products.

While NRDC has warned the public that many of their favorite products are subtly poisoning them, actual toxicologists fail to subscribe to NRDC's doomsday forecasts. The Center for Health and Risk Communication at George Mason University surveyed members of the Society of Toxicology and **found** that these experienced toxicologists "overwhelmingly reject the notion that exposure to even the smallest amounts of harmful chemicals is dangerous or that the detection of any level of a chemical in your body by biomonitoring indicates a significant health risks."

The toxicologists surveyed were asked specifically about their opinions of NRDC and 79 percent of respondents were critical of the organization.

Instead of recognizing that professionals who study chemicals for a living question NRDC's position on chemicals, NRDC slammed the survey for lack of peer review—even though few publicly released polls are peer reviewed. When asked if NRDC released its data for peer review, Linda Greer, NRDC's Health and Environment Program Director, **responded**: "We're an advocacy group and we don't hold ourselves out as scientific researchers."

After successfully stirring up groundless fears of Alar, NRDC is now pushing to ban bisphenol A (BPA), a common chemical used in plastics. Though research from the U.S. government**found** that it would be very difficult for BPA to cause health effects in humans, NRDC has sued the Food and Drug Administration for failing to ban BPA. The FDA has **determined** that science does not justify a ban of BPA from all food and drink containers.

A comprehensive study of BPA by the FDA concludes that the chemical is safe at normal doses and notes that "Many of the studies that report low dose effects of BPA utilized an insufficient number of dose groups to establish a clear dose-response relationship, used small numbers of animals, and/or failed to appropriately account for possible litter effects in the analysis of the data."

"Sue and Settle" Collusion with the EPA

The Natural Resources Defense Council is one of the many environmental groups that have colluded with federal agencies in "sue and settle" lawsuits. Since 2009, the NRDC has accepted at least **nine settlements** from the EPA.

In these cases, environmental activists sue the Environmental Protection Agency (EPA), arguing that the agency is taking too long to issue a particular regulation or that the agency isn't meeting a specific legal requirement. The EPA can then either defend itself in court or settle with the environmentalists. In several cases the EPA issued a consent agreement to settle cases the very same day activists filed their lawsuits.

In many cases, if the environmentalists are successful in suing the EPA, the groups' attorneys' fees are paid by the federal government. According to a 2011 **report** from the Government Accountability Office, between 1995 and 2010, taxpayers reimbursed the Natural Resources Defense Council to the tune of $252,004.

Professor David Schoenbrod—a staff attorney for NRDC during the 1970s who is now Trustee Professor at New York Law School and a visiting scholar at the American Enterprise Institute—**explained** the "sue and settle" strategy:

I used to do this when I was at the Natural Resources Defense Council. There are thousands of such suits brought. Environmental groups would crank these out by the hundreds. They get an intern to look at a company's emissions reports and compare those figures with what the permit authorized.

NEPA Hypocrisy

The National Environmental Policy Act (NEPA), which took effect in 1970, requires all government agencies to weigh environmental factors when making decisions and requires agencies to prepare an environmental statement to accompany reports and recommendations for funding from Congress. NRDC has heaped praise on the legislation, calling it the "environmental Magna Carta" and saying "NEPA is democratic at its core."

Why then is NRDC now trying to stop the federal government from using the NEPA process?

Before developers could even file a NEPA permit application to begin copper mining in Alaska's Bristol Bay region, NRDC began leading a call for the Environmental Protection Agency to veto the project before the government ever reviewed the development's environmental impact strategy and plans. Rather than trusting in the environmental review process it treasures, NRDC hopes to stifle new developments before they're ever vetted—simply because NRDC, like most radical environmentalist groups, essentially never met a mining project it liked.

Cherry-Picking "Scientific Consensus"

NRDC is one of many environmental activist organizations support its push for the end of fossil fuels because of a "scientific consensus" that carbon emissions have led to climate change. However, NRDC and its activist allies neglect to acknowledge a similar scientific consensus regarding genetically modified foods.

The U.S. National Academy of Sciences, British Royal Society, World Health Organization, American Medical Association, and American Association for the Advancement of Science have all expressed their support for the Intergovernmental Panel on Climate Change's report that carbon emissions have resulted in a warming climate. Those same organizations also agree that no adverse health effects have been attributed to genetically modified foods.

Yet despite the agreement that GMOs are not harmful, NRDC is pushing for the labeling of foods containing GMOs. Science has not shown that there is any reason to label GMO foods as any different from conventional foods. The American Association for the Advancement of Science notes:

Foods containing ingredients from genetically modified (GM) crops pose no greater risk than the same foods made from crops modified by conventional plant breeding techniques.

The labeling campaign, however, has been heavily funded by individuals and groups that aren't interested in consumer knowledge—they're interested in banning GMOs outright, despite the significant costs to food productions that this would entail. It's a purely ideological crusade, not a pragmatic one, and it shows that NRDC and anti-GMO activists prefer to adapt the term "scientific consensus" only when it suits their needs.

CHICAGO

JOHN M. OLIN LAW & ECONOMICS WORKING PAPER NO. 302
(2D SERIES)

Montreal vs. Kyoto: A Tale of Two Protocols

Cass R. Sunstein

THE LAW SCHOOL
THE UNIVERSITY OF CHICAGO

August 2006

Preliminary draft 8/18/2006
Forthcoming *Harvard Environmental Law Review*

Montreal versus Kyoto: A Tale of Two Protocols

Cass R. Sunstein*

Abstract

Over the last thirty years, climate change and depletion of the ozone layer have been widely believed to be the world's largest environmental problems. The two problems have many similarities. Both involve global risks created by diverse nations, and both seem to be best handled through international agreements. In addition, both raise serious issues of intergenerational and international equity. Future generations stand to lose a great deal, whereas the costs of restrictions would be borne in the first instance by the current generation; and while wealthy nations are largely responsible for the current situation, poorer nations, above all Africa and India, are anticipated to be quite vulnerable in the future. But an extraordinarily successful agreement, the Montreal Protocol, has served largely to eliminate the production and use of ozone-depleting chemicals, while the Kyoto Protocol has spurred only modest steps toward stabilizing greenhouse gas emissions. What accounts for the dramatic difference between the two protocols? Part of the explanation lies in the radically different self-interested judgments of the United States; part of the explanation lies in the very different payoff structures of the two agreements. Influenced by the outcome of a purely domestic cost-benefit analysis involving reductions in ozone-depleting chemicals, the United States enthusiastically supported the Montreal Protocol. Influenced by the very different outcome of cost-benefit analyses for reductions in greenhouse gas emissions, the United States aggressively opposed the Kyoto Protocol. An examination of the two protocols suggests that neither agreement fit the simple structure of a prisoner's dilemma, in which a nation gains from an enforceable agreement, gains even more if it is the only nation not to comply while all others do, and loses most if it, and everyone else, pursue their own national self-interest. For the United States, at least, compliance with the Montreal Protocol would have been justified even if ***no*** *other country had complied; for the United States, and for several other countries, compliance with the Kyoto Protocol would not have been justified even if* ***all*** *other parties had complied. An understanding of the judgments that surround the two protocols indicates that even though moral considerations require the United States to spend a great deal to protect citizens in other nations, and even though such considerations can influence behavior, the nation is unlikely to act in response solely to those considerations. A general implication is that any international agreement to control greenhouse gases is unlikely to be effective unless the United States believes that it has*

---

* Karl N. Llewellyn Distinguished Service Professor of Jurisprudence, Law School and Department of Political Science, University of Chicago. I am grateful to Elizabeth Emens, Jack Goldsmith, Robert Hahn, Eric Posner, and Adrian Vermeule for valuable comments on a previous draft.

more to gain than to lose. An illuminating wrinkle, also suggestive of the role of domestic self-interest, is that some European nations, above all the United Kingdom, initially contended that ozone depletion was a greatly exaggerated problem while later calling for strong controls on greenhouse gases. For an international accord, an exceedingly serious problem lies in the fact that while the United States and China would have to bear the lion's share of the cost of emissions reductions, both nations are projected to lose relatively less from climate change.

> "I am pleased to sign the instrument of ratification for the Montreal protocol [governing] substances that deplete the ozone layer. The protocol marks an important milestone for the future quality of the global environment and for the health and well-being of all peoples of the world. Unanimous approval of the protocol by the Senate on March 14th demonstrated to the world community this country's willingness to act promptly and decisively in carrying out its commitments to protect the stratospheric ozone layer . . ."
>
> — Ronald Reagan[1]

> "I oppose the Kyoto Protocol because it . . . would cause serious harm to the U.S. economy. The Senate's vote, 95-0, shows that there is a clear consensus that the Kyoto Protocol is an unfair and ineffective means of addressing global climate change concerns."
>
> — George W. Bush[2]

Of the world's environmental challenges, the two most significant may well be stratospheric ozone depletion and climate change. At first glance, the problems appear to be closely related. In fact ozone depletion and climate change are so similar that many Americans are unable to distinguish between them.[3] Consider seven similarities between the two problems:

1. Both ozone depletion and climate change have received public recognition on the basis of relatively recent scientific work, theoretical and empirical. The risks associated with ozone depletion were first explored in a theoretical paper in 1974.[4] The risks of climate change have a much longer history, with an

---

[1] See http://www.findarticles.com/p/articles/mi_m1079/is_n2135_v88/ai_6495606

[2] See http://www.whitehouse.gov/news/releases/2001/03/20010314.html

[3] See Andrew Dessler and Edward Parson, The Science and Politics of Global Climate Change 10-11 (2006)

[4] See Robert Percival et al., Environmental Regulation 1047 (2003).

early paper in 1896,[5] but the current scientific consensus is very much a product of the 1990s.[6]

2. Both problems involve the effects of emissions from man-made technologies that come from diverse nations and that threaten to cause large-scale harm.
3. Both ozone-depleting chemicals and greenhouse gases stay in the atmosphere for an extremely long time. Hence the relevant risks are difficult to reverse; even with action that is both immediate and aggressive, the underlying problems will hardly be eliminated all at once.[7] This point has significant implications for issues of timing.
4. No nation is able to eliminate either problem on its own. Indeed, no nation is even able to make significant progress on either problem on its own, certainly not in the long run.[8] Because of the diversity of contributors, both problems seem to be best handled through international agreements.[9]
5. Both problems involve extremely serious problems of international equity. Wealthy nations have been the principal contributors to both ozone depletion and climate change, and hence it is plausible to argue that corrective justice requires wealthy nations to pay poorer ones to reduce the underlying risks. This argument might well mean that poor nations should be compensated for their willingness to enter into any international agreements that reduce emissions levels. Wealthy countries might owe significant duties of financial and technological assistance, either to help in emissions reduction or to pay for adaptation to the underlying problems.
6. Both problems present extremely serious problems of intergenerational equity. Future generations are likely to face greater risks than the current generation, and a key question is how much the present should be willing to sacrifice for the benefit of the future. The answer to this question is complicated by two facts: Future generations are likely to be much wealthier than our own, and expenditures by the present, decreasing national wealth, may end up harming

[5] See Scott Barrett, Environment & Statecraft 363 (2005). Indeed, an even earlier paper, from 1827, sketched the possible contribution of greenhouse gases. See James Houghton, Global Warming: The Complete Briefing 17 (3d edition 2004).

[6] Dessler and Parson, supra note, at 64-66. I refer to a scientific consensus, but there are dissenting voices. See, e.g., Nir Shaviv, The Spiral Structure of the Milky Way, Cosmic Rays, and Ice Age Epochs on Earth, 8 New Astronomy 39 (2003) (arguing that cosmic rays are responsible for most of recent variations in global temperatures); Nir Shaviv and J. Veizer, Celestial driver of Phanerozoic climate?, 13 GSA Today, 4 (2003). A reply is Stefan Rahmstorf et al., Cosmic Rays, Carbon Dioxide and Climate, in Eos, Transactions of the American Geophysical Union (January 27, 2004).

[7] For ozone depletion, see Barrett, supra note; for climate change, the point is emphasized and explored in Richard Posner, Catastrophe 161-63 (2004).

[8] A qualification is that the United States now accounts for about one-fifth of the world's emissions, and that by 2025, China will account for nearly one-fourth of the world's emissions. See infra. If either nation entirely eliminated its emissions – to say the least, an unlikely prospect – the progress might count as significant. Note, however, that because greenhouse gas emissions are cumulative, even a total elimination of greenhouse gas emissions, from the United States and China, would not make a major dent in the problem.

[9] As we shall see, however, these statements must be qualified for ozone depletion. For some nations, including the United States, unilateral action was worthwhile. See below; James Murdoch and Todd Sandler, The Voluntary Provision of a Public Good: The Case of Reduced CFC Emissions and the Montreal Protocol, 63 J Public Economics 331 (1997).

future generations, simply by ensuring that they too have less wealth on which to draw.

7. With respect to both problems, the United States is a crucial actor, probably the most important in the world.[10] The importance of the United States lies not only in its wealth and power; it also lies in the fact that the United States has been an extremely significant source of both ozone-depleting chemicals and greenhouse gases.[11]

Notwithstanding these similarities, there is one obvious difference between the two problems. An international agreement, originally signed in Montreal and designed to control ozone-depleting chemicals, has been ratified by almost all nations in the world (including the United States, where ratification was unanimous).[12] At last count, 183 nations have ratified the Montreal Protocol.[13] Nations are complying with their obligations; global emissions of ozone-depleting chemicals have been reduced by over 95%; and atmospheric concentrations of such chemicals have been declining since 1994.[14] By 2050, the ozone layer is expected to return to its natural level.[15] The Montreal Protocol, the foundation for this process, thus stands as an extraordinary and even spectacular success story. Its success owes a great deal to the actions not only of the United States government, which played an exceedingly aggressive role in producing the Protocol,[16] but to American companies as well, which stood in the forefront of technical innovation leading to substitutes for ozone-depleting chemicals.[17]

With climate change, the situation is altogether different. To be sure, an international agreement, produced in Kyoto in 1997, did go into force in 2005, when Russia ratified it[18]; the Kyoto Protocol has now been ratified by over 130 nations.[19] But numerous nations are not complying with their obligations under the Kyoto Protocol,[20] and the United States firmly rejects the agreement, with unanimous bipartisan opposition to its ratification. Far from leading technical innovation, American companies have sharply opposed efforts to regulate greenhouse gas emissions, and have insisted that the costs of regulation are likely to be prohibitive.[21] Between 1990 and 2004, the United

---

[10] On ozone depletion, see Robert Percival et al., Environmental Regulation 1048 (2003) (United States accounted for almost one-half of global CFC use in the mid-1970s); Record Increase in U.S. Greenhouse Gas Emissions Reported (2006), available at http://www.ens-newswire.com/ens/apr2006/2006-04-18-02.asp (United States accounts for about 25% of the world's greenhouse gas emissions).

[11] See id.

[12] For the text of the Montreal Protocol, as amended, see http://www.unep.org/ozone/Montreal-Protocol/Montreal-Protocol2000.shtml

[13] Scott Barrett, Environment & Statecraft 239 (2005).

[14] See id.

[15] Id.

[16] See Edward Parson, Protecting the Ozone Layer 252-53 (2003).

[17] See Percival et al., supra note, at 1051; Edward Parson, Protecting the Ozone Layer 126-27, 176-77, 180-82 (2003).

[18] See Andrew Dessler and Edward Parson, The Science and Politics of Global Climate Change 129 (2006).

[19] See Al Gore, An Inconvenient Truth 282-83 (2006).

[20] See below.

[21] Seer George Pring, The United States Perspective, in Kyoto: From Principles to Practice 185, 195-97 (Peter Cameron and Donald Zillman eds. 2001).

States experienced a decline in emissions of ozone-depleting chemicals, to the point where such emissions are essentially zero. But in the same period, the United States experienced a rapid growth in greenhouse gases.[22] In part as a result, worldwide emissions of greenhouse gases are projected to rise at a rapid rate. An additional complication stems from the fact that developing nations have refused to join the Kyoto Protocol, and it is in those nations that greenhouse gases are increasingly most rapidly. In particular, India and China have shown explosive growth in recent years, and China will soon become the leading greenhouse gas emitter in the world. [23]

My goal in this Article is to understand why the Montreal Protocol has been so much more successful than the Kyoto Protocol, and in the process to shed some light on the prospects for other international agreements, including those designed to control the problem of climate change. A central conclusion is simple: Both the success of the Montreal Protocol and the mixed picture for the Kyoto Protocol were largely driven by the decisions of the United States, and those decisions were driven in turn by a form of purely domestic cost-benefit analysis. To the United States, the monetized benefits of the Montreal Protocol dwarfed the monetized costs, and hence the circumstances were extremely promising for American support and even enthusiasm for the agreement. Remarkably, the United States had so much to lose from depletion of the ozone layer that it would have been worthwhile for the nation to act unilaterally to take the steps required by the Montreal Protocol.[24] For the world as a whole, the argument for the Montreal Protocol was overwhelmingly strong.

The Kyoto Protocol presented a radically different picture. To the United States alone, the monetized benefits of the Kyoto Protocol appeared to be dwarfed by the monetized costs.[25] If the United States complied with the Kyoto Protocol on its own, it would spend a great deal and gain relatively little. If all parties complied, some of the most influential analyses suggested that the United States would nonetheless be a net loser. Because of the distinctive properties of the agreement, it was not at all clear that the world as a whole had more to gain than to lose from the Kyoto Protocol. Hence the circumstances were unpromising for a successful agreement—and they were especially unpromising for American participation, no matter the political affiliation of the relevant president. The different cost-benefit assessments, for the United States in particular but also for the world, provide the central explanation for the success of one agreement and the complex picture for the other.

There is a more general point. For the United States, and for other key nations as well, the payoff structures of the two agreements were fundamentally different. For some

---

[22] See below.
[23] See infra.
[24] See Parson, supra note, at 228.
[25] See William Nordhaus and Joseph Boyer, Warming the World (2000); below. In the Clinton Administration, certain studies suggested low costs from compliance with Kyoto, see Pring, supra note, at 194, but those studies were not widely accepted even within the executive branch, see id. at 196. Throughout I emphasize the importance of an analysis of costs and benefits, but that analysis is not the only relevant factor. Enforcement issues, for example, create serious problems for the Kyoto Protocol – more serious than for the Montreal Protocol. See Barrett, supra note.

nations, most prominently including the United States, unilateral compliance with the requirements of the Montreal Protocol was justified, even if *no* other nation complied. It would be impossible to make this point about the Kyoto Protocol. Indeed, it is plausible to suggest that for the United States, and for some other nations including China in particular, compliance with the Kyoto Protocol was not justified even if such compliance was both necessary and sufficient to ensure that *all* parties complied. Neither situation presented the simplest situation for an international agreement: a prisoner's dilemma in which all or most nations will do badly if each acts in its individual self-interest, but gain a great deal if all are able to enter into a binding agreement.

The Montreal Protocol did not present a prisoner's dilemma because key nations, including the United States, would gain from unilateral action; and in fact, many nations engaged in such action.[26] The problem of climate change might well present a prisoner's dilemma, in the sense that nations and their citizens, acting in their private self-interest, may produce bad or even catastrophic outcomes that can be avoided with a binding agreement (whose provisions of course must be specified). But for the United States, and for at least some other nations as well, the Kyoto Protocol did not solve the prisoner's dilemma, because it led to an outcome even worse than what would follow from unregulated self-interested action by all sides.

In both cases, the United States (and it was hardly alone in this respect) acted like *homo economicus*—a self-interested welfare maximizer, focusing not on its moral obligations, but on the material incentives.[27] If this point generalizes, we might think of it as suggesting a kind of individual rationality constraint, or at least constraining factor, operating at the level of nations.[28] The different cost-benefit assessments help to explain other apparent anomalies as well. For example, they illuminate the pattern of apparently universal compliance with the Montreal Protocol and the likelihood of widespread noncompliance with the Kyoto Protocol. They help explain why many nations reduced their CFC emissions *before* the Montreal Protocol took effect—and why their reductions were not only in advance but also in excess of the mandates of the agreement.[29] They also help explain the fact that American companies strongly supported the Montreal Protocol

[26] See Murdoch and Sandler, supra note.

[27] A helpful, supportive discussion, which also requires a qualification, is Stephen J. DeCanio, Economic Analysis, Environmental Policy, and Intergenerational Justice in the Reagan Administration, 3 International Environmental Agreements: Politics, Law and Economics 299 (2003). The support stems from the fact that the core analysis came from "projected health risks to the U.S. population from stratospheric ozone depletion." Id. at 302. The qualification is that the choice of a relatively low discount rate, for the future, can be taken to suggest a degree of altruism toward future generations, through a principle of intergenerational neutrality. See id. Note, however, that these were future generations of Americans.

[28] The point is emphasized more generally in Jack Goldsmith and Eric Posner, The Limits of International Law (2005). An evident problem with rational actor models, for both individual and states, is that such models are powerless to explain decisions without a sense of the relevant utility functions – of what concerns the relevant actors. If the relevant actors care about endangered species, wherever they might be found, then it is in their rational self-interest to attempt to protect endangered species, wherever they might be found. In the context of the Montreal and Kyoto Protocols, I shall emphasize the role of purely material concerns, including of course concerns about the health and wealth of American citizens.

[29] See Murdoch and Sandler, supra note, at 347.

while sharply opposing the Kyoto Protocol. They help explain why China and India refused to participate in the Kyoto Protocol. They illuminate another apparent anomaly: European nations, above all the United Kingdom, were initially quite cautious in reacting to the problem of ozone depletion, suggesting that the scientific evidence was both theoretical and speculative, while European nations, above all the United Kingdom, have been quite aggressive in reacting to the problem of climate change.

For the future, the implications of these points are simple. With respect to international agreements in general, the participation of the United States, and of other nations as well, is greatly affected by perceived domestic consequences.[30] To say this is not to deny that moral judgments may play some role and perhaps a significant one—not only but above all if injured nations are in a position to punish those who do not diminish their injury. Many billions of dollars are spend each year on foreign aid,[31] and an international agreement to control global environmental problems might operate as a form of such aid. If, for example, the citizens of the United States care a great deal about the welfare of endangered species, the nation may well be willing to enter into a costly agreement to protect endangered species. As we shall see, there are exceedingly good reasons, grounded in corrective justice, to ask the United States to assist those nations that are most vulnerable as a result of climate change. But if the United States is spending much more than it receives, it is unlikely to be an enthusiastic participant.

For climate change in particular, it is reasonable to predict that the United States will ratify an international agreement to reduce greenhouse gases only if the perceived domestic costs of the relevant reductions decrease, the perceived domestic benefits increase, or both. There is a more general lesson. Without the participation of the United States, the success of any such agreement is likely to be limited, if only because the United States accounts for such a high percentage of the world's greenhouse gas emissions. Indeed, I have noted that China and India are anticipated to be large emitters in the near future,[32] and they are most unlikely to participate if the United States does not. The case of China is particularly important. China will soon be the world's leading emitter of greenhouse gases, and both the United States and China are in the position of having relatively less to lose from climate change and relatively much to lose from controls on greenhouse gases. These points have large implications for the prospects for and contents of a successful agreement, to which I shall turn in due course.

The remainder of this Article comes in three parts. Part II explores the Montreal Protocol and the role of scientific evidence, European caution, American enthusiasm, and cost-benefit analysis in producing it. Part III examines the Kyoto Protocol and American

[30] This is an explicit theme of James H. Maxwell and Sanford L. Weiner, Green Consciousness or Dollar Diplomacy? The British Response to the Threat of Ozone Depletion, 5 International Environmental Affairs 19 (1993).

[31] See Congressional Research Service, Foreign Aid: An Introductory Overview of U.S. Programs and Policy (January 19, 2005) (reporting, among other things, $7.35 billion for development assistant, id. at 4, and $2.68 billion in humanitarian assistance, id. at 6).

[32] See James Houghton, Global Warming: The Complete Briefing 244-45 (3d ed. 2004) (noting that between 1990 and 2000, China saw a nineteen percent increase in greenhouse gas emissions, and India a sixty-eight percent increase).

reservations, with special emphasis on the possibility that the agreement would deliver low benefits for the world and impose significant costs—with particularly high costs, and particularly low benefits, expected for the United States. Part IV explores the lessons and implications of the two tales.

I. Ozone and Montreal

A. Science and Policy

Chlorofluorocarbons (CFCs) were originally used as working fluids for refrigerators, in part because they appeared to be far safer than the alternatives, which were either inflammable or dangerously toxic.[33] In the decades that followed, CFCs were found to have numerous cooling applications, prominently including air-conditioning. But CFCs came to be used most significantly as propellants in aerosol spray cans.[34] CFCs and related chemicals, prominently including halons, acquired widespread commercial and military uses,[35] producing billions of dollars in revenues.

The idea that CFCs posed a threat to the ozone layer was initially suggested in an academic paper in 1974, written by Sherwood Rowland and Mario Molina.[36] According to Rowland and Molina, CFCs would migrate slowly through the upper atmosphere, where they would release chlorine atoms that could endanger the ozone layer, which protects the earth from sunlight.[37] Rowland and Molina specified the "catalytic chain by which the chlorine atoms released would destroy ozone."[38] The potential consequences for human health were clear, for Rowland and Molina wrote only two years after the loss of ozone had been linked with skin cancer.[39] In 1971, it had been prominently suggested that a one percent ozone loss would cause an additional 7000 cases of skin cancer each year.[40] Hence the finding by Rowland and Molina indicated that significant health risks might well be created by emissions of CFCs.

In the immediately following years, depletion of the ozone layer received widespread attention in the United States, which was the world's leading contributor to the problem, accounting for nearly 50 percent of global CFC use.[41] A great deal of theoretical and empirical work was done within the scientific community; the National Academy of Sciences and many others made contributions.[42] Much of the relevant research was supportive of the initial claims by Molina and Rowland.[43] At the same time, industry attempted to conduct and publicize its own research, mounting an aggressive

[33] See Parson, supra note, at 20.
[34] Id. at 21.
[35] Id. at 22.
[36] See Percival et al., at 1047.
[37] Id. at 1047-49.
[38] Parson, supra note, at 23.
[39] Id. at 24.
[40] Id. at 25.
[41] See Benedick, supra note, at 26.
[42] Benedick, supra note, at 11.
[43] Parson, supra note, at 33.

public relations campaign to discredit the association between CFCs and ozone depletion.[44] A senior executive at DuPont, the world's largest producer, testified before a Senate panel that the "chlorine-ozone hypothesis is at this time purely speculative with no concrete evidence . . . to support it."[45] At the very least, industry representatives suggested no harm would come from each year's delay and that costly regulation should not be imposed until further research had been established that real risks were involved.[46]

Nonetheless, intense media attention to the problem greatly affected consumer behavior. In a brief period, American consumers responded to warnings by cutting their demand for aerosol sprays by more than half, thus dramatically affecting the market.[47] The same public concern spurred domestic regulation. In 1977, Congress amended the Clean Air Act to permit the Administrator of the Environmental Protection Agency (EPA) to regulate "any substance . . . which in his judgment may reasonably be anticipated to affect the stratosphere, especially ozone in the stratosphere, if such effect may reasonably be anticipated to endanger public health or welfare."[48] In 1978, EPA used the Toxic Substances Control Act[49] to ban the use of CFCs as aerosol propellants in nonessential applications and defined criteria for exemptions of "essential uses."[50] As a result of the ban, aerosol production in the United States fell by nearly 95 percent.[51] A significant reduction in the American contribution to ozone depletion was achieved in a way that "was remarkably fast, simple, and seemingly rational"—and that imposed little cost.[52]

The role of the public is especially noteworthy here. It is not surprising to find considerable mobilization on the part of environmentalists and those with environmentalist inclinations. But changes in consumer behavior were quite widespread, in a way that makes a sharp contrast with other domains (including climate change). Two points seem relevant here. The first is that skin cancer, the harm associated with ozone depletion, is highly salient and easily envisioned; and a salient, easily envisioned harm is especially likely to affect behavior.[53] This point is connected to the fact that it is not difficult to energize people with the vivid image of a loss of the earth's "protective shield." The second point is that the change in consumer behavior was not, in fact, extremely burdensome to consumers. Aerosol spray cans are not central to daily life, and a refusal to purchase them, or a decision to take other steps to reduce uses of ozone-depleting chemicals, did not impose large costs. Because the relevant harms were vivid, directly involving human health, and because no real hardship was imposed by taking steps to reduce those costs, consumer behavior was significantly affected. As we shall see, there is no parallel in the context of climate change.

---

[44] Benedick, supra note, at 12.
[45] Id.
[46] Parson, supra note, at 33.
[47] Benedick, supra note, at 28, 31.
[48] 42 USC 7457(b).
[49] 15 USC 2605.
[50] 43 Fed Reg 11301 (1978).
[51] Benedick, supra note, at 24.
[52] Parson, supra note, at 40.
[53] See Cass R. Sunstein, Laws of Fear: Beyond the Precautionary Principle (2005).

Despite the flurry of domestic activity, no international agreement was in sight. In fact the effort to produce international cooperation was at first "an unmitigated failure."[54] A central reason was the skepticism and opposition of the European Community, which firmly rejected regulatory measures of the sort taken by the United States.[55] In Europe, it was widely believed that science did not justify those measures, which would inflict high costs for speculative benefits. In most European countries, unlike in the United States, the public was relatively indifferent to the ozone question.[56] Heavily influenced by private groups with an economic stake in the outcome, most European nations resorted to symbols rather than regulatory restrictions.[57] Such symbols included voluntary emissions codes, unaccompanied by regulatory requirements of any kind.[58] Industry arguments about the expense of such requirements, and the potential loss of tens of thousands of jobs, contributed heavily to the weak response of the European Community.[59] The result of the disparity in reactions, and a source of continuing tensions between the United States and Europe, was a significant shift from American to European dominance in emissions of CFCs.[60]

While American companies, above all DuPont, showed some sensitivity to the scientific evidence and potential risks, their European counterparts sought "to preserve market dominance and to avoid for as long as possible the costs of switching to alternative products."[61] The United Kingdom was a central actor here, and it was not a coincidence that the export of CFCs played a large role in Britain's foreign exchange.[62] The British government was heavily influenced by Imperial Chemical Industries, among the largest CFC producers in the world.[63] But facing significant public concern, and regulatory restrictions, major American producers began the process of finding effective substitutes.[64] To be sure, DuPont and other companies also emphasized the tentative and theoretical nature of the evidence, and lobbied hard against the most aggressive domestic controls.[65] The election of President Reagan in 1980 signaled a period of skepticism about imposing new restrictions on CFCs, and hence little happened in the period from 1980 to 1982.[66] In 1982, in fact, members of the U.S. delegation to an international negotiations indicated if they had known in 1977 what they now knew, they would have declined to ban aerosols.[67]

---

[54] Id. at 44.
[55] Benedick, supra note, at 24.
[56] Parson, supra note, at 43.
[57] Id at 24.
[58] Id. at 25.
[59] Id.
[60] Id. at 26-27.
[61] Id. at 33.
[62] Id. at 38-39.
[63] See James H. Maxwell and Sanford L. Weiner, Green Consciousness or Dollar Diplomacy? The British Response to the Threat of Ozone Depletion, 5 International Environmental Affairs 19, 21 (1993).
[64] Parson, supra note, at 53.
[65] Id. at 57-58.
[66] Id. at 58-59.
[67] Id. at 114-15.

In 1983, however, the United States started to support international controls, essentially asking the world to follow its own policies by banning uses of CFCs in aerosol propellants.[68] Notably, the United States did not ask for international action that would inflict new costs on the nation; it sought an agreement that would replicate its existing domestic action,[69] imposing regulatory burdens on others and thus conferring benefits on Americans at little or no additional expense. Industry organizations within the United States initially objected vigorously to the new position, contending that it gave undue credence to speculative science and fearing the rise of further controls on CFCs.[70] While the government maintained its position in the face of these objections, continuing negotiations produced an international stalemate through 1984.[71]

In 1985, the United States emphasized that a new theory indicated that truly catastrophic harm was possible, stemming from a sudden collapse of ozone concentrations. Because of the worst-case scenario, immediate action would be desirable.[72] Still skeptical of the science, and attuned to the costs, European leaders continued to reject the effort to produce an international agreement, contending that the United States was engaged in "scare-mongering"[73] and that "Americans had been panicked into 'over-hasty measures.'"[74] Strikingly, the British government played an important role in steering public opposition to regulatory controls.[75] A relevant fact was that "a ban on CFCs as aerosol propellants would have imposed economic consequences for the United Kingdom that would be markedly different from those for the United States."[76] Because of European skepticism, an international agreement seemed highly unlikely, with industry favoring the European position.[77]

B. The Road to Montreal

A great deal changed as a result of the emergence of strengthened scientific consensus, suggesting that the problem was both more serious and less disputable than had previously been thought. New findings in 1985 and 1987 showed a "hole" in the ozone layer over Antarctica, one that had grown to the size of the United States.[78] A paper published in 1985 suggested that between 1957 and 1984, there had been a 40 percent depletion in levels of total column ozone over Antarctica.[79] The discovery of the Antarctica hole "dramatically transformed the politics of the international negotiations as

[68] Percival et al., supra note, at 1048. The shift in American policy appears to have had something to do with the replacement of Ann Gorsuch, as Administrator of the Environmental Protection Agency, with William Ruckelshaus. See Parson, supra note, at 115.
[69] Parson, supra note, at 116-17.
[70] Id. at 117.
[71] Id. at 121.
[72] Benedick, supra note, at 43.
[73] Id.
[74] Benedick, supra note, at 33.
[75] Percival, supra note, at 1050.
[76] Maxwell and Weiner, supra note, at 21.
[77] Parson, supra note, at 125.
[78] Percival at 1048.
[79] See Maxwell and Weiner, supra note, at 26.

well as the science."[80] A significant role was played by the sheer vividness of the discovery, which "captured the public's imagination."[81]

Equally important, perhaps, were major assessments of the problem from 1986 and 1988. In 1986, a NASA/World Meteorological Association group provided an exceptionally detailed review of the evidence, concluding that continued growth in CFCs would produce large losses in the ozone layer.[82] In 1988, the Ozone Trends Panel, established by NASA, reiterated the basic finding that CFCs were the primary cause of the ozone hole with a new analysis of a significant global trend.[83] These conclusions, generally taken as authoritative, helped to pave the way toward the negotiations that led to the Montreal Protocol.

Within the United States, the position of industry began to shift in 1986, apparently as a result of significant progress in producing safe substitutes for CFCs.[84] While arguing that CFCs produced no imminent hazard, DuPont supported an international freeze on CFC emissions, seeing that step as a justified precautionary measure[85] after the discovery of the Antarctic ozone hole.[86] Indeed, DuPont and other producers pledged to phase out production by an early date and also supported international controls.[87] The reasons for this shift remain unclear. It is likely that public relations concerns played a significant role, especially in light of the fact that the relevant products were not especially profitable.[88] It is also likely that American producers saw that good commercial opportunities lay in the development and marketing of new products for which they had a comparative advantage over foreign producers.[89] In support of this hypothesis, consider the companies' warning "that international cooperation was essential, and that participation in an agreement to phase out CFCs needed to be as broad as possible, to avoid production by other manufacturers relocating to non-signatory states."[90] It is noteworthy in this regard that the European Community speculated that the Reagan Administration's support for aggressive controls was driven by the fact that "U.S. producers had secretly developed substitutes."[91]

In December 1986, the international negotiations became increasingly serious. Within the United States, there was mounting disagreement within the executive branch, as some officials agreed with the industry suggestion that a freeze might be justified, but not emissions reductions.[92] But the legislative view was unambiguous. By a vote of 80-2,

---

[80] Id.
[81] Id.
[82] See Parson, supra note, at 251.
[83] Id. at 252.
[84] Id. at 127.
[85] Id. at 126.
[86] See James Hammitt, Stratospheric-Ozone Depletion, in Economic Analyses At EPA 131, 157 (Richard Morgenstern ed. 1997).
[87] Id.
[88] Id.
[89] Id.
[90] Scott Barrett, Environment & Statecraft 234 (2005).
[91] Hammitt, supra note, at 157.
[92] Id. at 133.

the Senate voted in 1987 to ask President Reagan to take aggressive action to protect the ozone layer.[93] The relevant resolution said that the President should "strongly endorse the United States' original position . . . and continue to seek aggressively . . . an immediate freeze . . . a prompt automatic reduction of not less than fifty percent . . . and the virtual elimination of [ozone-depleting] chemicals."[94]

What followed was a period of intense discussions within the Reagan Administration,[95] with sharp differences between the Office of Management and Budget, skeptical of aggressive controls, and the Environmental Protection Agency, favorably disposed to such controls.[96] The internal disagreement was resolved after a careful cost-benefit analysis suggested that the costs of controls would be far lower than anticipated, and the benefits far higher.[97] In the words of a high-level participant in the proceedings: "A major break . . . came in the form of a cost-benefit study from the President's Council of Economic Advisers. The analysis concluded that, despite the scientific and economic uncertainties, the monetary benefits of preventing future deaths from skin cancer far outweighed the costs of CFC controls as estimated either by industry or by EPA."[98] This conclusion was generally in line with the EPA's own analysis of the problem, in the sense that both were highly supportive of aggressive controls.[99] In particular, both EPA and the Council of Economic Advisers concluded that the ozone layer depletion would cause a "staggering" increase in the number of deaths from skin cancer—over five million by 2165.[100]

Though the formal analysis played a role, "even a qualitative benefit-cost comparison was sufficient to support regulation," especially in light of the risk of "global-scale catastrophic damages."[101] Recall in this connection that skin cancer is a salient harm, one that is likely to energize citizens and officials alike. The association between skin cancer and cherished leisure activities—such as lying on the beach—undoubtedly helped to spur the sense that the problem needed to be addressed in aggressive terms.

With the American position fixed, the stage was set for the negotiation of a new protocol. At an early point, the European Community, led above all by France, Italy, and the United Kingdom, urged caution and a strategy of "wait and learn."[102] Concerned about the economic position of Imperial Chemical Industries, the United Kingdom rejected an aggressive approach.[103] The United States took the lead in endorsing stringent additional controls; it was joined by several other nations, including Canada, New

[93] Benedick, supra note, at 61-62.
[94] Congressional Record, June 5, 1987, at p. S57759.
[95] Benedick, supra note, at 62-65.
[96] Parson, supra note, at 135-36.
[97] See Barrett, supra note, at 227-30.
[98] See Benedict, supra note, at 63.
[99] See Hammitt, supra note, for a general discussion.
[100] See DeCanio, supra note, at 302.
[101] Hammitt, supra note, at 155.
[102] See Hammitt, supra note, at 68.
[103] See Maxwell and Weiner, supra note, at 27.

Zealand, Finland, and Norway.[104] Those urging stringent controls placed a particular emphasis on the problem of irreversibility. Because some CFCs last for a century or more, it was necessary to act immediately, to avoid the need for "even more costly measures in the future."[105]

Many months of discussions led to the decisive meeting in Montreal, starting on September 8, 1987 and including over 60 countries, more than half of them developing.[106] The key part of the resulting protocol was not merely a freeze on CFCs, but a dramatic 50% cut by 1998, accompanied by a freeze on the three major halons, beginning in 1992.[107] The most important factor behind this aggressive step "was the promotion by an activist fashion of U.S. officials of an extreme negotiating position and its maintenance through several months of increasingly intense domestic and international opposition."[108] The 50% figure operated as a compromise between the American proposal for 95% reductions and the European suggestion of a freeze; it was also supported by scientific evidence suggesting that minimal ozone depletion would follow if the 50% reduction were implemented.[109]

A knotty question involved the treatment of developing countries. While CFC consumption was low in those countries, their domestic requirements were increasing,[110] and a badly designed agreement could merely shift the production and use of CFCs from wealthy nations to poorer ones, leaving the global problem largely unaffected. On the other hand, developing nations reasonably contended that they should not be held to the same controls as wealthier nations, who were responsible for the problem in the first place. India and China emphasized that nations with less than 25 percent of the world's population had been responsible for over 90 percent of the world's CFCs.[111] This claim was meant by several steps, including both loosened restrictions on developing nations and financial assistance to them. Under Article 5 of the Montreal Protocol, developing countries are authorized to meet "basic domestic needs" by increasing to a specified level for ten years, after which they are subject to a 50 percent reduction for the next ten years. In addition, a funding mechanism was created by which substantial resources—initially $400 million—were transferred to poor countries.[112] These provisions have been criticized as unduly vague, essentially a way of deferring key questions[113]; but they provided an initial framework, one that has turned out to work exceedingly well.

---

[104] See Hammitt, supra note, at 69.
[105] Id.
[106] Id. at 74.
[107] Parson, supra note, at 240.
[108] Id. at 143.
[109] Hammitt, supra note, at 155-56.
[110] Benedict, supra note, at 93.
[111] Percival et al., supra note, at 1052.
[112] See id.; see also Bowser, History of the Montreal Protocol's Ozone Fund, 14 Intl Env Rep 636 (1991).
[113] Parson, supra note, at 146.

C. Costs and Benefits

Why did the United States adopt such an aggressive posture with respect to ozone depletion? I have referred to the significant effect of a study by the Council of Economic Advisors, suggesting that a well-designed agreement would give the United States far more than it would lose. A further clue is provided by the following contemporaneous account, by the Environmental Protection Agency, of the costs and benefits of the Montreal Protocol[114]:

Costs and Benefits of Montreal Protocol to the United States (in billions of 1985 dollars):

	No controls	Montreal Protocol	Unilateral Implementation of Montreal Protocol by the United States
Benefits	—	3,575	1,363
Costs	—	21	21
Net benefits	—	3,554	1,352

These figures were generated by a projection of over five million skin cancer deaths by 2165, together with over twenty-five million cataract cases by that year—figures that would be cut to 200,000 and two million, respectively, by a 50% CFC reduction.[115] Of course it is possible to question these numbers; the science does not allow uncontroversial point estimates here, and perhaps the EPA had an interest in showing that the agreement was desirable. What matters, however, is the perception of domestic costs and benefits, and in the late 1980s, no systematic analysis suggested that the Montreal Protocol was not in the interest of the United States. It should be clear that on these numbers, even unilateral action was well-justified for the United States, because the health benefits of American action would create substantial gains for the American public. But if the world joined the Montreal Protocol, the benefits would be nearly tripled, because it would prevent 245 million cancers, including more than five million cancer deaths, by 2100.[116] At the same time, the relatively low expected cost of the Montreal Protocol—a mere $21 billion—dampened both public and private resistance; and the cost turned out to be even lower than anticipated because of technological innovation.[117]

One of the most noteworthy features of the ozone depletion problem is that over time, the United States was anticipated to be a decreasingly large contributor to that problem. By 2050, no controls were expected to mean a 15.7% decrease in the ozone layer—whereas unilateral American action would produce a 10.4% decrease, and the international agreement would result in a mere 1.9% decrease. By 2100, no controls were expected to mean a 50% decrease; unilateral action a 49% decrease; and the international agreement a 1.2% decrease.[118] In the short-run, aggressive action by the United States

[114] See Barrett, supra note, at 228.

[115] See DeCanio, supra note, at 302. See id. for more information on how these harms were turned into monetary equivalents and in particular for discussion of the choice of a low discount rate.

[116] Barrett, supra note, at 146.

[117] Id. at 231.

[118] Id.

alone was amply justified by the domestic cost-benefit calculus. In the long-run, the United States would do much better with global cooperation, especially from developing nations, which would be increasingly important sources of ozone-depleting chemicals. American enthusiasm for the Montreal Protocol, and for aggressive regulatory steps, can be understood only in this light.

There is no full accounting of the costs and benefits of the Montreal Protocol for the world. But if we build on a 1997 study in Canada, we can generate the following numbers as a rough approximation[119]:

Global Benefits and Costs of Montreal Protocol, 1987–2060

Avoided cases of skin cancer	20,600,000
Avoided cases of skin cancer deaths	333,500
Avoided cases of cataracts	129,100,000
Monetized benefits (including damages to fisheries, agriculture, and materials; not including the health benefits mentioned about)	$459 billion
Monetized benefits in terms of deaths averted	$333 billion
Monetized health benefits (nonfatal skin cancers and cataracts averted)	$339 billion
Monetized costs	$235 billion
Net benefits	>$900 billion

To be sure, many of these numbers might be questioned, because they depend on contentious assumptions.[120] But the conclusion is that the Montreal Protocol was an extraordinary bargain for the world in general, as well as for the United States in particular. Its success had everything to do with these facts.

This point raises an obvious question: Why was an agreement necessary at all? As we have seen, severe reductions in CFC emissions preceded the ratification of the agreement. At first glance, many nations had self-interested motives with respect to the ozone problem, sufficient to justify large reductions in such emissions.[121] If so, an international accord might not be required at all. It is true that the United States made substantial reductions on its own, as did other nations, and that still more nations might have done so without the Montreal Protocol.[122] But an agreement was nonetheless

[119] Barrett, supra note, at 237.

[120] For example, the economic value of a human life is highly controversial, as is the adoption of a uniform number. For discussion, see DeCanio, supra note, at 304-06; Cass R. Sunstein, Laws of Fear: Beyond the Precautionary Principle (2005).

[121] See James Murdoch and Todd Sandler, The Voluntary Provision of a Pure Public Good: The Case of Reduced CFC Emissions and the Montreal Protocol, 63 J Public Economics 331 (1997).

[122] Indeed, many nations did so. See id. at 347. It is not clear, however, whether all or most of their reductions would have occurred without the shadow of obligations under the Montreal Protocol. It is possible that the protocol helped spurred this ahead-of-schedule reductions, and above-requirement reductions, in part because of the information the meetings and the protocol provided, in part because of the

important. As we have seen, the United States itself was much better off with agreement from other countries, and for many of those countries, the purely domestic cost-benefit calculus was less clear than it was for the United States. It is plausible to think that numerous nations were willing to make significant cuts only on the assumption that other nations would do so as well. Recall that at the time of the Montreal Protocol, European nations sought a freeze, not a 50% emissions reduction. Perhaps their position was uninformed by an accurate understanding of the domestic costs and benefits; but the agreement was nonetheless necessary to ensure significant cuts in CFC emissions.

The posture of the developing nations also helps explain why an agreement was valuable. For them, cuts were not perceived as justified by reference to the domestic calculus; side-payments were required. Perhaps it is relevant here that the skin cancer risks associated with ozone depletion primarily threaten light-skinned people,[123] and hence nations with mostly dark-skinned populations had relatively little to gain from the agreement. And in understanding why an agreement was necessary, it is relevant that American producers, such as DuPont, were more enthusiastic about the development of substitutes on the assumption that there would be an international market for them—and on the assumption that they would not be losing, and might even be gaining, in the global marketplace by virtue of their efforts to produce CFC substitutes. The final point is that an international process, culminating in the Montreal Protocol, helped to spread relevant information about both costs and benefits, spurring nations to take notice of a problem that some of them might have neglected on their own.

None of this means that the problem of ozone depletion presented a standard prisoner's dilemma, in which all or most nations needed an enforceable agreement to produce a result better than what would emerge from purely self-interested action. The ozone problem had no such structure. As we have seen, the United States essentially complied with the requirements of the Montreal Protocol before the Montreal Protocol, and many nations went well beyond those requirements both before and after the protocol.[124] There was no incentive to defect. But the agreement was certainly in the interest of the United States, because it greatly increased the health benefits for the nation's citizens, and at least some of the parties would not have reduced at all or as much on their own.

Perhaps it is relevant here that the skin cancer risks associated with ozone depletion primarily threaten like-skinned people, and hence nations with mostly dark-skinned populations had relatively little to gain from the agreement. On this count, the problem of climate change is altogether different.

---

technology-forcing role of the protocol, in part because of the symbolic value of early and substantial reductions both domestically and internationally.

[123] See DeCanio, supra note, at 302.

[124] Id. at 347.

D. Beyond Montreal

After the Montreal Protocol, restrictions on ozone-depleting substances have been rapidly strengthened,[125] to the point where a world-wide phase-out of fifteen different CFCs was accepted in London in 1990.[126] At that stage, the European Community, now convinced, sought a clear timetable for further reductions, leading to an agreement for total elimination of CFC use and production by 2000.[127] Imperial Chemical Industries, an original source of the British and hence European skepticism about regulatory controls, now played a different role, having "realized—even more strongly than before—the potential commercial opportunities, as well as the risks, involved in shifting to substitute chemicals."[128]

Remarkably, the European Community announced that it would phase out CFCs by 1997. Not to be outdone, the United States announced that it would do so by 1996. The accelerated action was spurred by evidence that the costs of the phase-out would be much lower than expected—and that the damage to the ozone layer was even greater. Action to control ozone-depleting chemicals has increased since that time, to the point where almost all nations have agreed to it. As a result of the various restrictions, new damage to the ozone layer has essentially ceased; the ozone "hole" is shrinking; and ozone concentrations are expected to return to natural levels by 2050.[129] This, then, is a stunning story of successful international cooperation.

If we examine the American role here, we can see that the development of the Montreal Protocol is a distinctive and striking case study in a well-known phenomenon in the political science literature, which involves the provision of public goods by international powers, or "hegemons."[130] On this view, the most powerful nations are often in a good position to provide global public goods, such as financial stability and peace, entirely on their own. Consider protection against terrorist threats: If the United States succeeds in reducing those threats, it might well benefit many nations, not simply the United States.[131] The domestic actions of the United States—significantly reducing CFC emissions before any international requirements—conferred substantial benefits on other nations (though admittedly, those benefits might be characterized as a reduction of harm). And in pressing successfully for aggressive action at the international level, the United States provided large health benefits to citizens all over the globe.

---

[125] An informative capsule summary can be found in Parson, supra note, at 240-41.

[126] Parson, supra note, at 235.

[127] On the British turnaround, see Maxwell and Weiner, supra note, at 32.

[128] Id. at 33.

[129] Parson, supra note, at 239.

[130] See Kris James Mitchener and Marc Weidenmier, Empire, Public Goods, and the Roosevelt Corollary, 65 J Ec History 658 (2005); Deepak Lal, Globalization, Imperialism, and Regulation, 14 Camb Rev. International Aff. 107 (2001); Charles Kindleberger, Dominance and Leadership in the International Economy: Exploitation, Public Goods, and Free Rides, 25 International Studies Q. 242 (1981).

[131] It is possible, however, that efforts to protect the United States from terrorist attacks will cause terrorists to shift their attention to other nations. To know whether the United States is conferring benefits on such nations, it is necessary to know the nature of its efforts: Discouraging global terrorism, through military or other means, will of course help multiple nations.

II. Climate Change

Concern about greenhouse gases has arisen in the same general period as concern about ozone-depleting chemicals. But there is an initial puzzle: In the two contexts, many of the major actors have reversed their positions. The best example is the United States, at once the most important agent behind the Montreal Protocol and among the most important obstacles to an international agreement to govern greenhouse gases.[132] For ozone depletion, the United States first acted unilaterally, and then sought international restrictions. For greenhouse gases, the United States has hardly acted unilaterally. On the contrary, international action came first, and has spurred the exceedingly modest domestic measures that are now on the books.[133]

For their part, European nations were significant obstacles to international regulation of ozone-depleting chemicals, favoring an approach of "wait and learn"; for climate change, they have been favorably disposed toward regulatory controls, with the United Kingdom in the forefront.[134] The reversal of positions suggests that it is inadequate to portray the United States as skeptical of global solutions to environmental problems, or to see the European Union as more committed to environmental goals. Nor is it adequate to portray the American position on greenhouse gases as entirely a function of Republican leadership. The difference depends instead on assessments of national interest, public opinion, and the role of powerful private actors.[135]

A. From Framework to Kyoto

Since the late 1980s, international organizations have shown a great deal of concern about climate change. The initial activity occurred in December 1988, when a resolution of the United Nations General Assembly declared climate change to be a "common concern of mankind" and asked for a global response.[136] In 1989, the European Community signaled that it would support an international agreement to deal with the problem. In 1992, more than 180 nations, including the United States, signed the Framework Convention on Climate Change during the Rio Conference on Environment and Development.[137] In fact the United States was the first industrialized nation to ratify the Framework Convention,[138] which set the stage for everything that has happened since.

---

[132] For a helpful overview, see Pring, supra note.

[133] Since 1992, the Department of Energy has been required to estimate aggregate greenhouse gas emissions in the United States, and annual reports are available; these estimates are mandated by the United Nations Framework Convention on Climate Change, signed by the United States. See Energy Information Administration, supra note, at ES-1; http://www.eia.doe.gov/oiaf/1605/1605a.html; http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html

[134] See Tony Blair, Foreword, in Avoiding Dangerous Climate Change (Hans Joachim Schellnhuber et al. eds. 2006).

[135] See Pring, supra note, at 201-05.

[136] Percival et al., supra note, at 1062.

[137] See Parson, supra note, at 368-69.

[138] See Pring, supra note, at 185.

Unlike the Montreal Protocol, the Framework Convention lacked quantitative limits for emissions reductions; the absence of such restrictions had everything to do with the posture of the United States, which strongly resisted them,[139] here occupying the place of the United Kingdom in the early stages of the debate over ozone-depleting chemicals. The Framework Convention generally limited itself to information-gathering requirements and general aspirations, calling in abstract terms for stabilization of emissions to prevent "dangerous interference" with global climate. Thus the convention urged that it would be desirable to "return by the end of the present decade to earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases." The parties agreed to produce, at a latter stage, a legal instrument that would establish quantitative limits for developing countries. The Convention was ratified by the United States Senate in 1992 and entered into force two years later.

The Framework Convention inaugurated a new process of meetings, to be held annually. In 1995, the parties to the convention (including the United States, now led by President Clinton) met in Berlin and agreed to set emissions limits at specific periods and to agree to a protocol that would embody those limits.[140] The Clinton Administration appeared to support the "Berlin Mandate," asking industrialized nations to accept restrictions on greenhouse gas emissions. But other national leaders were not enthusiastic about this commitment. In 1997 a unanimous Senate adopted Senate Resolution 98, which asked President Clinton not to agree to limits on greenhouse gas emissions if the agreement would injure the economic interests of the United States or if it would "mandate[] new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period" as for the United States.[141] Indeed, the unanimous Senate concluded that any "exemption for Developing Country Parties is inconsistent with the need for global action on climate change and is environmentally flawed" and indicated that it "strongly believed" that the proposals under consideration "could result in serious harm to the United States economy, including significant job loss, trade disadvantages, increased energy and consumer costs, or any combination thereof."[142] (Recall that a near-unanimous Senate had voted in favor of aggressive action to protect the ozone lawyer—and that a unanimous Senate voted to support a more rapid phase-out of CFCs than was required by the Montreal Protocol and its amendment.[143])

This was an exceedingly important resolution—even more important than it might have seemed. Because such commitments from developing countries were highly unlikely—indeed, no commitments "within the same compliance period" had been made even for the Montreal Protocol[144]—this vote was essentially a suggestion that the United States should accept no commitments at all. It is worth underlining the bipartisan nature of the vote; no Democratic member of the Senate opposed it. As we shall see, the

[139] Parson, supra note, at 368.
[140] Id. at 369.
[141] http://www.opic.gov/GeneralOPIC/senateresolution98.htm
[142] Id.
[143] Barrett, supra note, at 369-70.
[144] See supra.

opposition of developing countries stemmed from a calculation overlapping with that of the Senate. To be sure, it was possible for such countries to urge that wealthy nations had been responsible for the problem in the first instance, and that they should not have to bear significant costs when wealthy nations had already benefited from the technologies that contribute to climate change. This argument – invoking corrective justice, but with a distributional component – was not made and could not be made by the United States. But developing countries also believed, not without reason, that they would lose more than they would gain from restrictions on greenhouse gases. As we shall see, China was and remains the most important actor here. China stands to lose relatively little from climate change, and it would have to spend a great deal to reduce greenhouse gases[145]; hence China's reluctance to participate in an international accord parallels the analysis of the United States.

The Clinton Administration took an equivocal approach to this resolution and indeed to the Kyoto negotiations in general. In part because of the presence of Vice President Gore, the administration did favor some kind of international response.[146] Nonetheless, it spoke at some points in favor of voluntary responses rather than regulation and adopted negotiating positions that would impose relatively little burden on the national economy.[147] In the complex Kyoto negotiations in December 1997, the United States did support regulatory limits, but relatively modest ones, arguing against reductions in emissions levels and instead for stabilizing current levels.[148] (Again this posture is a sharp contrast from the negotiations that led to the Montreal Protocol, in which the United States sought significant reductions, while other nations urged stabilization.) The United States also urged several other steps: inclusion of the developing countries in the treaty, through their acceptance of some kind of quantitative limits; a rejection of early deadlines in favor of a ten-year delay; and a base year of 1995 rather than 1990, which would make quantitative limits less stringent. The United States also opposed mandatory "domestic measures," such as energy taxes,[149] and sought ample mechanisms to ensure emissions trading, a sensible idea that would have the advantage driving down costs. The restrictions supported by the United States were distinctly less aggressive than those sought by the European Union and Japan.[150] In conformity with Senate Resolution 98, American negotiators made serious efforts to persuade the major developing countries to agree to limit their emissions at some future date; they refused.[151]

In fact many of the American positions were rejected during the negotiations. Ultimately, most of the major developed nations, including the United States, agreed to the Kyoto Protocol, which sets forth firm quantitative limits on greenhouse gas emissions. Specified reductions were listed for, and limited to, the "Annex 1" nations—those bound by the Kyoto Protocol. The list was designed to ensure that taken as a whole, the nations would show a reduction of 5 percent over 1990 levels—a reduction that must

---

[145] See infra.
[146] Pring, supra note, at 196.
[147] Id. at 197.
[148] Id. at 198.
[149] Id. at 198-99.
[150] See Pervival et al., supra note, at 1063.
[151] Percival et al., supra note, at 1063.

be met in the period between 2008 and 2012. For example, the United States was required to reduce emission by 7 percent; Japan by 6 percent; the European Union by 8 percent. Some nations were permitted to have increased emissions; these included Iceland, Norway, and Australia. Developing nations made no commitments at all, though they were permitted to engage in emissions trading with Annex 1 nations.

It is worth asking why, exactly, these particular targets were chosen. The simplest answer is that national self-interest played a key role.[152] The point is most obviously true for developing nations. India's greenhouse gas emissions exceed Germany's; those of South Korea exceed France; next to the United States, China is the largest emitter of greenhouse gases in the world.[153] But none of these nations is controlled by the Kyoto Protocol. Russia was given a target of 100 percent of its 1990 emissions, but in 1997, its actual emissions were already merely 70 percent of that amount, because of economic difficulties. The trading system created by the Kyoto Protocol actually ensured a huge economic boon to Russia, as everyone was aware.[154] Germany appeared to accept a significant reductions requirement—8 percent by 2012—but in 1997, its own emissions were already 10 percent lower than 1990, as a result of reunification with the former East Germany, whose plummeting economy resulted in radical emissions decreases.[155] For the United Kingdom, the story is not altogether different. The target, a reduction of 8 percent, was less severe than it seemed, because state subsidization of natural gas had already led, in 1997, to a level 5 percent below that of 1990.[156] The real loser, in terms of the actual costs of mandatory cuts, was the United States.

It should therefore be unsurprising that in the United States, a strong bipartisan consensus stood in opposition to ratification; no member of the Senate, Democratic or Republican, supported ratification. Although Vice President Gore played a key role in producing the Kyoto Protocol, the Clinton Administration took an ambivalent approach in the aftermath of negotiations. On the one hand, it emphasized the flexible nature of some of the provisions—including emissions trading—and urged that developing countries might eventually be persuaded to be included.[157] On the other hand, the Clinton Administration promised Congress that it would not adopt measures to implement the Kyoto Protocol before Senate ratification and that it would not seek such ratification unless it had obtained "meaningful participation" from developing countries.[158] Under intense international pressure, the United States signed the protocol on September 12, 1998.[159] But it is an understatement to say that the signing was not well-received in Congress, which added a proviso to the 1999 Environmental Protection Agency Appropriations Act banning the agency to use appropriations "to propose or issue rules, regulations, decrees or orders for the purpose of implementation, or in preparation for

[152] See Richard Benedick, Morals and Myths: A Commentary on Global Climate Policy, WZB-Mittelungen Heft 108, at 15-16 (Sept. 2005)
[153] Id. at 16.
[154] Id. at 16.
[155] Id.
[156] Id.
[157] Pring, supra note, at 200-01.
[158] Id. at 205.
[159] Id. at 206.

implementation" of the Kyoto Protocol.[160] At this point, Vice President Gore himself indicated that the protocol would not be submitted for ratification without meaningful participation by developing nations.[161] Indeed the whole process had an air of unreality to it, because "everyone on both sides of the Atlantic already knew in 1997 that the U.S. could never join the protocol as drafted."[162]

The Bush Administration offered no such ambivalent picture. In 2001, President Bush described the Kyoto Protocol as "fatally flawed" and "effectively dead," emphasizing the nonparticipation of developing countries. In the key letter, President Bush wrote, "I oppose the Kyoto Protocol because it exempts 80 percent of the world, including major population centers such as China and India, from compliance, and would cause serious harm to the U.S. economy."[163] In fact the United States attempted to persuade other nations, above all Japan and Russia, to reject the protocol as well.[164] In addition, the United States has done exceedingly little to reduce the emission of greenhouse gases, relying largely on collecting information about emissions levels and encouraging further research.[165] One of the nation's principal goals is an 18% improvement in greenhouse gas intensity between 2002 and 2012,[166] with intensity measured as emissions per unit of gross domestic product (GDP). But the goal is an aspiration, not a requirement,[167] and in any case significant reductions in greenhouse gas intensity can be accompanied by extremely large increases in greenhouse gas emissions.[168]

Nonetheless, the Kyoto Protocol went into effect in 2005, and the number of nations formally committed to it is impressive indeed. Of the original participants in the process that led to Kyoto, the United States and Australia are the only nonratifiers. In

---

[160] Id.

[161] Id. at 207.

[162] See Benedick, Morals and Myths, supra note, at 16.

[163] See note supra.

[164] Percival et al., supra note, at 1071.

[165] For overviews, see http://www.state.gov/g/oes/rls/fs/46741.htm and http://www.epa.gov/globalwarming/, in particular the reports mentioned at http://yosemite.epa.gov/oar/globalwarming.nsf/content/actions.html; http://www.whitehouse.gov/news/releases/2001/06/20010611-2.html; Daniel R. Abbasi, Americans and Climate Change 20-23 (2006). On June 22, 2005, a 53-44 majority of the United States Senate approved a "sense of the Senate" resolution to the effect that "Congress should enact a comprehensive and effective national program of mandatory market-based limits and incentives on greenhouse gases that slow, stop and reverse the growth of such emissions . . . ." Id. at 20. The most aggressive legislative proposal, from Senators John McCain and Joseph Lieberman in 2003, would have capped greenhouse gas emissions at 2000 levels. The proposal was defeated by a vote of 55-43. For an overview, see http://commerce.senate.gov/newsroom/printable.cfm?id=214305; for an analysis, see Sergey Paltsev et al., Emissions Trading to Reduce Greenhouse Gases in the United States: The McCain-Lieberman Proposal, available at http://web.mit.edu/globalchange/www/reports.html.

[166] For a helpful outline, see http://www.pewclimate.org/policy_center/analyses/response_bushpolicy.cfm

[167] See id.

[168] This in fact has been the experience of the United States between 1990 to 2004, with significant reductions in greenhouse gas intensity (by 21%) accompanied by significant growth in carbon dioxide emissions (by 19%). See Energy Information Administration, Emissions of Greenhouse Gases in the United States 2004 at xii (2005).

2001, the Marrakech accords led to further innovations, in which developing countries were made beneficiaries of funds to assist with technology transfer.[169] Although the level of the funds remain unspecified, donors led by the European Union pledged to grant $410 million annually.[170] To this extent, the Montreal Protocol and the Kyoto Protocol might appear to be roughly parallel. But the appearance is badly misleading, as we shall shortly see.

B. Costs and Benefits

For the United States and the world, the benefits of the Montreal Protocol were projected to dwarf the costs. What are the relevant figures for the Kyoto Protocol?

Begin with the United States, focusing on the cost side. At the time of ratification, this was a much-disputed question. An early analysis in the Clinton Administration found "modest" costs from the Kyoto Protocol, producing a mere $.04 to $.06 increase in the price of gasoline, and an annual increase in the average family's energy bill of $70-$110 by 2010.[171] Within the Clinton Administration itself, however, these projections were disputed. A study by the Department of Energy projected substantial gasoline price increases from $1.39 to $1.91, and 20 percent to 86 percent increases in the price of electricity by 2010.[172] Compare in this regard an industry-funded study done at the Wharton School, which projected costs far in excess of these projections[173]—including a loss of 2.4 million jobs and $300 billion in the nation's GDP, with an average annual cost of $2700 per household, including a 65 cent per gallon increase in the price of gasoline and a near-doubling of the price of energy and electricity.[174]

These figures are almost certainly inflated. One of the most careful, objective, and influential analyses comes from William Nordhaus and Joseph Boyer.[175] As Nordhaus and Boyer show, a great deal depends on the amount of emissions trading. If trading were freely available, the cost to American companies would be dramatically reduced, because they could avoid expensive emissions reduction requirements and rely instead on purchasing permits.[176] Additional uncertainty about the numbers stems from the fact that technological innovation might drive down costs—as indeed it did in the context of CFCs.[177] According to Nordhaus and Boyer, the worst-case scenario for the Kyoto Protocol, involving no effective trading, would produce total costs of $852 billion in present value.[178] The best case, involving global trading, would involve a cost of $91

[169] See id. at 1072-73; Vespa, Climate Change 2001: Kyoto at Bonn and Marrkech, 29 Ecol. L. Q. 395 (2002).
[170] Percival et al., at 1073.
[171] Pring, supra note, at 194.
[172] Id. at 196.
[173] *http://www.api.org/globalclimate/wefastateimpacts.htm*
[174] Id.
[175] Nordhaus and Boyer, supra note.
[176] Id. at 155-162.
[177] See above.
[178] Id. at 159.

billion.[179] The most likely figure is $325 billion, involving trading among the Annex 1 nations.[180]

For the world as a whole, however, the costs are actually lower—merely $217 billion in the case of Annex 1 trading, and $884 billion in the case of no trading.[181] The reason is that many nations, especially those in Eastern Europe, would receive a great deal of money from permit sales, and hence they would count as net winners quite apart from any benefits from reducing global warming. The mere grant of permits produces tens of billions of dollars in gains for both Russia and Europe—a total of $112 billion from Annex I trading.[182] It is a real question whether these billions of dollars in revenue, amounting to a kind of transfer, should count as a "benefit" from the Kyoto Protocol. But even if such amounts are included, the worldwide costs of the protocol are in the hundreds of billions of dollars.

What would the United States and the world receive in return for these costs? Here too there is a great deal of uncertainty.[183] In its 2001 report, the Intergovernmental Panel on Climate Change projected an increase of between 1.4 and 5.8 degrees Centigrade by 2001[184]—and an increase of 1.4 degrees would cause far less damage than an increase of 5.8 degrees. To these points it must be added that specialists greatly disagree about the likely damage from climate change, even assuming a particular increase in global mean temperatures.[185] If climate change is abrupt, the cost will be far higher than otherwise; abrupt climate change may lead to worldwide catastrophe.[186] The magnitude of the risk of catastrophe is disputed, and any such risk must be made part of the overall analysis.[187] In addition, a great deal turns on the selection of the discount rate; because many of the gains from emissions reductions will be experienced in the future, a low discount rate will obviously mean higher benefits from risk reduction than a high one.[188]

---

[179] Id.

[180] Id.

[181] Id.

[182] Id. at 162.

[183] For valuable overviews, see Avoiding Dangerous Climate Change (Hans Joachim Scellnhuber et al. eds 2006); Richard Tol, The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties, 33 Energy Policy 2064 (2005); Nordhaus and Boyer, supra note.

[184] Percival et al., supra note, at 1058.

[185] See Tol, supra note; Houghton, supra note.

[186] See Richard A. Posner, Catastrophe (2005); Avoiding Dangerous Climate Change, supra note.

[187] See Nordhaus and Boyer, supra note (projecting a catastrophic risk of between 2% and 6%); Peter Challenor et al., Towards the Probability of Rapid Climate Change, in Avoiding Dangerous Climate Change 55, 61 (projecting a risk of abrupt climate change, which is potentially catastrophic, at 30-40 percent).

[188] For relevant discussion, see DeCanio, supra note (supporting intergenerational neutrality and suggesting that a low discount rate is compatible with this principle); Richard B. Howarth, Against High Discount Rates, in Perspectives on Climate Change: Science, Economics, Politics, Ethics 99 (Walter Sinnott-Armstrong and Richard Howarth eds. 2005).

According to an influential estimate, however, the present worldwide cost of climate change is projected to be in the vicinity of four trillion dollars.[189] That cost should be put in perspective; the annual GDP of the United States is $10 trillion, suggesting a capital stock value of at least $100 trillion.[190] But four trillions dollars is a great deal, and even that figure may be far too low if climate change is abrupt.[191] According to other estimates, climate change will reduce the GDP of developed nations by one or two percent, and reduce the GDP of developing nations by five percent or more.[192] It is difficult to doubt the proposition that the Kyoto Protocol would be worthwhile if it would eliminate the total cost of climate change. But the agreement would actually have a meager effect, reducing anticipated warming by a mere 0.03 C by 2100.[193] The reason is that climate change is a function of aggregate emissions of greenhouse gases, and the Kyoto Protocol would have only a small effect on those aggregate emissions. There are three points here. First, China, India, and other developing countries—now substantial contributors to climate change, and anticipated to be larger contributors in the near future—are not included in the agreement at all. Second, past emissions of greenhouse gases will contribute to warming; it follows that even a substantial reduction in future emissions would not eliminate the problem. Third, the Kyoto Protocol requires the parties not to make substantial cuts in emissions, but merely to return to a point slightly below emissions levels in 1990. It is for these reasons that its contribution to the problems caused by climate change are anticipated to be small.

What are the anticipated effects of the agreement for the United States? The initial point is that the most serious damage from climate change is most unlikely to be felt in the United States.[194] On some estimates, American agriculture will actually be a net winner as a result of climate change.[195] On other estimates, Americans will be net losers, but not nearly to the same extent as other nations.[196] In this light, we can offer a plausible if rough projection of the costs and benefits of the Kyoto Protocol for the United States alone[197]:

---

[189] See Nordhaus and Boyer, supra note, at 130-32 ($4 trillion): see also Posner, supra note, at 44 (noting but raising doubts about estimates of $4 trillion or $5 trillion).

[190] See Posner, supra note, at 44.

[191] Id.

[192] See Houghton, supra note, at 188.

[193] Nordhaus and Boyer, supra note, at 152.

[194] See Nordhaus and Boyer, supra note, at 96-97.

[195] See Olivier Deschenes and Michael Greenstone, The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations of Weather (2006), available at http://www.aei-brookings.org/publications/abstract.php?pid=1031; compare the suggestion in Nordhaus and Boyer, supra note, at 97, that "the economic impact of gradual climate change (that is, omitting catastrophic outcomes) is close to zero for a moderate (2.5 degree C) global warming." Note that this conclusion does not come to terms with the economic effects on the United States that would come from the very fact of serious economic harms in other nations.

[196] See Nordhaus and Boyer, supra note.

[197] Compiled on the basis of Nordhaus and Boyer, supra note, at 156-67.

Costs and Benefits of Kyoto Protocol for the United States (in billions of 2000 dollars):

	No Controls	Kyoto Protocol	Unilateral Action to Comply with Kyoto Protocol
Benefits	—	12	0[198]
Costs	—	325	325
Net Benefits	—	–313	–325

It should be immediately clear that on these numbers, the Kyoto Protocol is not a good bargain for the United States. The anticipated benefits of $12 billion are hardly trivial, but they are dwarfed by the anticipated costs of $325 billion. For the United States, significant unilateral action to comply with the Kyoto Protocol may well produce no benefits at all, and it would not be easy to defend in cost-benefit terms. If the United States engaged in emissions reduction on its own, it would be taking extremely costly action for speculative benefits. To say this is not to say that unilateral action would have no rationale.[199] Perhaps such action could spur technological innovation in a way that would have substantial long-term consequences for the problem of climate change—and do so at a cost lower than what is now anticipated. As we have seen, something of this sort did happen with ozone depletion, as substitutes developed more rapidly, and more cheaply, than anyone expected.[200] But for climate change, any such strategy would be a gamble, and it would not be the simplest to defend in conventional terms.

The larger point is that for the United States, the perceived values presented a very different picture for the Kyoto Protocol than for the Montreal Protocol. The costs of the Kyoto Protocol were much higher than the costs of the Montreal Protocol (by some $313 billion), and the benefits of the former were much lower than the benefits of the later (by some $3,562 billion!). For the world as a whole, the picture is better, but not particularly good, and not nearly as good as that for the Montreal Protocol:

Costs and Benefits of Kyoto Protocol for the World (in Billions of 2000 Dollars)

	No Controls	Kyoto Protocol
Benefits	—	96
Costs	—	338 or 217 (if we include, as offsetting benefits, $112 billion in permits for Eastern Europe)
Net Benefits	—	–242 or –119

To be sure, these numbers must be taken with many grains of salt, depending as they do on contentious assumptions about the degree of emissions trading, about technological innovation, about discount rates, about the likelihood of abrupt or catastrophic warming, and about the valuation of life and health. Reasonable people might expect the costs to be significantly lower or offer a significantly higher estimate of

[198] This estimate is of course rough. It is based on the assumption that unilateral action would have no significant effect in reducing the harms associated with climate change for the United States – and that any such effect might be counteracted by benefits.

[199] See Richard A. Posner, Catastrophe (2005).

[200] See Percival et al., supra note, 1051.

the benefits. If climate change is abrupt, or if temperatures raise more sharply than anticipated, the benefits of the Kyoto Protocol will be higher than these numbers suggest. Perhaps the Kyoto Protocol would have served, and might still serve, as a start toward a broader and more inclusive agreement. But on the numbers that confronted the United States at the pertinent times, the argument for ratification of the Kyoto Protocol was certainly unclear—far more so than the argument for ratification of the Montreal Protocol.

If all of the relevant facts are taken together, it is possible to explain why the United States was skeptical of the Kyoto Protocol. But a mystery remains: Why did so many nations express enthusiasm for it? Why was the Kyoto Protocol possible at all? We already have some clues. Part of the answer undoubtedly involves an assessment of domestic costs and benefits—an assessment that uniquely unfavorable for the United States. Many nations undoubtedly had more to gain than to lose (consider Eastern European nations, which acquired valuable emissions licenses). Some of the nations that appeared to make ambitious promises, such as Germany and the United Kingdom, did no such thing. To be sure, it is possible that some such nations were acting as global altruists. Perhaps some of them had an unusually pessimistic account of the consequences of climate change; perhaps some, or many, believed that the Kyoto Protocol would initiate a set of agreements that would, in the end, do far more good than harm. But perhaps some nations, especially those with the most to lose, did not believe that the Kyoto Protocol would, in fact, prove to be binding. On this view, the agreement was a kind of "cheap talk"—a way of signaling a commitment that would not operate as a commitment in practice. Let us now explore some evidence for this view.

C. Notes on Practice

The Kyoto Protocol has been ratified by all of the Annex1 nations except the United States and Australia. But this simple fact is insufficiently informative. Moreover, it is impossible to come to terms with the conflicting American approaches to the two problems without exploring actual American practices. The key points here are that the United States is the world's leading contributor to climate change and that greenhouse gas emissions have been growing, not stabilizing, in recent years. Let us begin with some general numbers about national performance.

1. *Greenhouse gas emissions in the world.* The formal fact of ratification disguises a quite complex practice. Numerous nations are very far from their targets under the Kyoto Protocol. Begin with the EEC countries[201]:

[201] All data taken from: UNFCCC, Key GHG Data: Greenhouse Gas (GHG) Emissions Data for 1990--2003 submitted to the UNFCCC, at 16-17 (November 2005)

EEC Countries			
Country	Target	% Change in Emissions between 1990 and 2003	Compliant?
Austria	–13%	16.50%	no
Belgium	–7.50%	1.30%	no
Denmark	–21%	6.80%	no
Finland	0	21.50%	no
France	0	–1.90%	yes
Germany	–21%	–18.20%	almost
Greece	25%	25.80%	almost
Ireland	13%	25.60%	no
Italy	–6.50%	11.50%	no
Luxembourg	–28%	–16.10%	no
Netherlands	–6%	1.50%	no
Portugal	27%	36.70%	no
Spain	15%	41.70%	no
Sweden	4%	–2.30%	yes
United Kingdom	–12.50%	–13%	almost

Note that compliance is not required until some time between 2008 and 2012 (with the precise date varying by country); hence widespread noncompliance does not foreclose the possibility that the situation will be better when the actual due dates arrive. Nonetheless, Sweden and France (with its heavy reliance on nuclear power) are the only nations in the EEC that have already met their targets under the Kyoto Protocol. The current numbers, and the existing trends, suggest that it is highly likely that a majority of EEC nations will fail to meet their obligations. There is a large contrast here with the Montreal Protocol, for which compliance is essentially perfect. To be sure, the United Kingdom, Germany, and Greece are close to their targets; we have seen the explanation for the first two. The more important point is that the vast majority of nations are very far from what Kyoto requires, often showing increases where they should be showing reductions.

Now consider Annex I countries[202]:

Annex 1 Countries			
Country	Target	% Change in Emissions between 1990 and 2003	Compliant?
Bulgaria	–8%	–50%	yes
Czech Republic	–8%	–24.20%	yes
EEC	–8%	–1.40%	no
Estonia	–8%	–50.80%	yes
Latvia	–8%	–58.50%	yes
Liechtenstein	–8%	5.30%	no
Lithuania	–8%	–66.20%	yes
Monaco	–8%	30%	no
Romania	–8%	–46.10%	yes
Slovakia	–8%	–28.30%	yes
Slovenia	–8%	–1.90%	no
Switzerland	–8%	–0.40%	no
United States	–7%	13.34%	no—refuses to ratify
Canada	–6%	24.20%	no
Hungary	–6%	–31.90%	yes
Japan	–6%	12.80%	no
Poland	–6%	–34.40%	yes
Croatia	–5%	–6%	yes
New Zealand	0	22.50%	no
Russian Federation	0	–38.50%	yes
Ukraine	0	–46.20%	yes
Norway	1%	9.30%	no
Australia	8%	23.30%	no–refuses to ratify
Iceland	10%	–8.20%	yes

The most remarkable fact presented here is that while the United States is one of only two Annex 1 nations that have declined to ratify the Kyoto Protocol, a number of countries show emissions increases comparable to or higher than those of the United States. These include Canada, New Zealand, Australia, Austria, Greece, Ireland, Portugal, Spain, and Italy. It is true that substantial reductions in greenhouse gas emissions can be found in Bulgaria, Estonia, Latvia, the Czech Republic, Lithuania, Hungary, Poland, Russia, Ukraine, Iceland, Luxembourg, the United Kingdom, Sweden, and Germany.[203] But most of these nations are in Central and Eastern Europe, which has suffered serious

[202] Id.

[203] See UNFCCC, Key GHG Data: Greenhouse Gas (GHG) Emissions Data for 1990-2003, submitted to the UNFCCC, at 16-17 (November 2, 2005).

economic distress in the relevant period. That distress accounts for substantially lower levels of energy use and hence lower levels of emissions, in fact an overall reduction of 37 percent in the relevant period.[204]

Because of the latter figure, the good news is that from 1990 to 2003, greenhouse gas emissions from Annex I parties did decrease by 5.9 percent, or a total of 18.4 billion tons—an average decrease in line with the Kyoto target.[205] But it is important to be careful with this figure. It is true that the average decrease, under that target, is 5.2 percent, but Kyoto's distribution of targets among nations would produce far greater overall decreases than those captured by the immediately preceding table. The reason is that the decreases have occurred in nations with already low emissions rates, while the nations with high emissions rates (above all the United States) are generally increasing, not decreasing, their emissions. By 2010, overall emissions from wealthy nations may grow by as much as 17% from 2000.[206] In view of the likely increase in wealthy nations, and because the economies of Eastern European nations are recovering, Kyoto's goals are most unlikely to be met.[207]

An important qualification to the figures just given: The behavior of nations might well be interdependent, and whether nations are willing to make significant reductions in greenhouse gas emissions might be endogenous to the behavior of the United States in particular. If the world's leading emitter is unwilling to make reductions, other nations might be reluctant to do so. We do not have a clean test of how nations would behave if the United States were willing to alter its own practices. Let us now turn, in that light, to those practices.

2. *Greenhouse gas emissions in the United States.* For the United States, practices in the last decade will make compliance with Kyoto's goals, or anything like them, even more challenging than it would have been at an earlier stage. The reason is that by most measures, energy use has been moving in exactly the wrong directions.

Within the United States, greenhouse gas emissions increased by no less than 15.8 percent between 1990 and 2004.[208] In 1990, carbon dioxide emissions were 5,002.3 million metric tons; in 2004, they were 5.973.0 million metric tons, a jump of 19 percent.[209] To be sure, greenhouse gas *intensity*—understood as emissions per unit of Gross Domestic Product—has been decreasing in the same period, with a significant decline of 21%.[210] But because of increased energy usage, per capita emissions have actually increased over this period by 1.2%—an increase that, alongside population growth, produced the increase in aggregate emissions.[211]

[204] http://www.commondreams.org/headlines03/0610-07.htm

[205] Id at 14.

[206] http://www.commondreams.org/headlines03/0610-07.htm

[207] Id.

[208] See Energy Information Administration, supra note, at ix; Record Increase in U.S. Greenhouse Gas Emissions Sparks Global Controversy (2006), available at http://environment.about.com/b/a/256722.htm

[209] Energy Information Administration, supra note, at x, xii.

[210] Id.

[211] Id. at xii.

Fossil fuel combustion is by far the largest contributor to greenhouse gas emissions in the United States, accounting for well over ninety-five percent of total carbon dioxide emissions. Greenhouse gas emissions from this source has been growing in most sectors, with a 1.7% increase between 2003 and 2004.[212] The transportation sector, based on fossil fuels, accounts for over a quarter of emissions, and it is the most rapidly growing source.[213] While methane emissions were reduced by 10% in 2004, total greenhouse gas emissions increased by 1.7% in the same year, the largest increase on record from any nation.[214] The most important conclusion of this capsule summary is that if the United States were to attempt to meet the target set by the Kyoto Protocol—a 7 percent reduction in emissions since 1990—it would have to impose exceedingly aggressive regulatory restrictions, for the simple reason that existing emissions are substantially in excess of 1990 levels, and growing every year.

III. Lessons and Implications

What follows from an understanding of the extraordinary success of the Montreal Protocol and substantial failure of the Kyoto Protocol? There are only two data points here, and it is therefore important to be careful in drawing general conclusions. But it is noteworthy that the Montreal Protocol was produced and ratified under a Republican President, not known for his commitment to environmental protection, and that a unanimous Senate voted for ratification. It is noteworthy as well that the Kyoto Protocol produced an ambivalent reaction under a Democratic President, who sought less ambitious targets than those favored by other nations, and that the Senate was unanimously opposed to it. For these reasons, both tales are legitimately taken as exemplary. They fit with other accounts in domains that are both related[215] and quite different[216]; those accounts emphasize the centrality of domestic self-interest in national judgments with respect to whether to join, or to comply with, international obligations. Nothing in the discussion here demonstrates that domestic self-interest is the sole motivation for government behavior; but there is no question that it plays a significant role.[217] As suggestive evidence, consider the fact that a "revealed preference" study of American laws suggests that a non-American life is valued at 1/2000 an American life.[218]

We can sharpen the distinction between the two protocols by offering a more general point. Some international agreements can solve prisoner's dilemmas, by enabling nations to make binding promises to undertake action that no individual nation, or few

[212] Id.

[213] http://www.epa.gov/otaq/greenhousegases.htm

[214] See Energy Information Administration, Emissions of Greenhouse Gases in the United States 2004 (2005); Record Increase in United States Greenhouse Gases Reported (2006), http://www.ens-newswire.com/ens/apr2006/2006-04-18-02.asp

[215] See Barrett, supra note.

[216] See Jack Goldsmith and Eric A. Posner, The Limits of International Law (2005); Jack Goldsmith, Liberal Democracy and Cosmopolitan Duty, 54 Stan L Rev 1667 (2003).

[217] See Maxwell and Weiner, supra note, at 37-38.

[218] See Wojciech Kopszuk et al., The Limitations of Decentralized World Redistribution: An Optimal Taxation Approach, 30 European Economic Review 1051 (2005).

individual nations, would undertake on their own.[219] At first glance, the problems of ozone depletion and climate change might seem to have this structure. But neither the Montreal Protocol nor the Kyoto Protocol solves a prisoner's dilemma. As we have seen, unilateral compliance with the requirements of the Montreal Protocol was in the interest of the United States, and probably many other nations as well. Hence the United States and many others would rationally do as the Montreal Protocol required even if no other nation did so. By contrast, the Kyoto Protocol solved no prisoner's dilemma for the United States. On the contrary, compliance with the requirements of the Kyoto Protocol would probably make Americans worse off, even if such compliance ensured that all other parties complied as well.[220]

If all of the relevant figures are taken as a whole, however, it would be possible to offer the following objection to my emphasis on the importance of domestic self-interest to the decisions of the United States. Neither the Montreal Protocol nor the Kyoto Protocol presented a clear example of a case in which the interests of the United States sharply diverged from the interests of the world. The Montreal Protocol was strongly in both the national and international interest. According to some of the most influential numbers, the Kyoto Protocol was neither in the nation's interest nor in the world's interest. It would therefore seem consistent with American behavior in the two areas to say not that the United States follows its own domestic analysis, but the United States will not sign a costly agreement that is not in the world's interest. On that view, the two tales do not speak to the importance of domestic self-interest; they are consistent with the view that the United States operates as a kind of global altruist.

It is true that neither protocol presented an example of a case in which the United States based its decision on domestic consequences even though global consequences argued for a very different outcome. But the deliberations that led to both decisions demonstrate the centrality of the domestic calculation. We have seen that for the Montreal Protocol, a purely domestic analysis by the Council of Economic Advisers played a crucial role, and that low domestic costs, spurred by technical innovation, made the Montreal Protocol far more attractive than it would otherwise be. The economic analysis focused on the domestic costs and benefits, not the global costs and benefits.[221] We have also seen that the rejection of the Kyoto Protocol had everything to do with a perception of high domestic costs and low domestic benefits (because of the nonparticipation of developing nations). At the key points, American officials in the executive and legislative branches may not have been thinking solely of domestic consequences; but those consequences were the principal motivating force behind the different outcomes.

What lessons might be drawn from these tales?

---

219 See Goldsmith and Posner, supra note, at 29-32.

220 I put to one side the possibility that the Kyoto Protocol could be defended as starting a process toward a better agreement, or that aggressive technology-forcing, on the part of the United States, might create innovation that would greatly help with greenhouse gas emissions.

221 See DeCanio, supra note, at 302.

A. Public Opinion and Consumer Behavior

The first lesson is that public opinion greatly matters, at least if it is reflected in actual behavior.[222] Recall that the problem of ozone depletion received massive attention in the United States, and that American consumers responded by greatly reducing their consumption of aerosol sprays containing CFCs. This action softened industry opposition to regulation,[223] in part because it made regulatory controls far less costly than they would otherwise be. In addition, market pressures fed by consumer behavior can spur technological innovation. If environmentally unfriendly products are not popular in the market, industry is likely to respond with safer substitutes. In this sense, markets themselves can be technology-forcing, in the environmental domain as elsewhere. At the same time, public opinion put a great deal of pressure on public officials, affecting the behavior of legislators and the White House alike.[224]

By contrast, there was no public pressure on those involved it CFC production and use in Europe, certainly in the early stages. The absence of such pressure, combined with the efforts of well-organized private groups, helped to ensure that European nations would take a weak stand on the question of regulation, at least at the inception of negotiations. In the later stages, public opinion and consumer behavior were radically transformed in the United Kingdom and in Europe, and the transformation had large effects on the approach of political leaders in the United Kingdom and Europe as well.[225] Note in this regard that public opinion may or may not be justified by actual threats. In some domains, the public has been far more fearful than the facts warrant.[226] With respect to ozone depletion, public opinion did in fact track scientific understandings, or at least the understandings that turned out to be vindicated.

With respect to climate change, the attitude of the United States remains remarkably close to that of pre-Montreal Europe, urging an approach of "wait and learn," above all through research and voluntary action, rather than through emission reduction mandates.[227] It is true that between 1990 and the present, the problem of climate change has received a great deal of media attention in the United States. But the public has yet to respond to that attention through consumer choices, and the best evidence suggests that American citizens are not, in fact, greatly concerned about the risks associated with warmer climates.[228] Notwithstanding the publicity given to climate change in recent years, Americans recently ranked the environment twelfth on a list of the most important problems—below immigration, health care, and gas and heating oil prices. Among

---

[222] See Benedick, supra note.

[223] Cf. the public controversy over the pesticide Alar, which was used in apples and associated with an increase incidence of cancer among children. The controversy led to a substantial drop in apple consumption and Alar was voluntarily withdrawn from the market. See Percival, et al., supra note.

[224] See Benedick, supra note.

[225] See Maxwell and Weiner, supra note, at 32-33.

[226] See Aaron Wildavsky, But Is It True? (1999): Timur Kuran and Cass R. Sunstein, Availability Cascades and Risk Regulation, 51 Stan L Rev 683 (1999).

[227] For a vigorous challenge to this approach, see Houghton, supra note, at 227-30.

[228] See Cass R. Sunstein, On the Divergent American Reactions to Terrorism and Climate Change, Colum L Rev (forthcoming 2007).

environmental problems, climate change was ranked ninth, well below damage to the ozone layer.[229] Another recent poll found that strong majorities of Americans oppose an increase in taxes on electricity and gasoline as an attempt to reduce climate change.[230] Unlike in the context of depletion of the ozone layer, American consumers and voters are putting little pressure on either markets or officials.

None of this means that public opinion is so firm and fixed that public officials have no room to maneuver. On the contrary, there is reason to think that public opinion is malleable on this topic, especially in light of general enthusiasm for the Kyoto Protocol. But with respect to greenhouse gases, the unaggressive posture of the United States government has been consistent with the attitudes of American citizens. A salient incident—a kind of 9/11 for climate change—might be sufficient to change those attitudes; perhaps it is necessary as well.[231] Recall in this connection that public opinion with respect to ozone depletion was affected by the salience of skin cancer and by the discovery of an ozone "hole" over Antarctica. To date, there is no analogue in the context of climate change.

B. American Benefits, American Costs

The second lesson is that many international agreements for global environmental problems will be ineffective without the participation of the United States, and the United States is likely to participate only if the domestic benefits are perceived to be at least in the general domain of the domestic costs. In international law generally, the latter point is hardly novel,[232] though it is disputed in its strongest forms.[233] My modest suggestion here is that for global environmental problems, above all climate change, no international agreement is likely to be effective unless the United States can be persuaded that it will not lose much more than it will gain.

It is true that the United States accounts of only about one-fifth of global greenhouse gas emissions—a stunning per capita figure, but one that is not high enough to derail international action if other nations are willing to go forward without the United States. If the world were able to make significant cuts in what is 80 percent of total emissions, it could do a great deal about climate change. The problem is that if the United States stands to one side, it is almost certain that coordinated, aggressive action will be impossible. At Kyoto, China and India showed an unwillingness to commit to cuts even when the United States suggested that it would participate. Those nations, and other developing countries, will likely be reluctant to confer benefits on industrialized nations, including the United States, unless there is a degree of reciprocity, and perhaps significant side payments as well (as in the Montreal Protocol).[234]

---

[229] See the summary and overview in The New York Times, April 23, 2006, at 14.

[230] http://www.pollingreport.com/enviro.htm

[231] For more detailed discussion, see Sunstein, supra note.

[232] See Goldsmith and Posner, note supra.

[233] See Oona Hathaway and Ariel Lavinbuck, Rationalism and Revisionism in International Law, 119 Harv L Rev. 1404 (2006).

[234] On side payments in general, see Barrett, supra note, at 335-353.

As we shall soon see, China will be the world's largest contributor to greenhouse gases by 2025, and it would be surprising if China showed a willingness to make significant cuts without the participation of the United States.[235] The only possibility is if China, in the future, finds itself in something like the same position with respect to climate change as the United States occupied with respect to the ozone layer—gravely threatened by the very emissions from which it profits. If China perceives itself as seriously endangered by climate change, it might well be willing to scale back its emissions, because domestic self-interest might so require. But this is unlikely; let us now see why.

C. Contributors and Victims

Who has the most to lose from reductions in greenhouse gases, and who has the most to gain from such reductions? To see the prospects for some kind of parallel to the Montreal Protocol, it is necessary to answer this question. Four possibilities can be imagined: some nations might both contribute substantially to the problem and stand to lose a great deal from it; some might contribute little while standing to lose little; some might contribute a great deal while standing to lose little; and some might contribute little while standing to lose great deal. The most promising situation for an international accord would be one in which those who contribute most to the problem also have the most to lose. If so, they would face a strong incentive to scale back their emissions. The least promising situation would be one in which the major contributors also have little to lose. If so, they would have a weak incentive to do anything about the problem.

Here is a relevant estimate of anticipated losses[236]:

Damages of a 2.5 Degree Warming as a Percent of GDP

India	4.93
Africa	3.91
OECD Europe	2.83
High income OPEC	1.95
Eastern Europe	0.71
Japan	0.50
United States	0.45
China	0.22
Russia	–0.65

It is readily apparent that some nations are far more vulnerable than others. Strikingly, Russia stands to be a net gainer, with substantial benefits to agriculture. India

[235] Zhiguo Gao, The Kyoto Protocol and the International Energy Industry: Legal and Economic Implications of Implementation, The Chinese Perspective, in Kyoto: From Principles to Practice 275 (Peter Cameron and Donald Zillman eds. 2001).

[236] Nordhaus and Boyer, supra note, at 91.

is particularly vulnerable; nations in Africa also stand to lose a great deal. A central reason is that India is expected to have devastating losses in terms of both health and agriculture; for Africa, the major problem involves health, with a massive anticipated increase in climate-related diseases.[237] In light of these figures, we might therefore expect that Russia would not be especially enthusiastic about controls of greenhouse gas emissions—except, perhaps, is an emissions trading system ensured that Russia would gain a great deal of money from those controls (as the Kyoto system in fact does). The United States faces limited threats to agriculture and health. Like Russia, China is projected to benefit in terms of agriculture, and while it will suffer health losses, they are relatively modest, far below those expected in Africa and India.[238] We might therefore expect that the United States and China would be unlikely to be particularly interested in reducing greenhouse gas emissions, at least on these figures; and as we have seen, their behavior is consistent with that prediction. To be sure, these numbers are speculative. They depend on anticipated warming of 2.5 C; perhaps that number is understated. The world's economy is interdependent, and if many nations suffer serious adverse effects, the United States and China will be affected. But the central point is clear. The largest current contributor, the United States, ranks toward the bottom in terms of anticipated losses – and that the largest future contributor, China, ranks even lower.

But how much do nations stand to lose from reductions? We have seen that the costs of the Kyoto Protocol would be especially high for the United States. To see why, consider the following table, offering a snapshot of global contributors in a recent year (limited to carbon dioxide, the leading greenhouse gas):

Carbon Dioxide Contributors as of 2000[239]

Countries	
United States	20.6
China	14.7
European Union—25	14.0
Russia	5.7
India	5.6
Japan	3.9
Germany	3.0
Brazil	2.5
Canada	2.0
United Kingdom	1.9
Italy	1.6
South Korea	1.5
France	1.5
Mexico	1.5

[237] Id.
[238] Id.
[239] Keith Baumert et al., Navigating the Numbers 12 (2005).

An important question, of course, involves trends over time. Significant contributors in the past may not be significant contributors in the future. The existing data suggest that the largest contributors are likely to continue to qualify as such—but that there will be important shifts, above all with emissions growth in China and India, and emissions reductions in Russia and Germany.

Carbon Dioxide Emissions Changes, 1990–2002[240]

Countries	
China	49
United States	18
India	70
South Korea	97
Iran	93
Indonesia	97
Saudi Arabia	91
Brazil	57
Spain	44
Pakistan	60
Poland	–17
EU-25	–2
Germany	–13
Ukraine	–48
Russia	–23

With these trend lines, we can project changes by 2025. At that time, the developing world is expected to contribute no less than 84% of total emissions, with 35% coming from developed nations. At that time, the United States is expected to be well below China. Consider the figures for anticipated growth:

Projected Growth in Carbon Dioxide Emissions by 2025[241]

India	73–225
Mexico	68–215
China	50–181
Brazil	84–165
South Korea	43–117
European Union	–1–39
United States	20–52
World	33–93

In terms of aggregate contributions, these changes mean that there will be significant shifts among contributors:

240 Kevin Baumert et al., Navigating the Numbers 15 (2005).
241 Id. at 18.

Relative Contributions of Annual Carbon Dioxide Emissions by Country/Region (Approximate % of Worldwide Emissions)

	1990	2003	2010	2015	2020	2025	2030
United States	23.4%	22.8%	21.0%	20.0%	19.4%	18.9%	18.6%
Europe	28.0%	21.4%	19.1%	18.2%	17.4%	16.8%	16.3%
China	10.6%	14.1%	19.3%	20.8%	22.2%	23.3%	24.5%
India	2.7%	4.1%	4.5%	4.7%	4.9%	5.0%	5.0%
Japan	4.8%	4.8%	4.05%	3.6%	3.3%	3.0%	2.8%
Africa	3.1%	3.6%	3.9%	4.0%	4.0%	4.0%	4.0%

Source: EIA, Intenational Energy Outlook 2006, Table A10,
http://www.eia.doe.gov/oiaf/ieo/pdf/ieoreftab_10.pdf

We can now see a real obstacle to an international agreement to control greenhouse gases. The United States and China are the largest emitters; they also stand to lose relatively little from climate change. In terms of their own domestic self-interest, the argument for stringent controls is not easy to support. The nations of Africa stand to lose a great deal, but they are trivial greenhouse gas emitters. India is even more vulnerable, and its contribution, while not exactly trivial, is modest. Actually the analysis has an additional complexity. Some nations, above all China and India, might reasonably object that their own contribution is smaller than the aggregate figures suggest. In assessing relative contributions, we might be interested in cumulative emissions rather than annual emissions. The overall stock might matter, not the current flow. Here is the relevant data:

Cumulative CO2 Emissions, 1850–2002[242]

Countries	
United States	29.3
EU-25	26.5
Russia	8.1
China	7.6
Germany	7.3
United Kingdom	6.3
Japan	4.1
France	2.9
India	2.2
Ukraine	2.2
India	2.2

Even if China's emissions rates pass those of the United States by (say) 2020, it might well insist that it should not bear the same economic burden as a nation that is responsible for a much larger percentage of aggregate emissions. Undoubtedly the purely domestic calculus—of costs and benefits—will play a significant role in any nation's decisions. But fairness judgments, attending to cumulative contributions, are unlikely to be irrelevant.

[242] Id. at 32.

D. Normative Issues

These are descriptive points, and none of them should be taken to suggest that the domestic cost-benefit analysis ought to be decisive in principle. In fact it should not be. If one nation is imposing significant harms on citizens of another, it should not continue to do so even if, or because, a purely domestic analysis suggests that emissions reductions are not justified from the point of view of the nation that is imposing those harms. As I have suggested, the problems of ozone depletion and climate change stem disproportionately from the actions of wealthy nations, above all United States—actions from which citizens of wealthy nations, above all the United States, have disproportionately benefited. It is even possible to see the emission of greenhouse gases as a kind of tort, producing damage for which emitters, and those who gained from their actions, ought to pay.[243] For example, energy and gasoline prices in the United States have been far lower than they would have been if those prices had included an amount attributable to the increased risks of climate change—risks that are most serious, and that threaten to impose devastating harm on people in other countries.[244]

Whether nations as such should be held responsible, and what such responsibility should specifically entail, are complicated questions. But in view of the fact that Americans have gained so much from activities that impose risks on citizens of other nations, it seems clear that they have a special obligation to mitigate the harm, or to provide assistance to those who are likely to suffer. The assistance might take the form of financial or technological aid, making it easier to meet emissions targets, or monetary amounts designed to ease adaptation to hotter climates.

The moral issues raise many problems, and they must be seriously engaged as part of both domestic discussions and international negotiations.[245] The Montreal Protocol holds out some hope here; recall that judgments about moral responsibility, and capacity to pay, played a serious role in various provisions. We have also seen that incipient steps to help poor nations have been made in the context of climate change as well.[246] (It may not be irrelevant, and it is certainly worth noticing, that the health risks of ozone depletion were faced mostly by light-skinned people, most vulnerable to skin cancer, whereas the most serious risks of climate change are faced by a group that prominently includes dark-skinned people, above all in Africa.) But the evidence catalogued here raises doubts about the claim that by themselves, moral obligations will provide enough motivation in the face of a palpably unfavorable cost-benefit analysis.

But let us return to simpler matters. With respect to the United States, the lesson of the Montreal Protocol can be captured in a single sentence: *Where the domestic assessment strongly favors unilateral action, and where the same assessment suggests*

[243] See Dale Jamieson, Adaptation, Mitigation, and Justice, in Perspective on Climate Change: Science, Economics, Politics, Ethics 217 (Walter Sinnott-Armstrong and Richard Howarth eds. 2005); Julia Driver, Ideal Decision Making and Green Virtues, in id. at 249.

[244] See Nordhaus and Boyer, supra note.

[245] See Driver, supra note.

[246] See note supra.

that a nation is likely to gain a great deal from an international agreement, that nation will favor such an agreement—unless, perhaps, well-organized private groups are able to persuade it not to do so. For the Kyoto Protocol, the lesson is equally simple: *Where the domestic assessment suggests that unilateral action makes little sense, and where the same assessment suggests that a nation will lose a great deal from an international agreement, that nation is unlikely to favor such an agreement—unless, perhaps, the public is willing to demand that it do so.* In light of these simple lessons, the two protocols present polar cases, and actually fairly easy ones.

E. Possible Worlds

Nothing said here is inconsistent with the claim that an agreement to control greenhouse gases might be appealing or at least acceptable to the United States even if the cost-benefit calculation were fairly close, or perhaps mildly unfavorable to the deal. The Montreal Protocol and the Kyoto Protocol were at opposite extremes, in which the technocrats, both scientists and economists, seemed to demonstrate that the Montreal Protocol was a terrific bargain for the United States, while the Kyoto Protocol presented a much less favorable picture. The overwhelming votes in the Senate are at least suggestive on this count. Recall the nearly unanimous call for a strong response to the ozone problem, contrasting with a unanimous call for steps that would effectively prevent United States participation in the Kyoto Protocol; recall too the unanimous Senate ratification of the Montreal Protocol under President Reagan, contrasting with the absence of any support, within the Senate, for the Kyoto Protocol under President Clinton.

But for both agreements, the overall assessment would have been far more difficult if the relevant numbers were closer—if the scientific and economic judgments, working together, suggested that reasonable people could differ. Even if the United States was a modest net loser, perhaps moral considerations might have tipped, or might in the future tip, the national calculus in favor of an agreement to control climate change. But it should be clear that in order for such an agreement to be acceptable to the United States, a method must be found to drive down the costs and to increase the benefits.[247] Such a method would make the relevant agreement far more attractive to the world as well—and hence increase the likelihood of compliance by nations that are now showing unfavorable trends.

1. *Benefits*. Recall that the Kyoto Protocol was projected to decrease global mean temperatures by a mere 0.03 C. This difference is less trivial than it sounds, because it is projected to produce tens of billions in monetized benefits,[248] but it is nonetheless a relative drop in the bucket. Developing countries are projected to account for over half of

[247] I have touched only lightly on complex enforcement problems; it may be that the Montreal Protocol is not a good model in this regard. For discussion, see Barrett, supra note; David Victor, The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming (2001).

[248] See Nordhaus and Boyer, supra note.

total global emissions by 2020 and possibly before.[249] We have seen that a broader agreement, including China and India in particular, would significantly increase the benefits of greenhouse gas reduction and hence would make domestic controls far more attractive to both the United States and the world.[250] The trick is to make such an agreement sufficiently attractive to developing nations to make it possible for them to participate.

A useful step would involve a clear distinction between stocks and flows.[251] To come to terms with past contributions, nations might participate in the creation of some kind of fund for climate change damages, with their participation reflecting their contributions to the total existing stock of emissions. India and China need not contribute much to such a fund; the United States and Europe would be required to contribute a great deal. A step of this kind would be a sensible response to the fact, shown by the table above, that different nations have added dramatically different amounts to the current situation.

A different step would involve the response to existing flows. Perhaps a "polluters pay" principle could be made a part of an international agreement, so that nations would pay an amount to reflect their continuing contributions.[252] In short, greenhouse gas emissions might be taxed, with the hope that the tax would lead to reductions. It would be easy to do something of this kind domestically, and an international agreement might form the basis for the imposition of greenhouse taxes. Alternatively, an understanding of past contributions and current emissions rates might be built into a structure closer to that of the Montreal Protocol, helping to serve as the foundation for both reduction requirements and economic transfers. In particular, the transfers might be designed to compensate for past and future contributions to the problem. If high contributors make significant cuts, perhaps their transfers need not be so large. If they continue to be high contributors, their transfers might be very high. If the goal is to ensure significant benefits, steps of this sort would be the place to start.

2. *Costs*. On the cost side, two steps would be highly desirable. The first is to create an ambitious and reliable system for fully global emissions trading, which could make the cost-benefit ratio far more favorable for any agreement. The second is to produce better targets and requirements, in a way that allows stringency to increase over time.

Consider emissions trading first. In the context of acid deposition, the United States was able to reduce the cost of aggressive regulation by billions of dollars through an ambitious trading system.[253] For climate change, such a system would decrease the need for expensive regulation, by allowing American companies to "buy" American

[249] See Sheila M. Olmstead and Robert N. Stavins, An International Policy Architecture for the Post-Kyoto Era, 96 Am. Econ. Rev. 35, 35-36(Papers and Proceedings) (2006).
[250] See Nordhaus and Boyer, supra note, at 123-44; Barrett, supra note, at 379.
[251] See the excellent brief discussion in Jagdish Bhagwati, Global Warming Fund Could Succeed Where Kyoto Failed, Financial Times (Aug. 16, 2006).
[252] See id.
[253] See A. Denny Ellerman et al., Markets for Clean Air (1999).

emissions credits from greenhouse gas producers in other nations. For the Kyoto Protocol, a system of global trading would reduce domestic costs from $325 billion to $91 billion—and it would reduce worldwide costs from $217 billion to $59 billion.[254] The likelihood that China would participate in an international agreement would certainly increase with an emissions trading system. Perhaps China and India, and other poor nations, could be subsidized with especially high allocations of trading rights, so as to come to terms with their relatively low past contributions, their general poverty, and their overall needs.

The emissions reductions targets in the Kyoto Protocol are both rigid and arbitrary, at least from the standpoint of sensible policy. The key terms of that protocol involve an apparently random baseline year (1990) and ask nations to produce apparently random percentage reductions from that year.[255] As we have seen, there is a method, or at least domestic self-interest, behind this apparent madness; but the method has no connection with sensible policy.[256] A better approach would include carbon taxes or emissions reduction requirements that grow over time as technology advances.[257] For ozone-depleting chemicals, as for lead, the United States followed a phase-down policy, one that allowed time for the development and marketing of adequate substitutes.[258] No one is proposing the complete elimination of greenhouse gases; increasing restrictions over time would make a great deal of sense.[259]

3. *Manageability and enforcement.* There is an additional point, much bearing on the prospects for an effective international agreement and on the possible participation of the United States. The Montreal Protocol was negotiated by about thirty nations; current climate negotiations involve nearly 200 nations.[260] The large number of parties makes an agreement far less manageable, and reasonably makes some nations fearful that others will not comply.[261] Suppose, as seems reasonable, that an imaginable agreement could solve an international prisoner's dilemma with respect to global climate change. The parties to such an agreement must be able to be confident that others will not cheat. With 200 nations, and difficult issues of monitoring, key nations might well be tempted to defect—or not to join in the first instance.[262]

This is not the place to outline the ingredients of an international agreement to respond to the risks associated with climate change.[263] The steps I have outlined would have to be accompanied by clear steps to promote monitoring and enforcement of any

[254] See Nordhaus and Boyer, supra note, at 159.
[255] See id.
[256] See id.
[257] Id.
[258] See Cass R. Sunstein, Risk and Reason (2002).
[259] A counterargument is presented in Posner, supra note, on the ground that a sudden regulatory "shock" might be necessary and desirable as a way of spurring innovation.
[260] See Benedick, Morals and Myths, supra note.
[261] See Goldsmith and Posner, supra note, at 217.
[262] See Barrett, supra note, for detailed discussion.
[263] See note supra for valuable discussion.

limits.[264] The central points are that such an agreement is unlikely to be effective without the participation of the United States, and that such participation is unlikely without a much more favorable domestic cost-benefit ratio. Of course new information about the risks of climate change, suggesting that earlier projections are too optimistic, would inevitably help to alter the domestic equation.[265]

Conclusion

At first glance, the problems of ozone depletion and climate change seem exceedingly similar, and to present closely related challenges for the production of an international agreement to reduce the underlying risks. In both contexts, nations appear to have a great deal to gain from cooperative action. In both contexts, technological innovation is highly desirable as a means of reducing the costs of regulation. In both contexts, intergenerational equity is a serious and complex issue. In both contexts, wealthy nations are responsible for the problem in the first instance, and poor nations have a plausible claim to compensation, both for harm done and in return for their willingness to reduce emissions in the future.

Notwithstanding the similarities, the Montreal Protocol has proved a stunning success, and the Kyoto Protocol has largely failed. From one agreement to the other, the posture of many nations shifted, with European nations treating ozone depletion as a highly speculative theory, calling for further research, while later leading the call for aggressive regulation of greenhouse gases. The contrasting outcomes are best explained by reference to the radically different approaches taken by the United States—by far the most significant contributor, per capita, to both ozone depletion and climate change. It would be tempting to attribute those different approaches to the different political convictions of the relevant administrations. But the Reagan Administration, which pressed for the Montreal Protocol, was hardly known for its aggressiveness with respect to environmental policy, and the Senate showed no interest in the Kyoto Protocol during the Clinton Administration. The American posture, and hence the fate of the two protocols, was largely determined by perceived benefits and costs.

To the United States, the benefits of the Montreal Protocol were anticipated to be substantial in the short-term as well as the long-term. To the United States, the benefits of the Kyoto Protocol were perceived to be effectively zero in the short-term and modest in the long-term. The projected costs of the Montreal Protocol were relatively small—for the United States, $21 billion, a small fraction of the benefits. The costs of the Kyoto Protocol were projected to be high—for the United States, $325 billion, well in excess of the benefits. The picture was not altogether different for the world. The Montreal Protocol was a worldwide bargain, with costs a tiny percentage of benefits. By contrast, key analysts suggested that the Kyoto Protocol failed in cost-benefit terms, and the best that might be said is that the agreement provided an initial foundation for better and more inclusive ones. Of course the precise numbers are disputed, and legitimate questions can

[264] See Barrett, supra note; Victor, supra note.

[265] See Avoiding Dangerous Climate Change, supra note, for a number of alarming projections.

be raised about any particular account. What matters is that at the crucial times, the most authoritative accounts offered conflicting conclusions about the two agreements.

As we have seen, neither protocol fits the simple model of a solution to a prisoner's dilemma. The United States, and many other countries, appear to have had sufficient reason, from the standpoint of self-interest, to comply with the requirements of the Montreal Protocol even if *no* other country did the same. The United States, and some other countries, appear to have had no adequate reason, from the standpoint of self-interest, to comply with the requirements of the Kyoto Protocol even if such compliance would help to ensure that *every* other country did the same. For this reason, the payoff structure of the two agreements were fundamentally different, and their different fates have a great deal to do with that fact.

To this point it must be added that developing countries, above all China and India, refused to participate in the Kyoto Protocol, in large part because the domestic cost-benefit analysis was so unfavorable for them. For the future, a special problems lies in the distinctive incentives of the United States (the world's leading emitter of greenhouse gases) and China (soon to overtake the United States, which will still be far ahead on a per capita basis). Both nations would have to pay the lion's share of the cost of an agreement to limit emissions. At the same time, both nations appear to have disproportionately little to fear from climate change. Unless China and the United States can be convinced that the domestic cost-benefit is more favorable than it now appears, or that the requirements of morality call for significant emissions reductions, the prospects for their participation are limited.

For those who are concerned about the risks of climate change, it would be possible and even right to emphasize that the United States has been a principal contributor to those risks, and that the nation's economic self-interest does not exhaust its moral obligations. To the extent that the citizens of the United States have benefited from activities that inflict significant harms on other nations, those citizens are properly asked to help—through reducing their own emissions, through paying other nations to reduce theirs, and through payments to ease adaptation. But on the basis of tales of the Montreal and Kyoto Protocols, it is best to assume that domestic self-interest will continue to be an important motivating force. It follows that for the future, the task is to devise an international agreement that resembles the Montreal Protocol in one critical respect: Its signatories, including the United States, have reason to believe that they will gain more than they will lose.

Readers with comments should address them to:

Professor Cass R. Sunstein
University of Chicago Law School
1111 East 60th Street
Chicago, IL 60637
csunstei@midway.uchicago.edu

Chicago Working Papers in Law and Economics
(Second Series)

For a listing of papers 1–200 please go to Working Papers at http://www.law.uchicago.edu/Lawecon/index.html

201. Douglas G. Baird and Robert K. Rasmussen, Chapter 11 at Twilight (October 2003)
202. David A. Weisbach, Corporate Tax Avoidance (January 2004)
203. David A. Weisbach, The (Non)Taxation of Risk (January 2004)
204. Richard A. Epstein, Liberty versus Property? Cracks in the Foundations of Copyright Law (April 2004)
205. Lior Jacob Strahilevitz, The Right to Destroy (January 2004)
206. Eric A. Posner and John C. Yoo, A Theory of International Adjudication (February 2004)
207. Cass R. Sunstein, Are Poor People Worth Less Than Rich People? Disaggregating the Value of Statistical Lives (February 2004)
208. Richard A. Epstein, Disparities and Discrimination in Health Care Coverage: A Critique of the Institute of Medicine Study (March 2004)
209. Richard A. Epstein and Bruce N. Kuhlik, Navigating the Anticommons for Pharmaceutical Patents: Steady the Course on Hatch-Waxman (March 2004)
210. Richard A. Esptein, The Optimal Complexity of Legal Rules (April 2004)
211. Eric A. Posner and Alan O. Sykes, Optimal War and *Jus Ad Bellum* (April 2004)
212. Alan O. Sykes, The Persistent Puzzles of Safeguards: Lessons from the Steel Dispute (May 2004)
213. Luis Garicano and Thomas N. Hubbard, Specialization, Firms, and Markets: The Division of Labor within and between Law Firms (April 2004)
214. Luis Garicano and Thomas N. Hubbard, Hierarchies, Specialization, and the Utilization of Knowledge: Theory and Evidence from the Legal Services Industry (April 2004)
215. James C. Spindler, Conflict or Credibility: Analyst Conflicts of Interest and the Market for Underwriting Business (July 2004)
216. Alan O. Sykes, The Economics of Public International Law (July 2004)
217. Douglas Lichtman and Eric Posner, Holding Internet Service Providers Accountahle (July 2004)
218. Shlomo Benartzi, Richard H. Thaler, Stephen P. Utkus, and Cass R. Sunstein, Company Stock, Market Rationality, and Legal Reform (July 2004)
219. Cass R. Sunstein, Group Judgments: Deliberation, Statistical Means, and Information Markets (August 2004, revised October 2004)
220. Cass R. Sunstein, Precautions against What? The Availability Heuristic and Cross-Cultural Risk Perceptions (August 2004)
221. M. Todd Henderson and James C. Spindler, Corporate Heroin: A Defense of Perks (August 2004)
222. Eric A. Posner and Cass R. Sunstein, Dollars and Death (August 2004)
223. Randal C. Picker, Cyber Security: Of Heterogeneity and Autarky (August 2004)
224. Randal C. Picker, Unbundling Scope-of-Permission Goods: When Should We Invest in Reducing Entry Barriers? (September 2004)
225. Christine Jolls and Cass R. Sunstein, Debiasing through Law (September 2004)
226. Richard A. Posner, An Economic Analysis of the Use of Citations in the Law (2000)
227. Cass R. Sunstein, Cost-Benefit Analysis and the Environment (October 2004)
228. Kenneth W. Dam, Cordell Hull, the Reciprocal Trade Agreement Act, and the WTO (October 2004)
229. Richard A. Posner, The Law and Economics of Contract Interpretation (November 2004)
230. Lior Jacob Strahilevitz, A Social Networks Theory of Privacy (December 2004)
231. Cass R. Sunstein, Minimalism at War (December 2004)
232. Douglas Lichtman, How the Law Responds to Self-Help (December 2004)
233. Eric A. Posner, The Decline of the International Court of Justice (December 2004)
234. Eric A. Posner, Is the International Court of Justice Biased? (December 2004)
235. Alan O. Sykes, Public vs. Private Enforcement of International Economic Law: Of Standing and Remedy (February 2005)
236. Douglas G. Baird and Edward R. Morrison, Serial Entrepreneurs and Small Business Bankruptcies (March 2005)
237. Eric A. Posner, There Are No Penalty Default Rules in Contract Law (March 2005)
238. Randal C. Picker, Copyright and the DMCA: Market Locks and Technological Contracts (March 2005)
239. Cass R. Sunstein and Adrian Vermeule, Is Capital Punishment Morally Required? The Relevance of Life-Life Tradeoffs (March 2005)
240. Alan O. Sykes, Trade Remedy Laws (March 2005)
241. Randal C. Picker, Rewinding *Sony*: The Evolving Product, Phoning Home, and the Duty of Ongoing Design (March 2005)
242. Cass R. Sunstein, Irreversible and Catastrophic (April 2005)
243. James C. Spindler, IPO Liability and Entrepreneurial Response (May 2005)

244. Douglas Lichtman, Substitutes for the Doctrine of Equivalents: A Response to Meurer and Nard (May 2005)
245. Cass R. Sunstein, A New Progressivism (May 2005)
246. Douglas G. Baird, Property, Natural Monopoly, and the Uneasy Legacy of *INS v. AP* (May 2005)
247. Douglas G. Baird and Robert K. Rasmussen, Private Debt and the Missing Lever of Corporate Governance (May 2005)
248. Cass R. Sunstein, Administrative Law Goes to War (May 2005)
249. Cass R. Sunstein, Chevron Step Zero (May 2005)
250. Lior Jacob Strahilevitz, Exclusionary Amenities in Residential Communities (July 2005)
251. Joseph Bankman and David A. Weisbach, The Superiority of an Ideal Consumption Tax over an Ideal Income Tax (July 2005)
252. Cass R. Sunstein and Arden Rowell, On Discounting Regulatory Benefits: Risk, Money, and Intergenerational Equity (July 2005)
253. Cass R. Sunstein, Boundedly Rational Borrowing: A Consumer's Guide (July 2005)
254. Cass R. Sunstein, Ranking Law Schools: A Market Test? (July 2005)
255. David A. Weisbach, Paretian Intergenerational Discounting (August 2005)
256. Eric A. Posner, International Law: A Welfarist Approach (September 2005)
257. Adrian Vermeule, Absolute Voting Rules (August 2005)
258. Eric Posner and Adrian Vermeule, Emergencies and Democratic Failure (August 2005)
259. Douglas G. Baird and Donald S. Bernstein, Absolute Priority, Valuation Uncertainty, and the Reorganization Bargain (September 2005)
260. Adrian Vermeule, Reparations as Rough Justice (September 2005)
261. Arthur J. Jacobson and John P. McCormick, The Business of Business Is Democracy (September 2005)
262. Adrian Vermeule, Political Constraints on Supreme Court Reform (October 2005)
263. Cass R. Sunstein, The Availability Heuristic, Intuitive Cost-Benefit Analysis, and Climate Change (November 2005)
264. Lior Jacob Strahilevitz, Information Asymmetries and the Rights to Exclude (November 2005)
265. Cass R. Sunstein, Fast, Frugal, and (Sometimes) Wrong (November 2005)
266. Robert Cooter and Ariel Porat, Total Liability for Excessive Harm (November 2005)
267. Cass R. Sunstein, Justice Breyer's Democratic Pragmatism (November 2005)
268. Cass R. Sunstein, Beyond Marbury: The Executive's Power to Say What the Law Is (November 2005, revised January 2006)
269. Andrew V. Papachristos, Tracey L. Meares, and Jeffrey Fagan, Attention Felons: Evaluating Project Safe Neighborhoods in Chicago (November 2005)
270. Lucian A. Bebchuk and Richard A. Posner, One-Sided Contracts in Competitive Consumer Markets (December 2005)
271. Kenneth W. Dam, Institutions, History, and Economics Development (January 2006, revised October 2006)
272. Kenneth W. Dam, Land, Law and Economic Development (January 2006, revised October 2006)
273. Cass R. Sunstein, Burkean Minimalism (January 2006)
274. Cass R. Sunstein, Misfearing: A Reply (January 2006)
275. Kenneth W. Dam, China as a Test Case: Is the Rule of Law Essential for Economic Growth (January 2006, revised October 2006)
276. Cass R. Sunstein, Problems with Minimalism (January 2006, revised August 2006)
277. Bernard E. Harcourt, Should We Aggregate Mental Hospitalization and Prison Population Rates in Empirical Research on the Relationship between Incarceration and Crime, Unemployment, Poverty, and Other Social Indicators? On the Continuity of Spatial Exclusion and Confinement in Twentieth Century United States (January 2006)
278. Elizabeth Garrett and Adrian Vermeule, Transparency in the Budget Process (January 2006)
279. Eric A. Posner and Alan O. Sykes, An Economic Analysis of State and Individual Responsibility under International Law (February 2006)
280. Kenneth W. Dam, Equity Markets, The Corporation and Economic Development (February 2006, revised October 2006)
281. Kenneth W. Dam, Credit Markets, Creditors' Rights and Economic Development (February 2006)
282. Douglas G. Lichtman, Defusing DRM (February 2006)
283. Jeff Leslie and Cass R. Sunstein, Animal Rights without Controversy (March 2006)
284. Adrian Vermeule, The Delegation Lottery (March 2006)
285. Shahar J. Dilbary, Famous Trademarks and the Rational Basis for Protecting "Irrational Beliefs" (March 2006)
286. Adrian Vermeule, Self-Defeating Proposals: Ackerman on Emergency Powers (March 2006)
287. Kenneth W. Dam, The Judiciary and Economic Development (March 2006, revised October 2006)
288. Bernard E. Harcourt: Muslim Profiles Post 9/11: Is Racial Profiling an Effective Counterterrorist Measure and Does It Violate the Right to Be Free from Discrimination? (March 2006)
289. Christine Jolls and Cass R. Sunstein, The Law of Implicit Bias (April 2006)

290. Lior J. Strahilevitz, "How's My Driving?" for Everyone (and Everything?) (April 2006)
291. Randal C. Picker, Mistrust-Based Digital Rights Management (April 2006)
292. Douglas Lichtman, Patent Holdouts and the Standard-Setting Process (May 2006)
293. Jacob E. Gersen and Adrian Vermeule, *Chevron* as a Voting Rule (June 2006)
294. Thomas J. Miles and Cass R. Sunstein, Do Judges Make Regulatory Policy? An Empirical Investigation of *Chevron* (June 2006)
295. Cass R. Sunstein, On the Divergent American Reactions to Terrorism and Climate Change (June 2006)
296. Jacob E. Gersen, Temporary Legislation (Jnne 2006)
297. David A. Weisbach, Implementing Income and Consumption Taxes: An Essay in Honor of David Bradford (June 2006)
298. David Schkade, Cass R. Sunstein, and Reid Hastie, What Happened on Deliberation Day? (June 2006)
299. David A. Weisbach, Tax Expenditures, Principle Agent Problems, and Redundancy (Jnne 2006)
300. Adam B. Cox, The Temporal Dimension of Voting Rights (July 2006)
301. Adam B. Cox, Designing Redistricting Institutions (July 2006)
302. Cass R. Sunstein, Montreal vs. Kyoto: A Tale of Two Protocols (August 2006)

PwC Blog, Monday, March 23, 2015

Does the EU really lead the US on climate ambition?

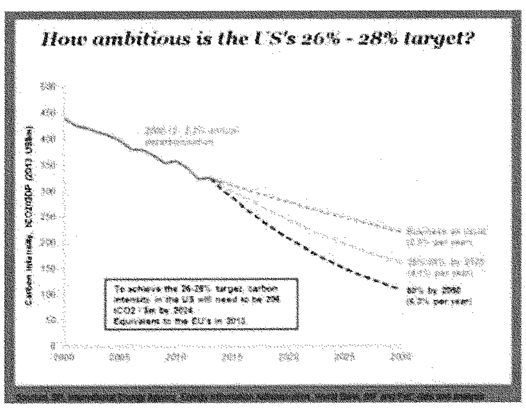
(http://pwc.blogs.com/sustainability/2015/03/does-the-eu-really-lead-the-us-on-climate-ambition.html)

23 March 2015

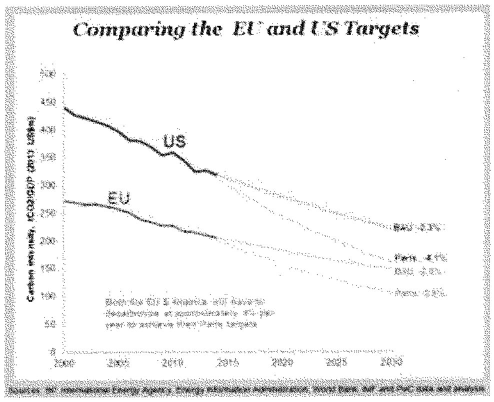
Assessing countries' relative level of ambition or effort will be a critical political issue this year. So how does the US target of a 26-28% reduction on 2005 levels compare with the EU's target of a 40% reduction on 1990 levels? Jonathan Grant and Rob Milnes looked at the numbers and were surprised to find that the US appears to be as ambitious as the EU.

Although carbon intensity in the US is significantly higher than in the EU, it has fallen faster since 2000: by 2.3% per year on average. The EU's carbon intensity has fallen by 2% per year on average over that period. The US economy is expected to grow by close to 3% over the next five years and then at 2.2% each year in the 2020's according to our latest 'World in 2050' report. So the US's GDP will be 84% higher in 2030 compared to 2000 (the EU's will grow by 62%).

This rate of GDP growth means that if the US continues on its current decarbonisation path, emissions will be only 8% below 2005 levels by 2025. The US will need to nearly double its current rate of decarbonisation to achieve the 26-28% reduction target announced by President Obama in November last year. This is compared with our business as usual emissions scenario for the US, which combines our GDP growth projections with its historical average decarbonisation rate.

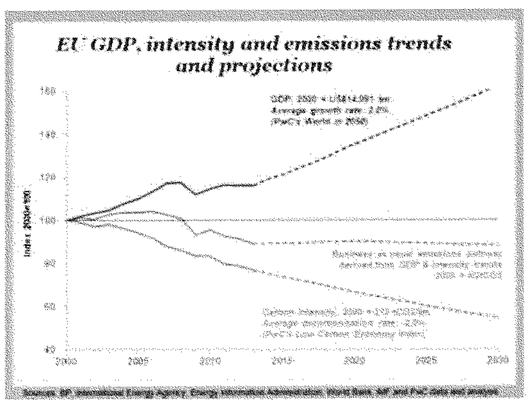


Both the EU and US will have to decarbonise at approximately 4% each year (assuming their economies grow as expected) to hit their Paris targets. In other words, the US target appears to be as ambitious as the EU one. And both will need a step change to the levels of incentives and penalties to shift businesses and consumers down the low carbon pathway.



It is striking that both the EU and US fall far short of their own long term targets which are more closely aligned with a 2 degrees pathway. Decarbonisation of 7% and 6% respectively is required by the EU and US to achieve their 2050 goals.

While goalless draws are acceptable in the Premier League, they are less popular across the pond. Carbon intensity in the US is 326 tCO_2/$ million GDP compared with 209 in the EU which also has a stronger track record of greenhouse gas legislation. We suspect that there are more lower cost reduction opportunities in the US, so perhaps the EU 2030 target is slightly more ambitious as it may have to work harder to achieve it.



A Practical and Realistic Climate Change Agenda
James L. Connaughton

Ever since the United Nation's Framework Convention on Climate Change (UNFCCC) was adopted more than 20 years ago, the international climate change policy agenda has been marked by an overabundance of rhetoric, ambition, and conflict, and an undersupply of reason, specificity, and cooperation. With recent news about the "global warming pause," the intensity of activism among the so-called believers and deniers of climate change science is increasing, even as the intensity of interest among general public and politicians more broadly is decreasing. So what should the Parties to the UNFCCC do as they try for a new agreement in Paris at the end of 2015? Go back to the future. Reaffirm the original UNFCCC principles by modeling a new approach on the Montreal Protocol on Substances that Deplete the Ozone Layer—the international agreement that has actually worked over the last 20 years.

The original UNFCCC provide a set of guiding principles that are as relevant and useful today as when first envisioned in 1992:

- ensure widest possible cooperation;
- all countries have a common responsibility to take action, which should only be differentiated by each country's capabilities and social and economic conditions;
- respect national sovereignty in the exploitation of resources in accordance with a country's own environmental and development policies;
- the most effective measures to address climate change will be based on scientific, technical and economic information that is continually re-evaluated,
- take advantage of fact that some actions to address climate change provide positive economic benefits and can help solve other environmental problems and vice versa,
- pursue a comprehensive response strategy that involves global, regional, and national actions as to all greenhouse gases, sources and sinks, taking into account their relative contributions to climate change, and
- coordinate and integrate actions with social and economic development, to assure sustained economic growth and poverty eradication.

Notwithstanding these guideposts, the international community has proceeded on two very divergent tracks. Mainly departing from UNFCCC principles, the first track has been the formal process of the Kyoto Protocol: a top-down, politically charged, aimless, largely failed and unpromising path to making meaningful progress in the future. Hewing closer to the UNFCCC principles, the second track is occurring outside of the Kyoto Protocol process: a bottom-up, cooperative, multi-faceted, technically and economically sound, and increasingly successful path to making meaningful progress.

At the 2011 UNFCCC meetings in Durban, the Parties committed "to adopt a universal legal agreement on climate change as soon as possible, but not later than

2015." Yet without a complete rethinking of the process, structure, scope and nature of participation of all of the Parties to the UNFCCC, the conversation over the last 3 years has mirrored that of the preceding 20 years, and is not likely to lead to more meaningful results. Indeed, even as some countries at the UNFCCC meetings in Doha in 2012 agreed to amend and extend the Kyoto Protocol until 2020, the Protocol's future demise was sealed with the formal withdrawal of Canada, Russia, and Japan, along with the continued non-participation of the United States and the major emerging economies whose combined emissions now exceed those of the developed countries. So if the UNFCCC is to maintain its relevance, it must effectively incorporate what is happening outside the UNFCCC to devise a new arrangement among the countries responsible for most of the greenhouse gas emissions.

We already know what works. Even as UNFCCC negotiators unyieldingly persist in restating their positions of the last 20 years, all of the OECD countries and most of the major emerging economies have developed a very broad and increasingly deep portfolio of marketplace innovations, regulatory mandates, incentives, and technology research and development programs. Each portfolio is tailored to each nation's unique circumstances, incorporates a wide array of goals and processes, and respects national sovereignty and local needs in its development, adoption and enforcement. For example, the emissions trajectory for the U.S. is finally declining as a result of dozens of new, bi-partisan federal and state laws (most using market mechanisms), tens of billions of dollars in research and development funding and market incentives, and innumerable public-private partnerships. Most importantly, private-sector advances in efficiency and in technologies like hydraulic fracturing for shale gas are dramatically altering emissions projections from electricity generation and other industrial sources to a degree unforeseen even five years ago--with limited to no government role. A growing number of public-private multinational initiatives have also emerged, including the Climate and Clean Air Coalition to Reduce Short Lived Climate Pollutants, Global Research Alliance on Agricultural Greenhouse Gases, Global Methane Initiative, Global Alliance for Clean Cookstoves, Adaptation Partnership, Low Emission Development Global Partnership, Global Gas Flaring Reduction Partnership. Regional experiments like the six-country Asia Pacific Partnership on Clean Development and Climate also showed the specific promise of public-private partnerships to achieve mutually beneficial sector-specific outcomes. Regrettably, this effort was abandoned in 2011, undermining progress on a series of reasonable, feasible and concrete sector-based objectives with China in particular, which has eroded private sector confidence that participation in such efforts is worthwhile. Beyond this, the private sector has largely been excluded from any meaningful role in the UNFCCC and related national government processes.

We also have a good understanding of how to incorporate such activities into a more realistic, flexible and inclusive international framework. The best of several examples is the Montreal Protocol on Ozone Depleting Substances. Unlike the Kyoto Protocol, the Montreal Protocol employs a bottom up approach that establishes a series of substance specific targets and sector-specific targets, employing different timelines for different countries based on an agreed understanding of what is technologically feasible and economically reasonable for each country. These targets and timetables can be accelerated or delayed, or tailored to a country's situation, based on a reasonably objective technical and economic review process that continually takes into account new information. The Montreal Protocol includes commitments from all nations—developed and developing—responsible for ODS emissions. And all countries measure and report progress according to the same methods. So while major greenhouse gas emitting countries such as China, India, Brazil and South Africa reject broad national commitments and reporting requirements under the Kyoto Protocol, they are fully comfortable with sector-based commitments and reporting requirements under the Montreal Protocol. Notably, the most recently adopted set of commitments to phase out HFCs (also a potent greenhouse gas) under the Montreal Protocol will more certainly reduce more greenhouse gas emissions than what the Kyoto Protocol was supposed to achieve if all countries had met their commitments, which they did not.

A practical and realistic agenda for climate change should return to the guiding principles of the UNFCCC, incorporate what countries are actually doing and are willing to do alone and in partnership with others, and build on the sector-based international framework that is working, rather than clinging to the one that is not.

Different Approaches Yield Different Results

UNFCC/Kyoto Protocol (1992/1997)	Montreal Protocol (1987)
➢ Top down, economy-wide approach	➢ Bottom up, sector specific approach
➢ Single, inflexible short term targets	➢ Multiple, flexible long term targets
➢ No developing nation commitments	➢ Developing nation commitments
➢ Small and declining private sector role	➢ Robust private sector engagement
➢ Promises of major wealth transfers	➢ No promise of major wealth transfers
➢ No meaningful technical review process	➢ Objective technical review process
➢ No meaningful economic review process	➢ Objective economic review process
➢ Focused on international implementation	➢ Focused on national implementation
➢ Achieving less GHG reductions than KP	➢ Achieving more GHG reductions than KP
Mostly Unsuccessful International Treaty	**Mostly Successful International Treaty**

CLEARVIEW ENERGY PARTNERS LLC

CLIMATE: U.S. FORMALLY SUBMITS GHG REDUCTIONS

Climate Change and Emissions

SUMMARY

MARCH 31, 2015

Today, the White House formally submitted the U.S. Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC). The INDC formally establishes the greenhouse gas (GHG) emissions reduction target President Obama outlined last November and elaborates on how the U.S. expects to achieve those goals.

In light of today's formal submission, this report considers the ongoing progress of international climate talks with a focus on new and existing differences among countries. We continue to expect international negotiators to reach a deal this December in Paris, France, but ambition and accountability may depend on the resolution of ongoing disagreements. We also see signs that the U.S. may need to impose new regulations in order to meet its climate target.

KEY POINTS

- *The path to Paris.* International climate negotiators have approximately eight months to resolve longstanding differences as they approach the December climate talks in Paris. In the past, we have focused on the following key differences:

  (1) The notion of "common but differentiated responsibilities" (CBDR), where developed nations would bear most of the burden to reduce emissions;

  (2) The degree to which any deal could be enforced or would be legally binding; and

  (3) Climate financing.

  With each step towards resolution of these issues, new disagreements seem to emerge in other areas. We believe climate negotiators are likely to reach a global agreement this coming December, but unless they bridge new and historical differences, the resulting international deal could lack ambition and accountability, setting up unilateral actions or the formation of bi-/multi-lateral schemes. In other words, countries are likely to impose new GHG emissions reduction policies irrespective of the outcome in Paris. Disparate international programs could foment trade issues.

- *U.S. climate change.* On November 12, 2014, the U.S. and China jointly announced GHG emissions reduction plans, helping set the stage as international negotiators and stakeholders approach the 2015 Paris climate talks. In some ways, the announcement may have helped international negotiations move forward by bringing together the two largest emitters and by further cementing CBDR. Environmentalists heralded the announcement as historic and ambitious. Some Republican members of Congress complained that the agreement would require the U.S. to reduce emissions while allowing Chinese emissions to continue increasing, signaling possible legislative pushback.

  President Obama announced a target to cut "net "GHG emissions by between 26 and 28% below 2005 levels by 2025. Chinese President Xi Jinping's target would establish peak CO_2 emissions "around 2030, with the intention to try to peak early."

  Although the White House believes the targets are "achievable under existing law," our estimate of emissions reductions required implies that this or future administrations would likely need to require emissions reductions beyond existing (final or proposed) rules in order to meet the 2025 reduction target. ▼

TIMOTHY T. CHEUNG
KEVIN BOOK
F. CHASE HUTTO, III
CHRISTI TEZAK
TIMOTHY Y. FOX

RESEARCH@CVENERGY.COM
(202) 506-5744

Contents

International climate negotiators have approximately eight months to resolve longstanding differences as they approach the December climate talks in Paris. In the past, we have focused on the following key differences: (1) the notion of "common but differentiated responsibilities" (CBDR), where developed nations would bear most of the burden to reduce emissions; (2) the degree to which any deal could be enforced or would be legally binding; and (3) climate financing.

With each step towards resolution of these issues, new disagreements seem to emerge in other areas. We believe climate negotiators are likely to reach a global agreement this coming December, but unless they bridge new and historical differences, the resulting international deal could lack ambition and accountability, setting up unilateral action or the formation of bi-/multi-lateral schemes. In other words, countries are likely to impose new GHG emissions reduction policies irrespective of the outcome in Paris. Disparate international programs could foment trade issues.

The role of leadership and inclusion

Building momentum towards Paris. In 2012, the top ten emitting countries accounted for 75% of global energy-related CO_2 emissions (Figure 1).

Figure 1 – Top Ten Country-Level Emitters in 2012 and their Emission Reduction Pledges

COUNTRY	% OF 1990 GLOBAL CO_2	% OF 2012 GLOBAL CO_2	COPENHAGEN PLEDGE	PRE-PARIS PLEDGE*
China	10.5%	25.1%	Reduce emissions intensity of its GDP by 40-45%/2005/2020	Peak emissions by ~2030. Increase non-fossil energy's share to about 20% by 2030
U.S.	23.3%	16.3%	17%/2005/2020	26-28%/2005/2025
E.U.	19.3%	11.7%	20%/1990/2020, 30% reduction if developed countries commit to comparable emission reductions	40%/1990/2030
India	2.7%	5.7%	Reduce emissions intensity of its GDP by 20-25%/2005/2020	NA
Russia	10.1%	5.5%	15-25%/1990/2020 if all major emitters agree to a legally binding treaty	25-30%/1990/2030
Japan	4.8%	3.9%	25%/1990/2020	NA
South Korea	1.1%	2.0%	30%/BAU/2020	NA
Canada	2.2%	1.7%	17%/2005/2020, to be aligned with the final US economy-wide emissions target in enacted legislation.	NA
Brazil	1.1%	1.5%	Expected 36.1-38.9% GHG emissions reduction relative to 2020 BAU levels with their voluntary domestic commitments	NA
South Africa	1.4%	1.5%	34%/BAU/2020, 42%/BAU/2025	NA
Total	77%	75%		

Notes
1- Emissions data correspond to CO_2 emissions from energy consumption
2- China has not yet formally submitted its INDC

Source: ClearView Energy Partners, LLC using EIA and UNFCCC data as of March 31, 2015

Of the top ten, the E.U. was the first major emitter to announce its post-2020 emissions target. In October 2014, several weeks ahead of the Lima climate conference, the E.U. released its goal: to reduce GHG emissions by 40% from 1990 levels by 2030 (40%/1990/2030). In November 2014, President Obama and President Xi announced joint GHG emissions reduction targets, also ahead of the Lima talks (see next section for more details). The Presidents also said they are "committed to reaching an ambitious 2015 agreement that reflects the principle" of CBDR, potentially creating momentum for overcoming a historically contentious issue.

Despite these early leadership efforts ahead of last year's talks, old divisions quickly emerged during the Lima meeting. China, for example, demurred on including a reporting requirement, suggesting instead that the reporting process should reflect CBDR. The E.U. reiterated its support for a legally binding agreement at the international level, whereas the U.S. pushed for a "politically binding" agreement. At the end of the Lima talks, international negotiators released a 39-page "elements" text, including a menu of topics that could be included in a final climate agreement in Paris.

At the Geneva climate talks in February of this year, instead of reducing the 39-page draft, negotiators expanded the document to an 86-page draft negotiating text. The larger text included sometimes conflicting provisions (Figure 12, in appendix). For example, one option calls for a top-down emissions budget to be divided among member states, contrasting with another option that calls for individual member state actions based on CBDR. According to Executive Secretary of the UNFCCC Christiana Figueres, the latest text included the "views and concerns of all countries," a potential nod to developing countries that argued they were excluded from part of the process during 2009 Copenhagen climate talks.

Disparate pledges indicating challenges ahead?

Early submissions, early differences. As of March 31, six countries – the U.S., E.U., Russia, Mexico, Switzerland and Norway – have officially submitted INDCs to the UNFCCC (Figure 2).

Figure 2 – INDCs Submissions Reveal Disparate Goals

Country	2012 CO_2 Emissions % of World	Emissions Pledge	Enforcement	% Emissions Covered	International Market Based Mechanism	Adaptation	Finance
U.S.	16.3%	26-28%/2005/2025	NA	100%	Does not intend to use IMBM	Not included in official submission	Not included in official submission
E.U.	11.7%	40%/1990/2030	Legally binding	100%	No contribution of IMBM Credits	Not included in official submission	Not included in official submission
Russia	5.5%	25-30%/1990/2030; conditional on others' INDCs	NA	NA	No contribution of IMBM Credits	Not included in official submission	Not included in official submission
Mexico	1.4%	Unconditional: 25%/BAU/2030; Conditional: 40%/BAU/2030	Could support legally binding	NA	Require IMBM to achieve conditional target	Components include: social; ecosystems; and infrastructure / productive systems	Capacity building; transfer of technology and finance for adaptation
Switzerland	0.1%	50%/1990/2030	Equal enforcement	NA	Includes IMBM	Not included in official submission	Not included in official submission
Norway	0.1%	40%/1990/2030	NA	100%	Supports IMBM	Not included in official submission	Not included in official submission

Source: ClearView Energy Partners, LLC using UNFCCC data as of March 31, 2015

Even though only six countries have submitted their INDCs at this point, early differences – beyond the varying GHG emissions reduction targets – appear to point to key hurdles that we've identified in the past. For example, the E.U. continues to explicitly call for legally binding commitments, whereas other countries offer tepid support, or exclude such language altogether. Mexico, the only developing country to submit its INDCs so far, directly includes adaptation and finance measures in its submission. The other four developed countries did not, although the E.U. has publicly supported inclusion of such measures in INDCs in the past. According to Mexico:

> *Capacity building requires both cooperation from developed countries to developing countries as well as south-south cooperation.*
>
> *Furthermore, Mexico requires international support for the development of its own technologies as well as for technology transfer and innovation to increase its adaptive capacity.*

Not only is Mexico including adaptation as part of its INDC, but it's calling for assistance to prepare those plans. We believe other developing countries could follow Mexico's lead by offering their own conditional targets (i.e. more aggressive reduction goals) "if additional resources and transfer of technology are available through international cooperation." Also, a final Russian INDC appears to be contingent on "the outcome of the negotiating process underway throughout the year of 2015 and the INDCs announced by major emitters of greenhouse gases."

Another potential issue that could arise is the use of international market-based mechanisms (IMBM), or international carbon credits. The E.U. projects that IMBM credits will not contribute towards meeting its GHG emissions reduction goal. Other countries include or support IMBM usage. The U.S. "does not intend to utilize international market mechanisms" to achieve its 2025 goal. We would interpret that to mean: the U.S. reserves the right to use IMBM should regulatory initiatives fall short on delivering expected GHG emissions reductions.

We expect international negotiators to work through ongoing differences *en route* to Paris, and several upcoming meetings could offer incremental checkpoints on that progress (Figure 3).

Figure 3 – The Path to Paris

DATE(S)	LOCATION	EVENT
6/1-11/2015	Bonn, Germany	Bonn Climate Change Conference
8/31-9/4/2015	Bonn, Germany	Climate meeting concerning negotiating text
9/2015	NA	Second window for countries to submit GHG emissions plans under the UNFCCC
10/19-23/2015	Bonn, Germany	Climate meeting concerning negotiating text
11/1/2015	NA	U.N. report on cumulative impact of GHG plans by all Parties that submitted targets by October 1
11/30-12/11/2015	Paris, France	21st session of the Conference of the Parties and the 11th session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol

Source: ClearView Energy Partners, LLC using UNFCCC data as of March 30, 2015

Next round of submissions. Although the actual deadline for submitting INDCs might be during the Paris conference in December, international negotiators have set informal target windows, the first of which was 1Q2015. The next window appears to be September, since the U.N. is planning on preparing a "synthesis report on the aggregate effect of the INDCs" submitted by October 1.

U.S. CLIMATE CHANGE

On November 12, 2014, the U.S. and China jointly announced GHG emissions reduction plans, helping set the stage as international negotiators and stakeholders approach the 2015 Paris climate talks. In some ways, the announcement may have helped international negotiations move forward by bringing together the two largest emitters and by further cementing CBDR. Environmentalists heralded the announcement as historic and ambitious. Some Republican Members of Congress complained that the agreement would require the U.S. to reduce emissions while allowing Chinese emissions to continue increasing, foreshadowing possible legislative pushback.

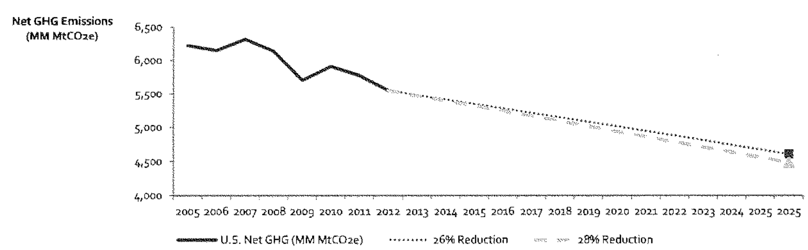
President Obama announced a target to cut "net "GHG emissions by between 26 and 28% below 2005 levels by 2025. President Xi's target would establish peak CO_2 emissions "around 2030, with the intention to try to peak early."

Although the White House believes the targets are "achievable under existing law," our estimate of emissions reductions required implies that this or future administrations would likely need to require emissions reductions beyond existing (final or proposed) rules in order to meet the 2025 reduction target.

U.S. formalizes targets

Deciphering the U.S. target. Today's submission to the UNFCCC formally establishes the targets laid out last November, but does little to quantify those reductions goals. In 2005, net GHG emissions were 6,223 MM $MtCO_2e$, according to the Environmental Protection Agency (EPA) GHG Inventory data. A 26% reduction corresponds to 2025 emissions equal to 4,605 MM $MtCO_2e$, or a total reduction of 1,618 MM $MtCO_2e$ (Figure 4). A 28% reduction corresponds to a target of 4,481 MM $MtCO_2e$, or a 1,742 MM $MtCO_2e$ reduction.

Figure 4 – U.S. GHG Emissions Pledge: 26-28%/2005/2025



Source: ClearView Energy Partners, LLC, using EPA and White House data as of February 13, 2015

By 2012, net emissions had fallen by 677 MM $MtCO_2e$ from 2005 levels to 5,546 MM $MtCO_2e$. That would imply another 941 MM $MtCO_2e$ reduction to reach the 26% target, and 1,066 MM $MtCO_2e$ reduction to reach the 28% target. To reiterate, although the White House believes existing statutes and new and existing regulations could meet the target (Figure 5), the White House has not publicly quantified how each of these mechanisms might reduce GHG emissions.

Figure 5 – Excerpt from U.S. Formal INDC Submission to UNFCCC (Emphasis Added)

Domestic laws, regulations, and measures relevant to implementation:

Several U.S. laws, as well as existing and proposed regulations thereunder, are relevant to the implementation of the U.S. target, including the **Clean Air Act** (42 U.S.C. §7401 et seq.), the **Energy Policy Act** (42 U.S.C. §13201 et seq.), and the **Energy Independence and Security Act** 42 U.S.C. § 17001 et seq.).

Since 2009, the United States has completed the following regulatory actions:

• Under the Clean Air Act, the United States Department of Transportation and the United States Environmental Protection Agency adopted **fuel economy standards** for light-duty vehicles for model years 2012-2025 and for heavy-duty vehicles for model years 2014-2018.

• Under the Energy Policy Act and the Energy Independence and Security Act, the United States Department of Energy has finalized multiple measures addressing buildings sector emissions including **energy conservation standards** for 29 categories of appliances and equipment as well as a building code determination for commercial buildings.

• Under the Clean Air Act, the United States Environmental Protection Agency has approved the use of specific **alternatives to high-GWP HFCs** in certain applications through the **Significant New Alternatives Policy** program.

At this time:

• Under the Clean Air Act, the United States Environmental Protection Agency is moving to finalize by summer 2015 **regulations to cut carbon pollution from new and existing power plants**.

• Under the Clean Air Act, the United States Department of Transportation and the United States Environmental Protection Agency are moving to promulgate **post-2018 fuel economy standards for heavy-duty vehicles**.

• Under the Clean Air Act, the United States Environmental Protection Agency is developing standards to address **methane emissions from landfills and the oil and gas sector**.

• Under the Clean Air Act, the United States Environmental Protection Agency is moving to **reduce the use and emissions of high-GWP HFCs through the Significant New Alternatives Policy program**.

• Under the Energy Policy Act and the Energy Independence and Security Act, the United States Department of Energy is continuing to reduce buildings sector emissions including by promulgating **energy conservation standards** for a broad range of appliances and equipment, as well as a building code determination for residential buildings.

In addition, since 2008 the United States has **reduced greenhouse gas emissions from Federal Government operations** by 17 percent and, under Executive Order 13693 issued on March 25th 2015, has set a new target to reduce these emissions 40 percent below 2005 levels by 2025.

Source: ClearView Energy Partners, LLC, using verbatim text from U.S. INDC as of March 31, 2015

In order to close the potential emissions gaps, we considered possible emissions reductions attributable to (1) the EPA's *Clean Power Plan* (CPP); (2) final regulatory measures enumerated within State Department's 2014 progress report to the UNFCCC (Figure 6); and (3) the White House's January 14 methane plan.

We derived CPP reduction potential from EPA's November 6, 2014 technical support document (TSD). EPA data implied annual power sector emissions reductions in 2025 of approximately 363 MM $MtCO_2e$, if the new source performance standards for both new and existing power plants were converted to a single mass-based budget for each state.

Last year's State Department progress report to the UNFCCC identified a range of federal programs leading to emissions reductions. Counting only the mandatory measures, State identifies about 435 MM $MtCO_2e/Y$ in incremental emissions reductions between 2015 and 2020.

Figure 6 – Emissions Reductions Projected to Result from Regulatory Measures Identified in *2014 U.S. Climate Action Report*

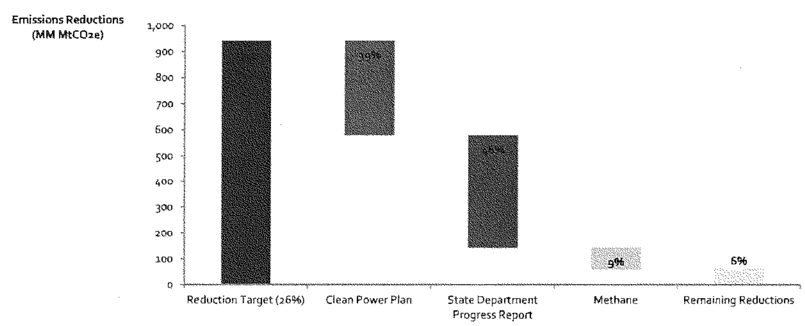
Regulatory Measure	Emissions Reduction (MM $MtCO_2e$/Y) 2011	2015	2020	2015-2020 Increment
Light-duty fuel economy standards	35	92	236	144
RFS	0	0	138.4	138.4
Heavy-duty fuel economy standards	0	0	37.7	37.7
Appliance and equipment energy efficiency standards	156	195	216	21
Lighting efficiency standards	19	38	41	3
$HFC/PFC/SF_6$ reductions	206.9	252	311.1	59.1
Oil and gas green completions	0	32.6	39.9	7.3
Landfill air regulations		162.7	183.1	20.4
Federal energy management program	4.2	10	14.4	4.4
Total				435.3

Source: ClearView Energy Partners, LLC, using State Department data as of January 14, 2015

In the January 14 methane plan for the oil and gas sector, the White House outlined a combination of regulatory and voluntary measures aimed at reducing oil and gas sector methane emissions to between 40% and 45% below 2012 levels by 2025. EPA inventory data for 2012 identify 161.6 MM $MtCO_2e$ of methane emissions from petroleum and oil and gas systems in 2012, although that figure represents a global warming potential (GWP) multiple of 21. EPA has since updated its GWP multiple for methane to 25, corresponding to a baseline of 192.4 MM $MtCO_2e$ /Y. Using that figure, we would translate the percentage range into a numerical reduction of between ~77 and ~87 MM $MtCO_2e$/Y from 2012 levels, or an average of 82 MM $MtCO_2e$/Y.

Adding up those reduction potentials, our back of the envelope calculation estimates that the CPP, standards identified in the State Department report and oil and gas methane measures could achieve reductions of 880 MM $MtCO_2e$/Y. That would still leave a 6% (or 61 MM $MtCO_2e$/Y) gap for the 26% reduction target and a 17% (or 185 MM $MtCO_2e$/Y) gap for the 28% reduction target (Figures 7 and 8). Although our three sources of emissions reduction potential has substantial overlap with the regulations enumerated in the U.S. INDC, it is unclear whether the White House is considering other regulations or is counting different levels of reductions attributable to different rules.

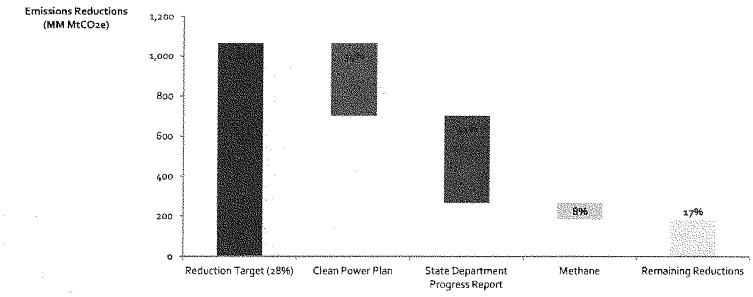
Figure 7 – Contribution of Different Programs Towards 26% Reduction Goal



Notes
- Absolute reduction target corresponds to difference between 2025 target and 2012 emissions
- Please see Chapter 4.9 in our *Macro Energy Briefing* for more methane reduction information

Source: ClearView Energy Partners, LLC, using EPA and White House data as of February 13, 2015

Figure 8 – Contribution of Different Programs Towards 28% Reduction Goal



Notes
- Absolute reduction target corresponds to difference between 2025 target and 2012 emissions
- Please see Chapter 4.9 in our *Macro Energy Briefing* for more methane reduction information

Source: ClearView Energy Partners, LLC, using EPA and White House data as of February 13, 2015

Congressional opposition and "naming and shaming"

Don't ask for Congressional approval. If history has taught the Obama Administration anything, it's don't ask Congress for approval of an international climate agreement. In 1997, the Senate passed non-binding sense of the Senate language in a 95-0 vote disapproving of the Kyoto Protocol and any other international climate agreement that wouldn't include developing countries. We were not surprised to learn that the White House was not pursuing an internationally, legally binding deal or a treaty for the 2015 Paris talks. In that context, Congress would not have to ratify or approve of a deal. The U.S. negotiating team has been pushing for a "politically binding" deal that would "name-and-shame" countries with low ambitions, or those that don't hit targets.

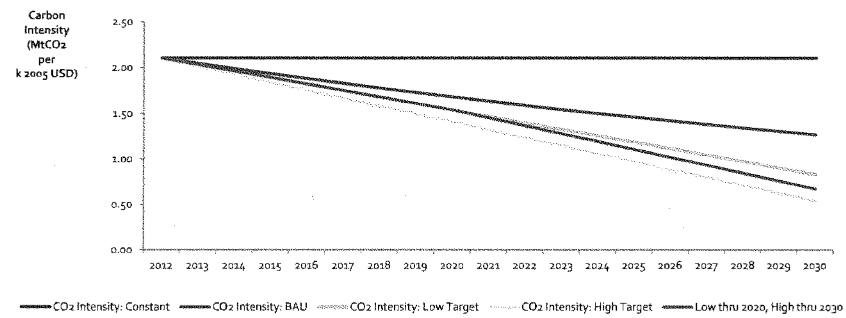
GOP opposition to international plans. GOP members of Congress responded almost immediately to the joint U.S.-China GHG emissions announcement back in November 2014. That opposition manifested as legislative activity early in the 114th Congress (Figure 13, appendix). At the first opportunity, during the markup of the Keystone XL bill, Senators Roy Blunt (R-MO) and Senate Environment and Public Works Committee Chairman Jim Inhofe (R-OK) introduced an amendment in the form of a non-binding sense of the Senate criticizing the joint announcement. The measure found that requiring U.S. GHG emissions cuts while allowing other countries to continue increasing emissions is "economically unfair." The amendment suggested that:

> *the United States should not agree to any bilateral or other international agreement imposing disparate greenhouse gas commitments for the United States and other countries.*

Unlike the 1997 vote on the *Byrd-Hagel Resolution*, the January 2015 vote on the Blunt-Inhofe measure failed 51Y-46N, far short of the unanimous 95-0 vote 18 years earlier. We wouldn't suggest that this Senate is more likely to approve of an international climate deal; on the contrary, we continue to believe that the GOP controlled Congress is unlikely to approve of a global agreement addressing GHG emissions.

What did Beijing offer, anyway? After the 2009 Copenhagen climate meeting, China pledged to reduce its CO_2 intensity ($MtCO_2$/unit of GDP) by between 40 and 45% by 2020 from 2005 levels. We estimate that China's CO_2 intensity was 2.57 $MtCO_2$ /k 2005USD in 2005, implying a target of between 1.41 and 1.54 $MtCO_2$ /k 2005USD by 2020. By 2012, we estimate that China had already reduced its CO_2 intensity to 2.11 $MtCO_2$ /k 2005USD, representing a compound annual growth rate (CAGR) of -2.78%. In the November 2014 joint statement, China announced plans "to achieve the peaking of CO_2 emissions around 2030 and to make best efforts to peak early…" To assess China's potential 2030 CO_2 emissions, we developed five emissions scenarios (Figure 9). We estimate that even if China continued reducing its CO_2 intensity at its 2005-2012 compound annual rate (2.78%) through 2030, Beijing would not peak emissions by 2030 (Figure 10). If, on the other hand, China achieves its Copenhagen pledge and carries those implied reduction rates forward, Beijing could beat its 2030 goal. China's goal only includes CO_2, whereas the U.S. pledged to reduce net GHG emissions. Including other GHG emissions could mean that China's total GHG emissions could continue increasing beyond 2030.

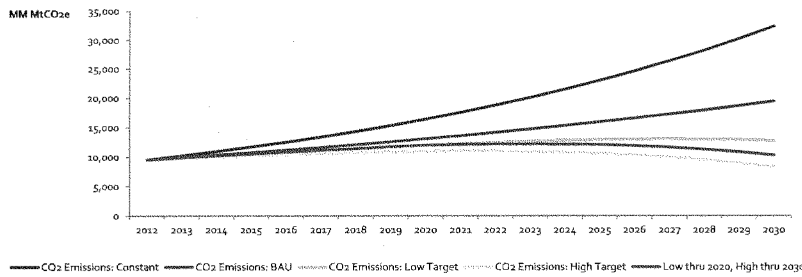
Figure 9 – CVEP Projection of Different Carbon Intensity Scenarios for China



Notes
To estimate 2030 emissions, we developed five carbon intensity scenarios:
(1) a "constant" case where carbon intensity remained at 2012 levels;
(2) a "business-as-usual" (BAU) case where carbon intensity continued declining at the CAGR between 2005 and 2012;
(3) a "low target" case, where China meets its 40% reduction goal by 2020, and continues reducing its carbon intensity at the same rate through 2030;
(4) a "high target" case, where China meets its 45% reduction goal by 2020, and continues reducing its carbon intensity at the same rate through 2030; and
(5) a blended "low/high" case, where China meets the low target by 2020, but ramps up thereafter at what could have been the reduction rate had Beijing met the high reduction target.

Source: ClearView Energy Partners, LLC, using EIA, UN, White House and World Bank data as of February 27, 2015

Figure 10 – CVEP Projection of Carbon Emissions Scenarios for China (MM $MtCO_2e$)



Scenario	Emissions in 2012	Peak CO_2 Emissions Year	Emissions in Peak Year*	Emissions in 2030
Constant	9,512	Likely beyond 2030	32,353	32,353
BAU	9,512	Likely beyond 2030	19,470	19,470
Low Target	9,512	2027	13,090	12,772
High Target	9,512	2021	11,066	8,338
Low thru 2020, High thru 2030	9,512	2023	12,236	10,308

Note: Peak year emissions for Constant and BAU cases correspond to emissions in 2030

Source: ClearView Energy Partners, LLC, using EIA, UN, White House and World Bank data as of February 27, 2015

U.S. Aircraft GHGs

Background. In December 2007, environmentalists asked EPA to make an "endangerment finding" and set regulations for aircraft GHG emissions. In June 2010, environmentalists sued EPA in the U.S. District Court for the District of Columbia (D.C. District Court). In July 2011, the D.C. District Court ruled that EPA must determine whether aircraft GHG emissions endanger public health or welfare. Since then, EPA had remained largely silent regarding aircraft GHG emissions. On August 5, 2014, environmentalists sent their notice of intent to sue EPA for failing to make the findings and develop regulations. Environmentalists may have little incentive to follow through unless EPA falls behind its new target timeframe for addressing aircraft GHG emissions.

EPA moves forward. On February 27, EPA sent two actions concerning aircraft GHG emissions to the White House Office of Management and Budget for review:

(1) a proposal regarding a possible endangerment finding; and

(2) an advanced notice of proposed rulemaking concerning the International Civil Aviation Organization (ICAO) Committee on Aviation and Environmental Protection's (CAEP) GHG emissions standard setting process.

If, as we expect, EPA finds that aircraft GHG emissions endanger public health, such a finding would not yet constitute a regulation. It could be very difficult for EPA to walk back from an endangerment finding and forego an eventual aircraft rule, however. At this time, we expect 2018 to be the earliest that a U.S. aircraft standard could take effect (Figure 11).

Other measures could be finalized before potential U.S. standards, like a global market-based mechanism (MBM) implemented by ICAO or the externalization of the E.U. Emissions Trading Scheme (ETS), which could occur as early as 2017. If EPA regulatory activity lags after the agency finalizes an endangerment finding, we would expect a "sue-and-settle" lawsuit that locks in a schedule for regulation.

Figure 11 – EPA Proposed Timeline Could Leave Next Administration with Task of Regulating Aircraft GHG Emissions

DATE	EVENT
Mar 2015	OMB receives (a) endangerment finding proposal; and (b) ANPRM related to ICAO/CAEP progress
May 2015	Possible window for OMB to conclude review and for EPA to release rules
4Q2015-1Q2016	Possible window for EPA to propose domestic GHG emissions standards for aircraft
Feb 2016	EPA expects ICAO/CAEP to adopt an aircraft GHG emissions standard by February 2016
May 2016	EPA expects to finalize the endangerment finding within approximately one year of the proposal
Sep 2016	ICAO Assembly meeting – possible date when international negotiators propose global MBM
2016–2017	Possible window for EPA to finalize domestic GHG emissions standards for aircraft
Jan 2017	Possible end of E.U. ETS aircraft "derogation" period, unless ICAO adopts international program

Source: ClearView Energy Partners, LLC, EPA

▼

Figure 12 – Paris Draft Negotiating Texts Casts Wide Net of (Sometimes Conflicting) Options

SECTION AND TOPIC	EXCERPT: OPTION 1	EXCERPT: OPTION 2	EXCERPT: OPTION 3
Preamble Text Broad participation and CBDR	*Acknowledging* that the global nature and urgency of climate change calls for the participation / widest possible participation, cooperation and ambitious action by all Parties	*Acknowledging* that the global nature and urgency of climate change calls for the widest possible cooperation of all Parties, as well as their participation and enhanced action in an effective and appropriate international response in accordance with [equity and] their common but differentiated responsibilities and respective capabilities, and their specific national and regional development priorities, [objectives and circumstances / social and economic conditions] with developed country Parties taking the lead	*Acknowledging* that the global nature and urgency of climate change calls for the widest possible cooperation of all Parties, as well as their participation and enhanced action in an effective and appropriate international response in accordance with their common but differentiated responsibilities and respective capabilities, in light of different national circumstances
Preamble Text GHG emissions reduction and distinction between developed and developing nations	*Recognizing* that deep cuts in global greenhouse gas emissions will be required to achieve the ultimate objective of the Convention and the long-term temperature limit / holding the increase in global average temperature, and that such cuts must be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner	*Recognizing* that deep cuts in global emissions will be required to achieve the ultimate objective of the Convention and emphasizing the need for urgency to address climate change	*Noting* that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs
Preamble Text Whether INDCs include adaptation	*Emphasizing* that adaptation is a global challenge and a common responsibility that requires global solidarity that must be addressed with the same urgency as, and in political / legal parity with, mitigation	*Emphasizing* that adaptation is a global challenge that must be addressed with the same urgency as, and in balance with, mitigation, and that enhanced action and international cooperation on adaptation is urgently required in order to enable and support the implementation of adaptation actions [and recognizing that both climate-resilient development and adaptation to the impacts of climate change will be essential]	*Emphasizing* that enhanced action and international cooperation on adaptation is urgently required to enable and support the implementation of adaptation actions aimed at reducing vulnerability and building resilience in [developing country Parties] [Parties not included in annex X], taking into account the urgent and immediate needs of those [developing countries] [Parties not included in annex X] that are particularly vulnerable
Objectives CBDR and contingencies	All Parties to strive to achieve low greenhouse gas climate-resilient economies and societies, on the basis of equity and in accordance with their historical responsibilities, common but differentiated responsibilities / evolving common but differentiated responsibilities and respective capabilities, in order to achieve sustainable development, poverty eradication and prosperity for the benefit of present and future generations of humankind, taking fully into account the historical responsibility of [developed country Parties][Parties included in annex X] and their leadership in combating climate change and the adverse effects thereof, and bearing in mind that economic and social development and poverty eradication are the first and overriding priorities of [developing country Parties [and the Parties included in Annex I undergoing the process of transition to a market economy]][Parties not included in annex X]	Consistent with Article 3, paragraph 1, of the Convention, the Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof. In accordance with Article 4, paragraph 7, of the Convention, the extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties	All Parties to strive to achieve low greenhouse gas climate resilient economies and societies on the basis of the principle of common but differentiated responsibilities and respective capabilities in light of different national circumstances.

SECTION AND TOPIC	EXCERPT: OPTION 1	EXCERPT: OPTION 2	EXCERPT: OPTION 3
<u>Objectives</u> Liming temperature rise and broad reduction goal	Ensuring significant global greenhouse gas emission reductions over the next few decades or a 40–70 per cent reduction in global greenhouse gas emissions below 2010 levels by 2050 and near-zero emissions of carbon dioxide (CO_2) and other long-lived greenhouse gases by the end of the century	Ensuring that global greenhouse gas emissions peak by 2020 at the latest, are reduced by at least 50 per cent by 2050 and continue to decline thereafter [reaching near-zero emissions of CO_2 and other long-lived greenhouse gases by the end of the century, consistent with the findings of the Intergovernmental Panel on Climate Change]	Ensuring significant global greenhouse gas emission reductions over the next few decades in order to achieve a global goal for substantially reducing global emissions by 2050 / consistent with the agreed global goal for substantially reducing global emissions by 2050 / consistent with the agreed global goal, and based on the best available scientific knowledge and equitable access to sustainable development
<u>Objectives</u> Ambition	Each Party to take action at the highest level of ambition / mitigation ambition, reflecting its national circumstances, and to progressively increase that level of ambition	All Parties to take action at the highest level of ambition and to progressively increase that level of ambition, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, with developed countries taking the lead	A global emission budget to be divided among all Parties, in accordance with the principles and provisions of the Convention, in order to limit global warming this century to below 1.5 °C according to the Intergovernmental Panel on Climate Change (IPCC) assessment. The distribution of the global emission budget should be undertaken in accordance with historical responsibilities, ecological footprint, capabilities and state of development
<u>Objectives</u> CBDR and contingencies	Commitments / contributions of Parties particularly vulnerable to the adverse effects of climate change, especially the least developed countries (LDCs) and small island developing States (SIDS), to reflect their efforts in the context of their specific needs and special situations	Commitments / contributions / actions of [developing country Parties] [Parties not included in Annex X], especially those referred to in Article 4, paragraphs 8–10, of the Convention, including the least developed countries (LDCs) and small island developing States (SIDS), to reflect their efforts in the context of sustainable development and their specific needs and special circumstances, bearing in mind that the extent to which [developing country Parties] [Parties not included in Annex X] will effectively implement their commitments under the Convention will depend on the effective implementation by [developed country Parties] [Parties included in Annex Y] of their commitments under the Convention related to financial resources and the transfer of technology	
<u>Objectives</u> Unilateral programs and international trade	Unilateral measures not to constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade	No reference to unilateral measures in the agreement	Decides that the developed country Parties shall not resort to any form of unilateral measures against goods and services from developing country Parties on any grounds related to climate change, recalling the principles and provisions of the Convention, in particular article 3, paragraphs 1, 4 and 5, and article 4, paragraphs 3, 5, 7, 8, 9 and 10, taking into account the principles of equity, common but differentiated responsibilities, and the obligations of developed country Parties to provide financial resources, transfer of technologies and capacity building support to developing country Parties

SECTION AND TOPIC	EXCERPT: OPTION 1	EXCERPT: OPTION 2	EXCERPT: OPTION 3
Mitigation Broad goal	All Parties, in accordance with Article 4 and their common but differentiated responsibilities and respective capabilities and on the basis of equity, to enhance mitigation ambition and cooperate with a view to achieving the long-term emission reductions, in the context of Article 2 of the Convention, consistent with limiting the global average temperature increase to below 2 °C or 1.5 °C above pre-industrial levels and in the context of equitable access to sustainable development[, with developed country Parties taking the lead by undertaking ambitious emission reductions and providing finance, technology and capacity-building support to developing country Parties][and the protection of the integrity of Mother Earth][in accordance with the shared vision resulting from the Bali Action Plan, with developed country Parties taking the lead by undertaking ambitious emission reductions and providing finance, technology and capacity-building support to developing country Parties]	All Parties [to][shall] make [individual] efforts and cooperate on enhancing mitigation ambition to ensure that the aggregate level of mitigation commitments / contributions increases over time, so as to achieve the long-term emission reductions, in the context of Article 2 of the Convention, [in accordance with common but differentiated responsibilities and respective capabilities in light of different national circumstances and equity,] consistent with limiting the global average temperature increase to below 2 °C or 1.5 °C above pre-industrial levels	Parties to make efforts and cooperate to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, in accordance with the shared vision resulting from the Bali Action Plan, including holding the increase in global average temperature below 2 °C or 1.5 °C above pre-industrial levels in the context of sustainable development, with [developed country Parties][Parties included in annex X] taking the lead by undertaking ambitious emission reductions and [Parties included in annex Y] providing finance, technology and capacity-building support to [developing country Parties][Parties not included in annex X]
Mitigation Mitigation goal update timelines	In accordance with Article 4 of the Convention, all Parties to progressively enhance the level of ambition of their mitigation commitments / contributions / actions such that [the aggregate commitments achieve the long-term global goal referred to in paragraph 13 above] each commitment / contribution / action is of a type, scope, scale and coverage more / no less ambitious than those previously undertaken under this agreement or the Convention or its Kyoto Protocol; [national commitments shall be inscribed as an integral part of the 2015 Agreement.]	All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, to formulate, implement, publish and regularly update programmes containing measures to mitigate climate change in order to enhance their level of ambition after 2020	In accordance with Article 4 of the Convention, all Parties to enhance the level of ambition of their mitigation commitments / contributions / actions, as appropriate. Developed country Parties shall take mitigation commitments for the post-2020 period that are more ambitious than emission reductions of at least 25–40 per cent below 1990 levels by 2020
Mitigation Transparency and communication	In accordance with the principles of the Convention and its Article 4, each Party to prepare, communicate and implement successive nationally determined mitigation commitments / contributions / actions...	Parties to prepare differentiated mitigation commitments for [developed][Parties included in annex X] and [developing country Parties][Parties not included in annex X], with [developed country Parties] [Parties included in annex X] to take the lead and [developing country Parties][Parties not included in annex X] to be provided flexibility...	In accordance with the principles of the Convention and its Article 4, all Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall enhance the implementation of their commitments under Article 4, paragraph 1, including through: (a) formulating, implementing, publishing and regularly updating programmes containing measures to mitigate climate change in order to enhance their level of ambition after 2020; (b) promoting and cooperating in the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic greenhouse gas emissions not controlled by the Montreal Protocol in all relevant sectors; (c) promoting sustainable management, and promoting and cooperating in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol

SECTION AND TOPIC	EXCERPT: OPTION 1	EXCERPT: OPTION 2	EXCERPT: OPTION 3
Mitigation Commitments and contingencies	Mitigation commitments / contributions / actions of all Parties to be communicated and implemented without conditions	Each Party to communicate commitments / contributions / actions specifying an unconditional portion and may also include a conditional one	Mitigation commitments / contributions / actions of [developing country Parties][Parties not included in annex X] to be prepared, communicated and implemented subject to the provision of finance, technology development and transfer, and capacity-building. [Developing country Parties][Parties not included in annex X] may specify additional enhanced levels of mitigation commitments / contributions according to different levels of enhanced support by [developed country Parties [Parties included in annex Y]
Mitigation Communication	Parties' proposed mitigation commitments / contributions / actions to be communicated and considered as well as formalized / finalized and reviewed in accordance with section K below	Upon joining the agreement, all Parties to submit a schedule reflecting the nationally determined contribution they intend to implement. Parties to maintain schedule thereafter	Each Party shall communicate successive mitigation proposed commitments at least 12 and no more than 18 months before they are to be inscribed, to be considered and formalized as commitments shall be implemented and reviewed in accordance with section K below
Adaptation Whether INDCs include adaptation	All Parties in accordance with the principles and provisions of the Convention, its Article 4 and their common but differentiated responsibilities, and previous decisions of the Conference of the Parties (COP) to commit to cooperate to adapt to the adverse effects of climate change, ensure resilience and protect citizens and ecosystems in the context of the long-term temperature limit and to achieve sustainable development [in the context of poverty reduction and maintaining food security], while recognizing the local, national and transboundary dimensions of adaptation...	No global goal for adaptation	Establish universal individual commitments/actions
Adaptation Communication	Parties to communicate their commitments / contributions / actions / commitments under Article 4 of the Convention / adaptation priorities / support / level of support needs through the intended nationally determined contribution (INDC) process, in accordance with the modalities and procedures to be developed and adopted by the governing body / progress in enhancing adaptation action or integrating adaptation into planning, policies or action through biennial communications...	Developed country Parties to communicate their commitments under Article 4 of the Convention and developing country Parties to communicate their actions on the level of support needed in order to enhance adaptation action or integrate adaptation into planning, policies or action through biennial communications, including INDCs/NDCs	All Parties should report and share the progress and experience in preparing and implementing plans and actions on adaptation through a common reporting system

SECTION AND TOPIC	EXCERPT: OPTION 1	EXCERPT: OPTION 2	EXCERPT: OPTION 3
Finance Contributions	All [[developed country Parties][Parties included in annex X] and other Parties included in [Annex II][annex Y]][Parties in a position to do so, considering evolving capabilities][countries in a position to do so] to provide climate finance as a means to [enhance action towards achieving the objective of the Convention][meet the goal of staying below the [2][1.5] °C temperature increase] and to achieve the [sustainable development trajectories that combine adaptation and mitigation to climate change and its impacts and the] transformation required to that end and in line with the needs of [developing countries][Parties not included in annex X]...	Each Party / All Parties individually or collectively to mobilize climate finance through a diversity of actions from a variety of sources as a means to stay below the long-term temperature limit and to achieve the transformation required to that end, according to and in line with their respective and evolving responsibilities and capabilities / the principles and objectives of the Convention, acknowledging the importance of leadership to be taken by [developed country Parties][Parties included in annex X] [Parties in a position to do so, considering evolving capabilities] [all countries in a position to do so], acknowledging that some Parties need support in order to take action, and acknowledging that the need for support by Parties may change over time or be met with different means of support/ [all [Parties][countries] in a position to do so][Parties included in annex X] [Parties in a position to do so, considering evolving capabilities] should provide financial support to Parties in need of support; acknowledging the need for climate-resilient economies and societies	All Parties shall individually or collectively mobilize climate finance through a diversity of actions from a variety of sources as a means to stay below the long-term temperature limit and to achieve the transformation required to that end, acknowledging that the actions to be taken will differ according to, and in line with, Parties' respective and evolving responsibilities and capabilities, acknowledging the importance of leadership to be taken by developed country Parties, also acknowledging that some Parties need support in order to take action, and further acknowledging that the need for support by Parties may change over time or be met with different means of support. All Parties in a position to do so shall provide financial support to Parties in need of support, acknowledging the need for climate-resilient economies and societies
Finance Funding levels	The provision of finance to be based on a floor of USD 100 billion per year	Agreement not to specify individual / quantified commitments, quantified targets or specific indicators for the post-2020 period	Climate finance provided by developed country Parties shall be based on a quantified target taking into consideration the following...
Finance Funding sources	Primarily public sources, with supplementary funding to be drawn from private / alternative sources...	The mobilization of finance may come from a wide variety of sources, including public, private and alternative sources, recognizing the need for a diversity of sources and instruments to suit recipients' priorities and changing economic circumstances	Financial resources to be provided from developed country Parties to developing country Parties. Public sources from developed country parties direct budget contributions primarily, with supplementary funding to be drawn from private / alternative sources in developed countries. Other financial sources from developed country Parties to be considered on the basis of clear criteria in order to avoid incidence on developing country Parties and to ensure the sustainability, predictability and additionality of sources
Technology Broad transfer goals	All Parties to strengthen cooperative action to promote and enhance technology development and transfer, including through the Technology Mechanism / institutional arrangements for technology established under the Convention and through the Financial Mechanism, in order to support the implementation of mitigation and adaptation commitments under this agreement	Parties, consistent with the principles and provisions of the Convention, including Article 4, paragraphs 1, 3 and 5 [and Article 11], / in accordance with their common but differentiated responsibilities, to strengthen cooperative action to promote and enhance technology development and transfer and better facilitate the implementation of the Convention, including through the Technology Mechanism / institutional arrangements for technology established under the Convention and through the Financial Mechanism [and the Climate Resilience and Sustainable Development Mechanism] / by enhancing the provision of support by [developed country Parties][Parties included in annex Y][all countries in a position to do so], in order to support the implementation of mitigation and adaptation [commitments][actions] under this agreement	Developed country Parties, consistent with the principles and provisions of the Convention, in particular Article 4, paragraphs 1, 3 and 5 and Article 11, shall promote and enhance access to environmentally sound technology and know-how for the implementation of the Convention, including through the Financial Mechanism.]

SECTION AND TOPIC	EXCERPT: OPTION 1	EXCERPT: OPTION 2	EXCERPT: OPTION 3
<u>Capacity Building</u> Goals	[The objective of capacity-building should be to enable [developing country Parties] [Parties not included in annex X] [all Parties] to identify, design and implement adaptation and mitigation actions and [to enable domestic development and absorption of technologies] [to enhance the capacities of national governments to be able to absorb technology and finance for the implementation of the Convention.]	No commitments on capacity-building in the agreement	Developed country Parties shall enhance the capacity of developing country Parties to support the implementation of their nationally determined contributions under this Agreement based on the principles and provisions of the Convention. Such enhancement of capacity may provide important and relevant guidance to developing country Parties, but shall not interfere with the nature, scope or substance of developing country Parties' nationally determined contributions
<u>Transparency</u> Applicability	A transparency framework, applicable to all Parties and differentiated between [developed] [Parties included in annex X] and [developing country Parties] [Parties not included in annex X], under the Convention and in accordance with previous decisions of the COP, shall promote transparency of action and support by providing information on the implementation of each Party's commitments / contributions in an efficient and flexible manner...	A [single] / common transparency framework, applicable to all Parties, [taking into account their common but differentiated responsibilities and respective capabilities in the light of different national circumstances and recognizing that Parties shall progressively enhance the level of transparency such that it is strengthened and more robust relative to the level currently existing under the Convention,] shall promote transparency of action and support by providing information on the implementation of each Party's commitments / contributions in an efficient and flexible manner, [recognizing that Parties with the least capacity may need additional support to do so,]...	A transparency framework, applicable to developed country Parties under the Convention and in accordance with previous decisions of the COP, shall promote transparency of action and support by providing information on the implementation of developed country Party's commitments / contributions in an efficient and flexible manner...
<u>INDCs</u> Timeline to update commitments	Pursuant to Article 2 of the Convention, [all] Parties to periodically communicate or update their proposed commitments / contributions[, with developing country Parties doing so within the context of the basis of the provision of support. Such periodic communications shall take into account national circumstances and factors which affect national determination of climate actions, such as public policy planning and execution cycles and domestic legislative requirements]	Commitments shall be inscribed every five years, beginning in 2015. All Parties shall communicate proposed commitments in the 12 to 18 months prior to their inscription. The commitments will cover a five-year period, ending 10 years after the inscription year. Parties may also propose an indicative commitment covering a further five–year period, which can be confirmed or enhanced five years later, when formally inscribed (2020)	Every five years for [developed country Parties][Parties included in annex X] and every 10 years for [developing country Parties][Parties not included in annex X]
<u>INDCs</u> Components	The scope of the commitments / contributions / actions will: ***Option (a)***: Be nationally determined; ***Option (b)***: Be defined by the provisions of this agreement; ***Option (c)***: Include mitigation, adaptation, finance, technology and capacity-building, and transparency of action and support; ***Option (d)***: Include mitigation, recognizing that commitments on adaptation, finance, technology and capacity-building, and transparency of action and support are subject to separate provisions of this agreement; ***Option (e)***: Include mitigation only	Implementation and ambition are related to: a. Mitigation, adaptation, finance, technology and capacity-building; b. For [developed country Parties][Parties included in annex X] : mitigation and finance, technology and capacity-building support to [developing country Parties][Parties not included in annex X] for their mitigation and adaptation actions; c. For [developing country Parties][Parties not included in annex X]: mitigation and/or adaptation.]	

SECTION AND TOPIC	EXCERPT: OPTION 1	EXCERPT: OPTION 2	EXCERPT: OPTION 3
INDCs Whether to pre-review	No ex ante consideration process / no arrangements for further facilitating transparency and clarity	After their communication, commitments / contributions / actions will be subject to an ex ante consideration process / further facilitation of transparency and clarity / a consultative period/process...	The aggregate consideration process will assess the progress towards the objective of the agreement, as stated in section C, as well as the adequacy, scale and predictability of the mobilization and provision of finance, technology development and transfer, and capacity-building to developing countries, taking into account the aggregate level of ambition as communicated through the nationally determined contributions...
INDCs Finalization	Inscribed in a single annex to this agreement	Adopted by a decision of the governing body	Contained in national schedules, to be communicated to the secretariat. The secretariat shall make all national schedules publicly available
Process Entry into force	This agreement shall enter into force on the thirtieth / ninetieth day after the date on which not less than 10/50/[X] (a number that is not over- or under-inclusive) Parties to the Convention have deposited their instruments of ratification, acceptance, approval or accession	double threshold that includes both a number of Parties ratifying and a percentage of global emission reductions covered by the ratifying Parties / a minimum of global emissions from Parties	Entry into force upon either a sufficiently high number ([X]) of Parties or a percentage ([X]) of global GHG emissions covered, whichever occurs first, but not earlier than on 1 January 2020

Note: Some topics may include more than three options; numbering may not correspond to exact UNFCCC ordering

Source: ClearView Energy Partners, LLC, using UNFCCC Draft Negotiating text from Geneva Climate Talks, as of February 12, 2015

Figure 13 – Congressional Activity during the 114th Congress Regarding Climate Change

Senator	Party	State	Sen. Schatz (1/21/2015)	Sens. Blunt-Inhofe (1/22/2015)	Sen. Sanders (3/25/2015)	Sen. Blunt (3/25/2015): Withdrawn	Sens. Blunt-Inhofe (3/25/2015): Introduced
Alexander	R	TN	Yea	Yea	Nay		
Ayotte	R	NH	Yea	Nay	Yea		
Baldwin	D	WI	Yea	Nay	Yea		
Barrasso	R	WY	Nay	Yea	Nay		
Bennet	D	CO	Yea	Nay	Yea		
Blumenthal	D	CT	Yea	Nay	Yea		
Blunt	R	MO	Nay	Yea	Nay		
Booker	D	NJ	Yea	Nay	Yea		
Boozman	R	AR	Nay	Yea	Nay		
Boxer	D	CA	Yea	Nay	Yea		
Brown	D	OH	Yea	Nay	Yea		
Burr	R	NC	Nay	Yea	Nay		
Cantwell	D	WA	Yea	Nay	Yea		
Capito	R	WV	Nay	Yea	Nay		
Cardin	D	MD	Yea	Nay	Yea		
Carper	D	DE	Yea	Nay	Yea		
Casey	D	PA	Yea	Nay	Yea		
Cassidy	R	LA	Nay	Yea	Nay		
Coats	R	IN	Nay	Yea	Nay		
Cochran	R	MS	Nay	Yea	Nay		
Collins	R	ME	Yea	Nay	Yea		
Coons	D	DE	Yea	Nay	Yea		
Corker	R	TN	Nay	Yea	Nay		
Cornyn	R	TX	Nay	Yea	Nay		
Cotton	R	AR	Nay	Yea	Nay		
Crapo	R	ID	Nay	Yea	Nay		
Cruz	R	TX	Nay	Yea	Not Voting		
Daines	R	MT	Nay	Yea	Nay		
Donnelly	D	IN	Yea	Nay	Yea		
Durbin	D	IL	Yea	Nay	Yea		
Enzi	R	WY	Nay	Yea	Nay		
Ernst	R	IA	Nay	Yea	Nay		
Feinstein	D	CA	Yea	Nay	Yea		
Fischer	R	NE	Nay	Yea	Nay		
Flake	R	AZ	Nay	Yea	Nay		
Franken	D	MN	Yea	Nay	Yea		
Gardner	R	CO	Nay	Yea	Nay		
Gillibrand	D	NY	Yea	Nay	Yea		
Graham	R	SC	Yea	Not Voting	Yea		
Grassley	R	IA	Nay	Yea	Nay		
Hatch	R	UT	Nay	Yea	Nay		
Heinrich	D	NM	Yea	Nay	Yea		
Heitkamp	D	ND	Yea	Nay	Nay		
Heller	R	NV	Nay	Yea	Nay		
Hirono	D	HI	Yea	Nay	Yea		
Hoeven	R	ND	Nay	Yea	Nay		
Inhofe	R	OK	Nay	Yea	Nay		
Isakson	R	GA	Nay	Yea	Nay		
Johnson	R	WI	Nay	Yea	Nay		
Kaine	D	VA	Yea	Nay	Yea		
King	I	ME	Yea	Nay	Yea		
Kirk	R	IL	Yea	Yea	Yea		
Klobuchar	D	MN	Yea	Nay	Yea		
Lankford	R	OK	Nay	Yea	Nay		
Leahy	D	VT	Yea	Nay	Yea		
Lee	R	UT	Nay	Not Voting	Nay		
Manchin	D	WV	Yea	Yea	Nay		
Markey	D	MA	Yea	Nay	Yea		
McCain	R	AZ	Nay	Yea	Nay		
McCaskill	D	MO	Yea	Nay	Yea		
McConnell	R	KY	Nay	Yea	Nay		
Menendez	D	NJ	Yea	Nay	Yea		
Merkley	D	OR	Yea	Nay	Yea		
Mikulski	D	MD	Yea	Nay	Yea		
Moran	R	KS	Nay	Yea	Nay		

Senator	Party	State	Sen. Schatz (1/21/2015)	Sens. Blunt-Inhofe (1/22/2015)	Sen. Sanders (3/25/2015)	Sen. Blunt (3/25/2015): Withdrawn	Sens. Blunt-Inhofe (3/25/2015): Introduced
Murkowski	R	AK	Nay	Yea	Nay		
Murphy	D	CT	Yea	Nay	Yea		
Murray	D	WA	Yea	Nay	Yea		
Nelson	D	FL	Yea	Nay	Yea		
Paul	R	KY	Nay	Yea	Nay		
Perdue	R	GA	Nay	Yea	Nay		
Peters	D	MI	Yea	Nay	Yea		
Portman	R	OH	Nay	Yea	Yea		
Reed	D	RI	Yea	Nay	Yea		
Reid	D	NV	Not Voting	Not Voting	Yea		
Risch	R	ID	Nay	Yea	Nay		
Roberts	R	KS	Nay	Yea	Nay		
Rounds	R	SD	Nay	Yea	Nay		
Rubio	R	FL	Nay	Yea	Nay		
Sanders	I	VT	Yea	Nay	Yea		
Sasse	R	NE	Nay	Yea	Nay		
Schatz	D	HI	Yea	Nay	Yea		
Schumer	D	NY	Yea	Nay	Yea		
Scott	R	SC	Nay	Yea	Nay		
Sessions	R	AL	Nay	Yea	Nay		
Shaheen	D	NH	Yea	Nay	Yea		
Shelby	R	AL	Nay	Yea	Nay		
Stabenow	D	MI	Yea	Nay	Yea		
Sullivan	R	AK	Nay	Yea	Nay		
Tester	D	MT	Yea	Nay	Yea		
Thune	R	SD	Nay	Yea	Nay		
Tillis	R	NC	Nay	Yea	Nay		
Toomey	R	PA	Nay	Yea	Nay		
Udall	D	NM	Yea	Nay	Yea		
Vitter	R	LA	Nay	Yea	Nay		
Warner	D	VA	Yea	Nay	Yea		
Warren	D	MA	Yea	Nay	Yea		
Whitehouse	D	RI	Yea	Nay	Yea		
Wicker	R	MS	Nay	Yea	Nay		
Wyden	D	OR	Yea	Nay	Yea		
			Failed	Failed	Failed		
			50 Yea - 49 Nay	51 Yea - 46 Nay	49 Yea - 50 Nay		

Notes

(1) Schatz: Sense of the Congress that climate change is real and human activity significantly contributes to climate change

(2) Blunt-Inhofe: Sense of the Senate that U.S.-China GHG announcement has no force

(3) Sanders: Non-binding budget resolution amendment calling for Congress to address human-induced climate change

(4) Blunt: Side-by-side amendment to Sanders; would have blocked taxes or fees on carbon emissions

(5) Blunt-Inhofe: non-binding budget resolution amendment calling for Congressional approval of bilateral or international climate agreement

Source: ClearView Energy Partners, LLC, using Library of Congress data as of March 30, 2015

▼

Risks and Disclosures

RISKS

Legislative, regulatory and diplomatic agendas are subject to change.

ANALYST CERTIFICATIONS

I hereby certify that the views expressed in the foregoing research report accurately reflect my personal views as of the date of this report. I further certify that no part of my compensation was, is or will be directly or indirectly related to the specific recommendations or views contained in this research report.

By: *Timothy T. Cheung*

I hereby certify that the views expressed in the foregoing research report accurately reflect my personal views as of the date of this report. I further certify that no part of my compensation was, is or will be directly or indirectly related to the specific recommendations or views contained in this research report.

By: *Kevin Book*

I hereby certify that the views expressed in the foregoing research report accurately reflect my personal views as of the date of this report. I further certify that no part of my compensation was, is or will be directly or indirectly related to the specific recommendations or views contained in this research report.

By: *F. Chase Hutto, III*

I hereby certify that the views expressed in the foregoing research report accurately reflect my personal views as of the date of this report. I further certify that no part of my compensation was, is or will be directly or indirectly related to the specific recommendations or views contained in this research report.

By: *Christine Tezak*

I hereby certify that the views expressed in the foregoing research report accurately reflect my personal views as of the date of this report. I further certify that no part of my compensation was, is or will be directly or indirectly related to the specific recommendations or views contained in this research report.

By: *Timothy Y. Fox*

DISCLOSURES

The opinions, forecasts, recommendations, projections and interpretations of macro events contained in this report are those of the analysts preparing this report and are based upon information available to them as of the publication date of this report.

The analysts preparing this report based the opinions, forecasts, recommendations, projections and interpretations of macro events contained herein on sources they believe to be accurate and reliable, but completeness and/or accuracy is neither implied nor guaranteed.

The opinions, forecasts, recommendations projections and interpretations of macro events contained herein are subject to change without notice.

The analysts preparing this report are not registered lobbyists and do not advocate or lobby for any particular policy action on behalf of clients.

Although this report may mention specific companies by name and/or specific industries and industry sectors, this report was not prepared, is not intended and should not be interpreted as a research report regarding the equity securities of any company.

Climate Sensitivity and Mitigation strategy

November 21, 2014

Yoichi Kaya, Mitsutsune Yamaguchi

RITE

Contents

IPCC has changed Climate Sensitivity from 2-4.5 degree to 1.5-4.5 degree

What is climate sensitivity?

1. Two methodologies of estimating Climate Sensitivity
2. 2050 target and 3 degree C climate sensitivity
3. Difference of trajectory to achieve so-called 2 degree target between climate sensitivity of 3 degree and 2.5 degree

Two methodologies

1. Global Circulation Model

    Take into consideration of all thinkable climate phenomenon

    Main stream methodologies at IPCC

2. Observed based calculation

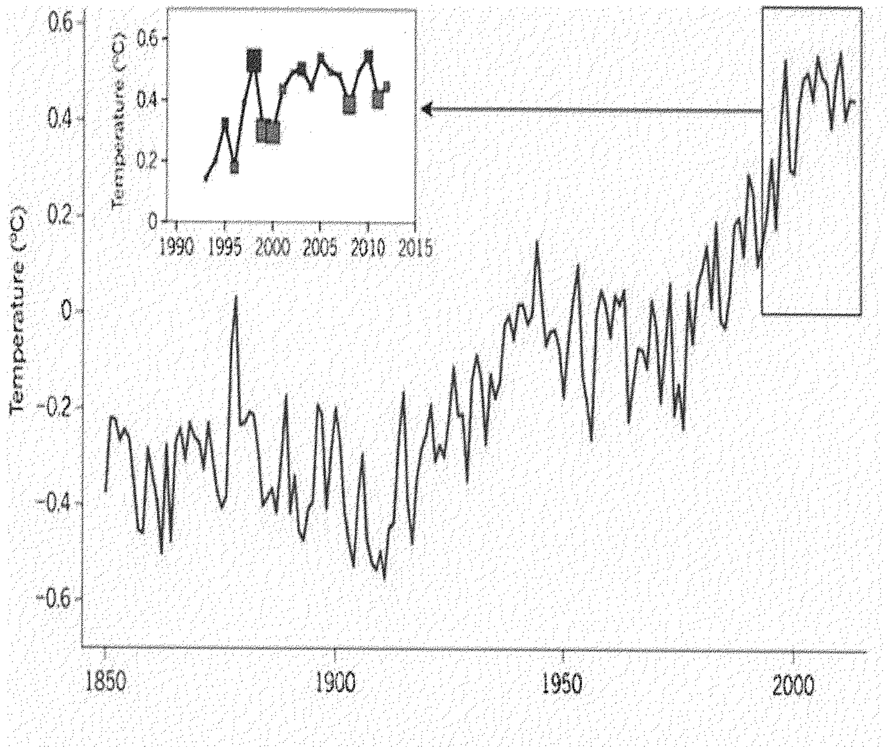
    Simple energy balance model based on observation (rather new)

Equilibrium Climate Sensitivities

Huge differences between two methodologies

	likely	best estimate
IPCC AR4	2.0 ~ 4.5 degree	3.0 degree
AR5	1.5 ~ 4.5 degree	not shown
J.Curry* (observation based)	1.25 ~ 2.45	1.64

*Base period 1859-1882, Final period 1995 -2011
from the paper "Climate dynamics" September, 2014



Hiatus

Source : Kosaka .Y & S.P. Xie,Nature,vol.501,2013

Main stream GCM can not explain hiatus, while observation Energy Balance Model can.

50% global reduction lost base in AR5

AR4: To achieve 2 degree target, at least 50% global reduction is necessary (base year 2000)

Table SPM.5: *Characteristics of post-TAR stabilization scenarios [Table TS 2, 3.10][a]*

Category	Radiative forcing (W/m^2)	CO_2 concentration[c] (ppm)	CO_2-eq concentration[c] (ppm)	Global mean temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity[b, c] (°C)	Peaking year for CO_2 emissions[d]	Change in global CO_2 emissions in 2050 (% of 2000 emissions)[d]
I	2.5-3.0	350-400	445-490	2.0-2.4	2000-2015	-85 to -50
II	3.0-3.5	400-440	490-535	2.4-2.8	2000-2020	-60 to -30

AR5 To achieve 2 degree target, at least 41% global reduction is necessary (base year 2010)

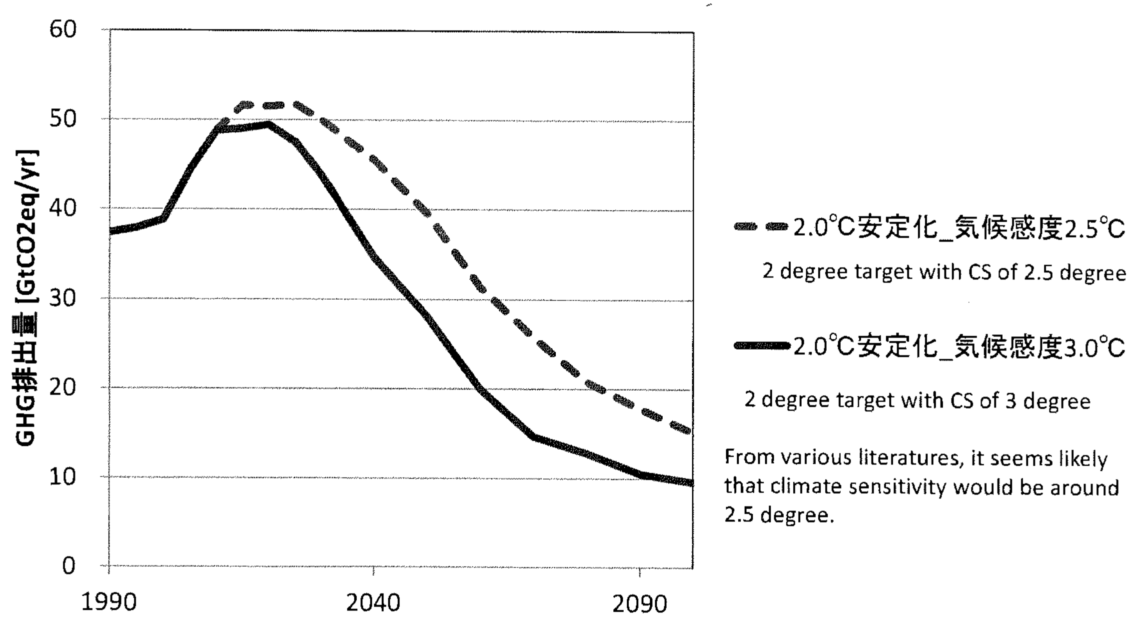
2100年濃度 (CO_2eq.) Category label (Concentration range)	オーバーシュートの有無	RCPとの関係	必要排出削減割合 (2010年比) 2050	必要排出削減割合 (2010年比) 2100	気温上昇 (1850-1900年比) 2100年の気温上昇 (℃)	気温上昇 (1850-1900年比) 21世紀中に2℃未満に止まる確率
<430	430 ppm CO_2eq.未満についてはモデルによる研究例僅少					
450 (430-530)	Total range	RCP2.6	-72 to -41	-118 to -78	1.5-1.7 (1.0-2.8)	66%以上
500 (480-530)	No overshoot of 530 ppm CO_2eq.		-57 to -42	-107 to -73	1.7-1.9 (1.2-2.9)	50%以上
	Overshoot of 530 ppm CO_2eq.		-55 to -25	-114 to -90	1.8-2.0 (1.2-3.3)	33-66%以上

72～41% reduction from 2010 ＝ 66～28% reduction from 2000
57～25% reduction from 2010 ＝47～ 8% reduction from 2000

Difference of emission trajectories

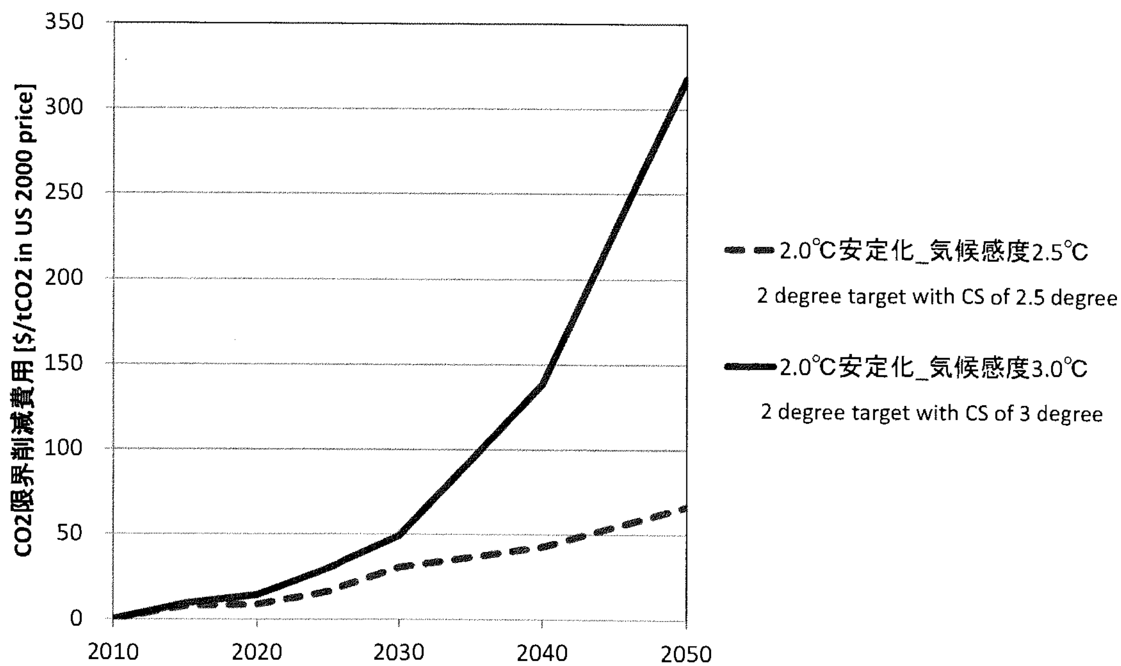
- As explained, IPCC has changed Climate sensitivity from 2.0-4.5 to 1.5-4.5 degree.
- Also best estimate was not shown in AR5, while it was 3.0 degree. The reason was “because of a lack of agreement on values across assessed lines of evidence and studies” (IPCC AR5/WG1). On the other hand, most calculations have been based on best estimate of 3 degree used in AR4.
- What will happen if we use best estimate of 2.5 degree or lower? This suggest huge uncertainty.

Difference of GHG emissions trajectories to achieve 2 degree target with different CSs

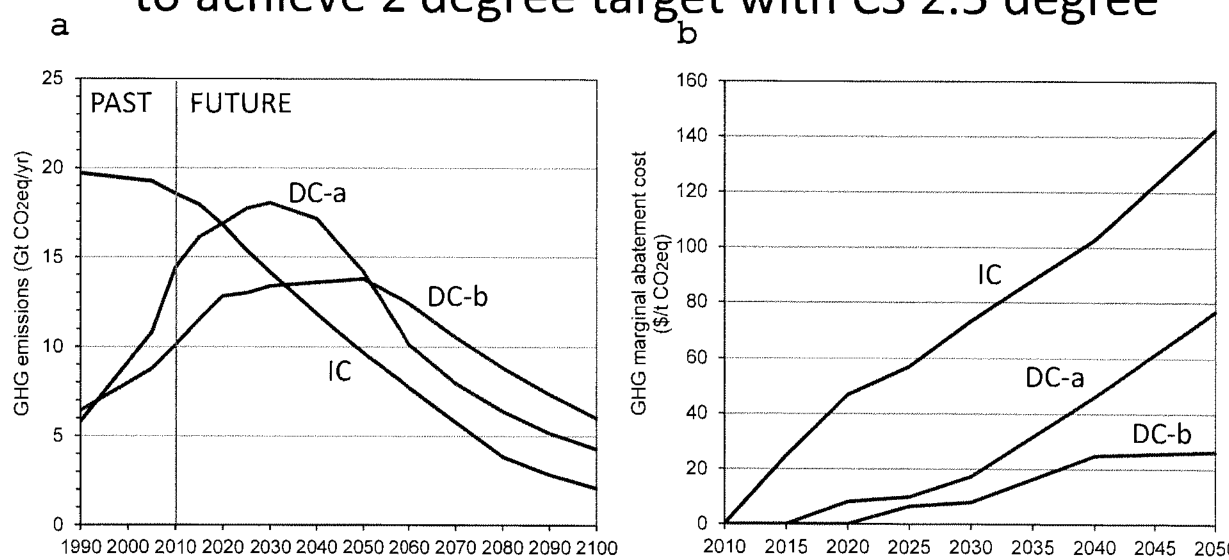


From various literatures, it seems likely that climate sensitivity would be around 2.5 degree.

Global Carbon prices with different CSs



Emissions pathways and costs for 3 groups to achieve 2 degree target with CS 2.5 degree



Carbon Prices of three different groups

IC: Industrialized countries

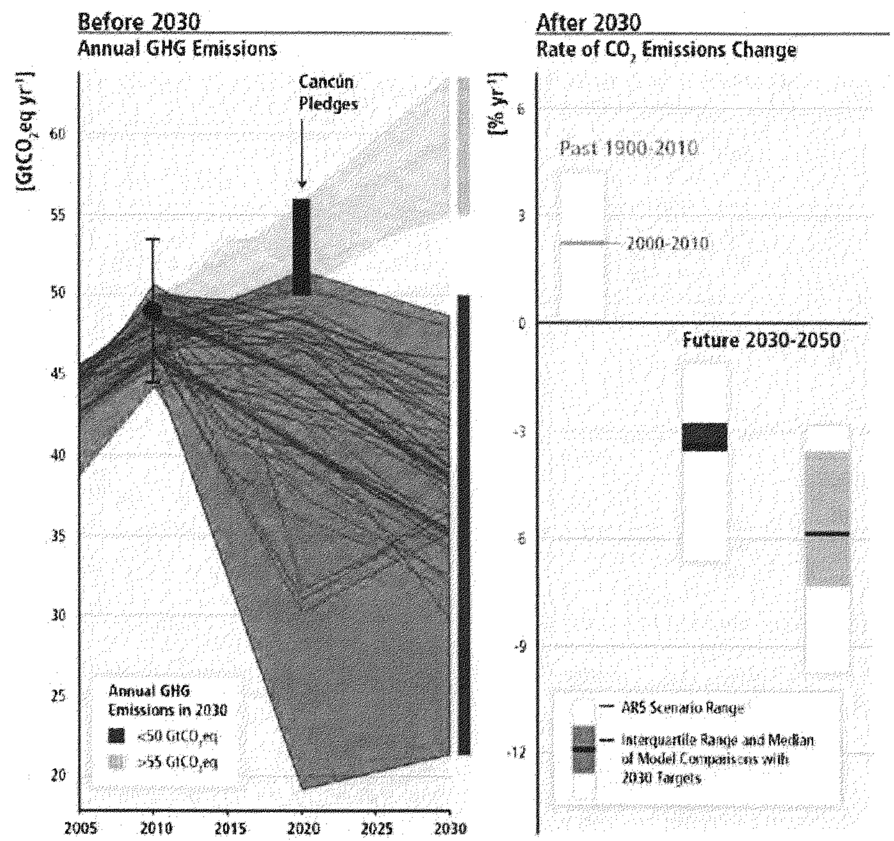
DC-a: China, India, Brazil（peaking 2030)

DC-b: Other developing countries （peaking 2040)

Feasibility of 2 degree target

2 degree target is not based on science

- Recent US-China deal on climate change made it impossible to achieve 2 degree target if we stick to climate sensitivity of 3 degree.
- Even Cancun pledge is not on track to 2 degree target. The deal means that China continues to increase its emissions until 2030. And both US and China are not domestically bound. Both countries “intends” to do their best.
- India may continue its emissions until 2050.



Cancun Pledge and 2 degree target

AR5 SYN Fig SPM.12

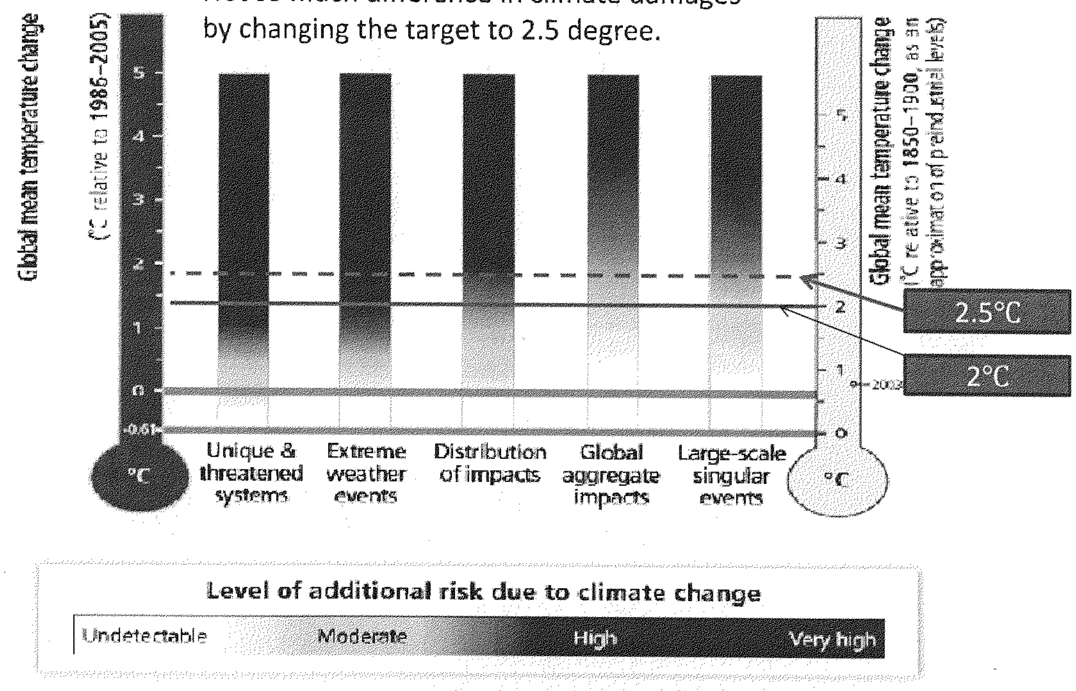
What we should do?

Strong weak agreement is better than weak strong agreement

1) Change the target to, for example, 2.5 degree
2) Make 2 degree as explicitly aspirational
3) If we follow AR5 outcome, 28% (not 50%) global reductions by 2050 can be "likely" to achieve the target (thanks to overshoot scenarios).
4) Even 8% global reductions, we still have 33-66% probability to achieve the target.
5) To use best estimate of CS such as 2 or 2.5 degrees. This makes trajectories very different.

IPCC WGII AR5 Summary for Policymakers

Not so much difference in climate damages by changing the target to 2.5 degree.



Reasons for Concern)

United States Senate

WASHINGTON, DC 20510

April 1, 2015

The Honorable Gina McCarthy
Administrator
Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460

Dear Madam Administrator:

During the March 4, 2015, Committee on Environment and Public Works hearing on the Environmental Protection Agency's (EPA) Fiscal Year 2016 budget, several important questions regarding current climate science and data were raised. Although questions regarding the impacts of climate change were clear and straightforward, none of the questions received direct answers, and many responses contained caveats and conditions.

We write today to emphasize that these questions were not posed lightly or in passing. In fact, questions related to whether projected climate impacts are actually occurring are critical to verifying EPA's commitment to the best science and data, especially as the agency proposes costly carbon dioxide emissions reductions throughout the United States. Stated differently, given that the Administration's proposal to fundamentally change the nature of domestic electricity generation is based on the apparent need to avoid "devastating" climate impacts to the United States and the planet, it is imperative that the agency be candid and forthright in assessing the reality of this projection.

EPA must demonstrate its commitment to sound science and data by providing prompt and thorough responses to questions from Congress. Accordingly, we request and look forward to detailed answers to the following questions:

Drought

1) In its 2013 Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) concluded the following:

> [T]here is not enough evidence at present to suggest more than low confidence in a global-scale observed trend in drought or dryness (lack of rainfall) since the middle of the 20th century, owing to lack of direct observations, geographical inconsistencies in the trends, and dependencies of inferred trends on the index choice. Based on updated studies, AR4 conclusions regarding global increasing trends in drought since the 1970s were probably overstated. However, it is likely that the frequency and intensity of drought has increased in the Mediterranean and West Africa and decreased in central North America and north-west Australia since 1950.

Do you agree or disagree with the IPCC's conclusion? Please provide all data, analyses, and other evidence that you reviewed and relied on to reach your conclusion.

2) In its Special Report on Extreme Events (*Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*), the IPCC concluded the following:

> There is medium confidence that since the 1950s some regions of the world have experienced a trend to more intense and longer droughts, in particular in southern Europe and West Africa, but in some regions droughts have become less frequent, less intense, or shorter, for example, in central North America and northwestern Australia.

Similarly, the U.S. Climate Change Science Program's 2008 report (*Weather and Climate Extremes in a Changing Climate*) concluded:

> [D]roughts have, for the most part, become shorter, less frequent, and cover a smaller portion of the U. S. over the last century.

Do you agree or disagree with these two conclusions? Please provide all data, analyses, and other evidence that you reviewed and relied on to reach your conclusion.

3) At the March 2015 budget hearing, Senator Sessions asked for "the worldwide data about whether or not we are having fewer or less droughts." You responded, "I am happy to provide it but I certainly am aware that droughts are becoming more extreme and frequent."

a. Please provide all data, analyses, and other evidence held or used by EPA regarding worldwide drought frequency.

b. Please provide all data, analyses, and other evidence which warranted your conclusion that "droughts are becoming more extreme and frequent."

<u>Hurricanes/cyclones</u>

1) The IPCC Fifth Assessment Report concluded the following:

> Current data sets indicate no significant observed trends in global tropical cyclone frequency over the past century. . . . No robust trends in annual numbers of tropical storms, hurricanes and major hurricanes counts have been identified over the past 100 years in the North Atlantic basin.

   Do you agree or disagree with the IPCC assessments regarding data sets on global tropical cyclone frequency and trends in annual tropical storms, hurricanes, and major hurricanes in the North Atlantic basin?

2) Does EPA have any data, analyses, or other evidence demonstrating an increase in global tropical cyclone (hurricane) frequency over the past century? If so, please provide such data, analyses, or evidence.

3) Does EPA have any data, analyses, or other evidence demonstrating an increase in the annual number of tropical storms, hurricanes and major hurricanes over the past 100 years in the North Atlantic basin? If so, please provide such data, analyses, or evidence.

4) At the March 2015 budget hearing, Senator Sessions asked whether there have been more or less hurricanes in the last decade. You responded that "[t]here have been more frequent hurricanes and more intense." Please provide all data, analyses, and other evidence which warranted your response.

5) Do you agree or disagree that is has been nearly ten years since the last major hurricane struck the United States?

Temperature data

1) Dating back to the 1970's, IPCC climate models have historically predicted a significant increase in global temperatures. At the March 2015 budget hearing, Senator Sessions asked "[i]f you take the average of the models predicting how fast the temperature would increase, is the temperature in fact increasing less than that or more than that?"

   You replied that you could not "answer that question specifically," but later committed to submitting written information explaining whether you believe the models have been proven correct and whether temperatures have increased less than projected or more than projected.

   Please provide data and analyses showing actual global average temperatures since 1979 versus IPCC predictions, including an EPA-produced chart comparing actual global average temperature increases since 1979 (when satellite temperature data became available) versus the latest IPCC predictions. Please also provide your conclusion on whether IPCC climate models have proven correct.

2) At the March 2015 budget hearing, you stated "[t]here are many models and sometimes it is actually going faster and sometimes slightly slower than the model predicts, but on the whole, *it makes no difference* to the validity and the robustness of climate science that is telling us that we are facing an absolute challenge that we must address both environmentally and economically from a national security perspective, and for EPA, from a public health perspective."

   Do you agree that EPA has a duty to review and verify the accuracy of climate projections which have served as the basis for the agency's regulatory policy and agenda?

Climate impact monitoring

1) According to EPA's website, the agency's Office of Environmental Information "manages the life cycle of information to support EPA's mission of protecting human health and the environment" and "ensure[s] the quality of EPA's information."

   The Office's Quality Management Program develops "Agency-wide policies, procedures and tools for quality-related activities relating to the collection and use of environmental information."

In addition, EPA's Office of Information Collection "works in collaboration with EPA partners and customers to develop and implement innovative policies, standards and services that ensure that environmental information is efficiently and accurately collected and managed."

What policies do these and other offices at EPA have in place to monitor and verify the accuracy of agency climate projections? Please provide all reports, analyses, memoranda, and other information from the past ten years in which EPA has reviewed the accuracy of its climate projections.

2) What portion of EPA's budget request for FY 2016 is dedicated to monitoring and verifying the accuracy of the agency's climate projections?

Please provide your responses no later than April 21, 2015.

Very truly yours,

Senator Jeff Sessions

Senator James M. Inhofe

Senator Roger Wicker

Senator John Barrasso

American Enterprise Institute
for Public Policy Research

Subcommittee on Oversight and Investigations

House Committee on Foreign Affairs

"UN Climate Talks and Power Politics: It's Not about the Temperature"

Prepared Statement of Steven F. Hayward

Resident Scholar

American Enterprise Institute

May 25, 2011

The views expressed in this testimony are those of the author alone and do not necessarily represent those of the American Enterprise Institute.

Chairman Rohrabacher, Ranking member Carnahan, and members of the committee:

I will begin with my contentious conclusion, which is that the international diplomacy of climate change is the most implausible and unpromising initiative since the disarmament talks of the 1930s, and for many of the same reasons; that the Kyoto Protocol and its progeny are the climate diplomacy equivalent of the Kellogg-Briand Pact of 1928 that promised to end war (a treaty that is still on the books, by the way), and finally, that future historians are going to look back on this whole period as the climate policy equivalent of wage and price controls to fight inflation in the 1970s.

The diplomatic approach—the United Nations Framework Convention on Climate Change UNFCCC)—first set in motion formally at the Rio Earth Summit in 1992 has reached a dead end. I think the dead end of what might be called "first generation climate diplomacy" was tacitly on view at the last major climate summit in Cancun a few months ago. It is important to understand the deeper reasons why if we are going to chart a new course on climate that has a better chance of making real progress.

When the issue of climate change came to the fore in the late 1980s, the diplomatic community approached it in a way that seemed eminently sensible on the surface: what diplomatic frameworks have worked before for similar kinds of global problems? In other words, diplomats reached for what was on the shelf. There were basically three models for problems of global reach that had shown varying degrees of success: the arms control and anti-proliferation regimes; the long-running and painstaking trade liberalization process; and third and perhaps most applicable, the Montreal Protocol that facilitated the organized phase out of chloroflourocarbons. The last two, especially the Montreal Protocol, are the precedents that former Vice President Gore liked to cite as reasons for his support and enthusiasm for the Kyoto Protocol. And on the surface the comparative logic seems plausible: if we can reach a binding and enforceable agreement to phase out chloroflourocarbons, why not a similarly-structured agreement to phase out hydrocarbons?

But once you poke beneath the surface, a number of fundamental asymmetries between these precedents and the problem of climate change become apparent, but whose implications were resisted for the understandable reasons of diplomatic and institutional inertia. I'll confine myself to just a few of the many that came into play.

First, the problem of climate change is orders of magnitude more complex and difficult than the problem of ozone depletion. It is not necessary to embrace the skeptical position about "uncertainty" in climate science to suggest that the same kind of policy dynamic found in the problem of the ozone layer would not work equally well for a warming planet. In the case of chlorofluorocarbons and the ozone layer, the scientific evidence was straightforward, the time scale was relatively short, and, most importantly, there were scalable substitutes for CFCs available at a reasonable cost. By contrast, the climate science is much more complex, and even if the complexities wash out, the focus on near-term reductions in greenhouse gas emissions is unlike the near-term reduction in CFCs under the Montreal Protocol for a blindingly simple reason: *There are no economically-scalable substitutes to fossil fuels available on the global level and in the relatively short time frame contemplated by climate orthodoxy.*

The second asymmetry concerns the divide in interests between wealthy nations and poorer developing nations. Poor nations have an overriding interest in affordable energy, which means cheap energy, which means fossil fuel energy. The architects of the Kyoto Protocol recognized this, just as we have recognized this in the trade liberalization process and in the phase out schedules of the Montreal Protocol. But the two-tiered structure of emission limit commitments contemplated in Kyoto came at the very moment that the mid-20th century's conceptual dichotomy between "developed" and "developing" nations was breaking down very rapidly. The hazard of potentially costly emissions limits for wealthy nations was that it would accelerate the globalizing trend of driving manufacturing activity to the developing nations. In fact, the two-tiered architecture of the climate emissions restrictions actually increased the near-term incentives for developing nations to resist emission limits. We should not have been surprised that many developing nations, especially China and India, made it clear that they will not go along with binding emission limits for future iterations of the Kyoto Protocol. In this respect climate diplomacy foundered on the same kind of problems that have made the trade liberalization process so slow and excruciating, even though it is a process that promises to make everyone richer. A process that entails slowing down economic growth, even marginally, is going to be much more difficult to achieve.

The more recent answer to this problem was climate assistance to developing nations. On the merits this policy is incommensurate with the nature and scale of the problem, and appears more as an attempt simply to bribe developing nations into going along with the preferred agenda of wealthy nations. Many developing nations are happy to go along with the charade if we'll actually send the cash.

One of the problems of the sheer sprawling nature of climate change science and policy is that it became something of an all-purpose issue on which advocates could attach their pet ideas and concerns. The idea of climate adjustment assistance has revived at the UN an old idea from the 1970s—what was called then the "New International Economic Order." The premise of the New International Economic Order, as explained at the time by West Germany's Chancellor Willy Brandt, was that there needed to be "a large scale transfer of resources to developing countries." This was back in the hey-day of post-colonial Western guilt, and it came to an abrupt end in the 1980s when President Reagan forcefully repudiated it at a UN summit in, coincidentally, Cancun.

But climate assistance has revived the old idea of requiring wealthy nations to indemnify poor nations. The German newspaper *Neue Zurcher Zeitung* observed shortly before the Cancun summit last year: "The next world climate summit in Cancun is actually an economy summit during which the distribution of the world's resources will be negotiated." What prompted this conclusion was a candid admission from a UN official closely involved with the climate negotiations, German economist Ottmar Edenhoffer: "But one must say clearly that we redistribute de facto the world's wealth by climate policy. Obviously, the owners of coal and oil will not be enthusiastic about this. One has to free oneself from the illusion that international climate policy is environmental policy. This has almost nothing to do with environmental policy anymore."

This is the kind of loose and unserious talk that brings discredit to the UN and to international climate diplomacy. But it is very popular with much of the UN's constituency, and America's diplomatic corps indulges this mentality with polite indifference. With only a few exceptions, such as under Pat Moynihan in the 1970s and Jeanne Kirkpatrick in the 1980s, American diplomats do not call out this kind of redistributionist enthusiasm, or if they have, that fact goes un-advertised to the American public, which quite sensibly hears these kinds of sentiments and forms a low opinion of the UN.

I conclude briefly with two observations. First, the nation that made the largest climate assistance commitment at Cancun—to the tune of $15 billion—was Japan. I don't think there is anyone who thinks Japan should make good on that commitment right now. This suggests how events may rapidly change our perceptions and priorities of risk.

Second, what approach can replace the UN diplomatic track? This is a long subject, but a more likely path to more significant climate outcomes would focus not on emissions limits but an emphasis on cheap decarbonization of energy through innovation, the approach we at AEI have recommended in collaboration with the Brookings Institution and the Progressive-leaning Breakthrough Institute in California in a report called "Post-Partisan Power." And the diplomatic framework for this would ignore the UN and start with the leading economies of the OECD nations, a process begun tentatively by the Bush Administration, but which now appears to have been embraced by the Obama Administration in the aftermath of the failures of Copenhagen and Cancun.

For a more detailed explanation of this strategy, I recommend "The Hartwell Paper," a very thoughtful analysis of the issue produced by the Institute for Science, Innovation, and Society at Oxford University in 2009 (http://www2.lse.ac.uk/researchAndExpertise/units/mackinder/theHartwellPaper/Home.aspx). A follow-up paper from the Hartwell group, which I have joined, is being finished this afternoon, in fact. I'd also recommend the recent book from Roger Pielke Jr. of the University of Colorado entitled *The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming.*

You Ought to Have a Look: Parisian Promises

APRIL 6, 2015 8:59AM

By PATRICK J. MICHAELS and PAUL C. "CHIP" KNAPPENBERGER

You Ought to Have a Look *is a feature from the Center for the Study of Science posted by Patrick J. Michaels and Paul C. ("Chip") Knappenberger. While this section will feature all of the areas of interest that we are emphasizing, the prominence of the climate issue is driving a tremendous amount of web traffic. Here we post a few of the best in recent days, along with our color commentary.*

—

In Paris this December, the U.N. will hold its 21st Conference of the Parties (COP) to the 1992 Rio Treaty (officially known as the UN framework Convention on Climate Change). Like the 20 previous COPs, the goal will be to entice (browbeat) as many countries as possible to commit to reducing greenhouse gas emissions in an attempt to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." ["Dangerous anthropogenic interference" has been defined to mean a global average temperature rise of more than 2.0°C above the preindustrial global average temperature. We are highly doubtful that a 2.0°C rise (of which we are more than a third of the way there) will actually prove "dangerous" especially when adaptations are factored in, but we digress.]

And like the 20 COPs that have come before, COP 21 will fail—largely because greenhouse gas emissions result primarily from burning fossil fuels to produce the energy which powers the modern economy. Those with a modern economy want to keep it rolling along, and those without, desperately strive for one. Neither group is willing to budge much from these wishes. Consequently global emissions continue to rise.

Even the U.N. now is beginning to realize that meeting a 2.0°C warming target is virtually impossible—this despite rather absurd new calls for the target to be lowered to 1.5°C.

Nevertheless, the U.N. continues to go through the motions (after all, COPs are big business).

At last year's COP 20, held in Lima, Peru, the best that everyone could agree on was assigning each country some homework along the lines of this: Describe what types of greenhouse gas emissions reductions (with targets and timetables) that you feel you may undertake; justify your answer. The assignment was due on March 31. Most countries are tardy.

Under U.N. terminology, the homework must include a declaration of each country's "Intended Nationally-Derived Contributions (INDCs)" –that is, what each "intends" to do to reduce their carbon dioxide (and other greenhouse gas) emissions.

A look through some of the work that has been handed in on time reveals a strange mèlange on "intentions."

For example, Russia's INDC reveals that its declared intent to the U.N. is less stringent than what it already intends to do via its own existing domestic programs. The chart below points out this rather odd occurrence:

Russia's Submitted INDC

INDC	**Limiting anthropogenic greenhouse gases in Russia to 70-75% of 1990 levels by the year 2030 might be a long-term indicator, subject to the maximum possible account of absorbing capacity of forests.**

Planning processes and forecasts	The Russian Federation currently has in force legally-binding instruments aimed at providing for limitation of the GHG emissions to 70-75% of 1990 levels by the year 2020 (Decree of the President of the Russian Federation of 30 September 2013 and Act of the Government of the Russian Federation of 2 April 2014 No. 504-p). These acts provide for organization of GHG emissions forecasting at the economy-wide scale and for each individual sector. The Russian Federation will further elaborate and adopt legislative and regulatory acts providing for achievement of the stated INDC target by 2030 based on the provisions of the Climate Doctrine and the Energy Strategy of the Russian Federation.

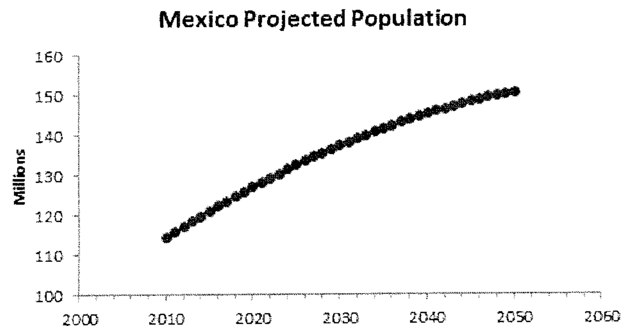
Basically, if we are understanding this right, Russia is proposing to the U.N. a more lax timetable than required via its existing domestic programs and a reliance to the "maximum possible" extent on carbon credits from carbon dioxide uptake by boreal forests.

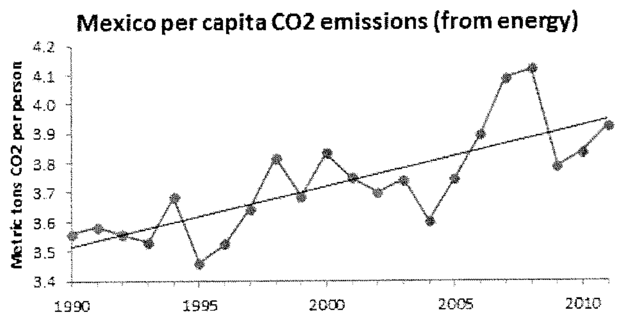
The Russian proposal already has enviros wringing their hands.

Let's move on to Mexico. What they claim they intend to do is virtually impossible.

Mexico says it intends to peak its national CO2 emissions in 2026—just 11 years from now.

That'll be some trick; the charts below show why. The top one is Mexico's population projections between 2010 and 2050. The forecast is for a robustly growing population, adding over 30 million people by 2050—all of which presumably will require energy to subsist. The bottom figure shows Mexico's per capita greenhouse gas emissions history for the past 20 years. Again, robust growth indicating that Mexico is increasingly meeting its growing energy needs via the use of greenhouse gas-emitting fossil fuels.





Yet Mexico tells the U.N. that it intends, in just over a decade, not only to halt the growth in per capita emissions, but to turn it downwards to such an extent as to offset population increases. And keep it heading that way.

Predictably, environmental activists hailed Mexico's announcement.

The real world, on the other hand, isn't so kind, revealing Mexico's "intention" as being an empty promise.

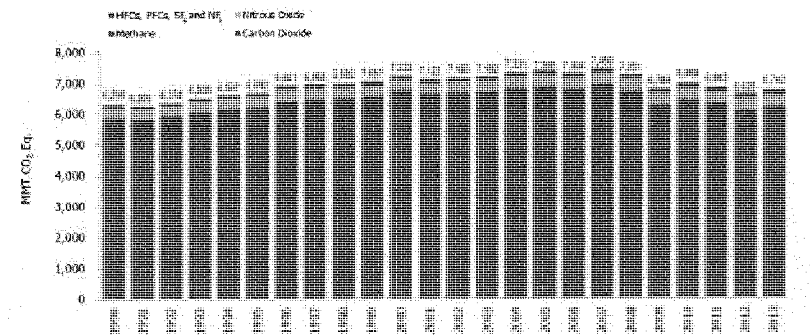
And what about the U.S.?

The U.S. announced its intentions as:

The United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26%-28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%.

Turns out that this a bit less than we proposed to do in when we were negotiating at the UN's 15th COP in Copenhagen in 2009. There we pledged a 30% reduction by 2025 and a 42% reduction by 2030. Our declining pledge is probably is deference to a thing called reality—as depicted in the figure below (taken from the EPA).

Figure ES-1: U.S. Greenhouse Gas Emissions by Gas
Note: Emissions values are presented in CO2 equivalent mass units using IPCC AR4 GWP values.



As seen in the figure, in Copenhagen, in 2009, greenhouse gas emissions from the U.S. had been on the decline for about 5 years, and stood at 8% below our emissions in 2005. Now, five years later, the picture isn't as rosy. Between 2009 and 2013 (the last year in the EPA has made data available), there has been scant change in our emissions (early indications for 2014 are for emissions up a bit from 2013). This despite natural gas replacing some coal-fired electricity generation (natural gas produces only about half the greenhouse gas emissions as does coal) and higher fuel economy cars.

The President is finding that it is hard to grow the economy and reduce greenhouse gas emissions at the same time (something that we have been saying for a long time).

Consequently, he is paring back our emission targets and timetables.

But no matter the details, *any* U.S. plan will never contribute much to mitigating future global climate change.

Here's why: even under the assumption we cut our fossil fuel emissions 100% by the year 2050 (the President's plan only calls for cuts of about 80%), the amount of future global warming that will be averted is about 0.05°C by the year 2050 and 0.14°C by the year 2100. That's it! Fourteen-hundredths of a degree—that's what all the hubbub over carbon taxes, power plant emissions restrictions, Keystone XL pipeline, electric cars, ethanol, etc. is all about. *Fourteen-hundredths of a degree.* And even that is being generous, because it assumes a climate sensitivity to greenhouse gas emissions that is a good 50 to 100 percent greater than what many new scientific studies are pointing to. If we do the same calculation using a climate sensitivity of 2°C rather than 3°C, the warming averted by the year 2100 drops to 0.10°C (one-tenth of a degree).

You can see all this for yourself using our global temperature savings calculator—a great tool (based on a model developed in part by EPA funding) that everyone contemplating greenhouse gas emissions limitations ought to have at their fingertips.

To get a sense of the temperature savings from what the U.S. is intending for Paris, use our tool and select a "CO2 Reduction" of 80% from the U.S.—that scenario matches very closely to the current U.S. plan.

You'll find a grand total of about 0.11°C of temperature savings by the end of the century. Too little to matter. Impossible to verify. Scientifically insignificant.

All in all, pretty much par for the course when compared with the other INDCs.

We'll continue to track the Road to Paris. But thus far, it is a Road to Nowhere.

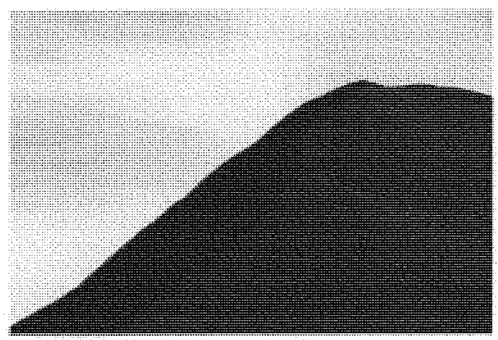
THE WALL STREET JOURNAL.

http://www.wsj.com/articles/japan-continues-to-re-embrace-coal-1426162227

JAPAN NEWS

Japan Continues to Re-Embrace Coal

Lack of nuclear energy prompts return to coal as other countries move away from 'dirty' fue source



Coal is stockpiled at the Onahama port of Iwaki in Fukushima Prefecture in February 2014. *PHOTO: BLOOMBERG NEWS*

By **MARI IWATA**
March 12, 2015 8:10 a.m. ET

TOKYO—Japan is continuing to re-embrace coal to make up for its lack of nuclear energy, with plans for another power station released Thursday bringing the number of new coal-fired plants announced this year to seven.

Utilities in Japan are eager to take advantage of coal's relative cheapness to give them a competitive edge at a time when other countries are seeking to reduce their greenhouse-gas emissions by moving away from a fuel source seen as dirty.

The liberalization of Japan's power industry by 2020 will pit power companies against each other as rivals for the first time. In addition, with a relaxation of restrictions on coal power and no new emissions targets on the horizon, utilities are increasingly seeing coal as an important part of their business plans.

Kansai Electric Power Co. and Marubeni Corp. informed Akita prefecture on Thursday of their plans to build a new, 1.3-gigawatt coal-fired power station in the northern prefecture of Japan, the two companies said.

If all seven projects including the plant in Akita materialize, they will increase the nation's coal-power generation by up to 7.26 gigawatts by around 2025. That is equivalent to seven medium-size nuclear reactors.

The two companies plan to build the power station in an industrial park on the northern coast of the Sea of Japan, with construction slated to begin around 2019 and commercial operations by around 2025. Spokespersons at each company said the relative shares in the project haven't been decided.

Kansai Electric, based in Osaka, plans to use the Akita project to supply electricity to customers in Tokyo, the only place in Japan where major growth in power demand is expected, a company spokesman said.

The other projects include Chubu Electric Power Co.'s plan to replace an old oil-power station near Nagoya with a 1 gigawatt coal-power station, and a 1.2 gigawatt coal-power station planned by Electric Power Development Co., Osaka Gas Co. and Ube Industries Ltd. in Yamaguchi prefecture in western Japan.

More projects are likely to be announced as the year goes on. Tokyo Electric Power Co. is holding a tender to build new power stations to replace 6 gigawatts of old oil-power capacity in Tokyo. The tender closes at the end of this month.

A company spokesman said it was likely coal would be used, given the need to secure competitive power sources, though he added that a decision hadn't been made yet.

The relative cheapness of coal was indicated in a 2011 government report that estimated the cost of coal power in Japan at ¥7.5, or about 6 cents, per kilowatt-hour including construction and operation. The same report put the cost of nuclear power at ¥9 per kwh, gas power at ¥10 per kwh and oil power at ¥19 per kwh.

The moves by the power companies are "understandable" in light of the prolonged nuclear outage that has forced power utilities to rely on old, inefficient oil- and gas-power stations, said Hidetoshi Shioda, energy-industry analyst of SMBC Nikko Securities.

All of Japan's 48 reactors are offline over safety concerns following the Fukushima nuclear accident, though four of them are expected to come back online later this year.

Before the nuclear accident in March 2011, the environment ministry had essentially blocked the building of new coal-power stations through tighter environmental assessments as Japan sought to meet ambitious greenhouse-gas reduction goals that have since been scrapped.

With the power industry straining to meet demand after the accident, the ministry loosened its policy to allow the building of new coal-power capacity provided it used the latest, most efficient technologies available.

Write to Mari Iwata at mari.iwata@wsj.com

A Practical and Realistic Climate Change Agenda

Honorable James L. Connaughton

February 2013

Current Situation in the United States

Global Goal:

- Bush and Obama: 50% Reduction by 2050
- Implies 80% from Developed Nations
- Not adopted by Congress under either party

National Goals:

- Bush (2002): Improve GHG Intensity 18% by 2012
  - ✓ Goal was achieved in 2012
- Bush (2008): Stop Emission Growth by 2025
  - ✓ May be on track, but outcome not certain
- Obama (2009): Reduce 17% Below 2005 by 2020
  - ✓ May be on track, but outcome not certain
- Obama (2011): 80% Clean Electricity by 2035

Contributing US Market Dynamics

Slower Economic Growth

- Lower Transportation Fuel Demand
- Flat and Potentially Decreasing Electricity Demand

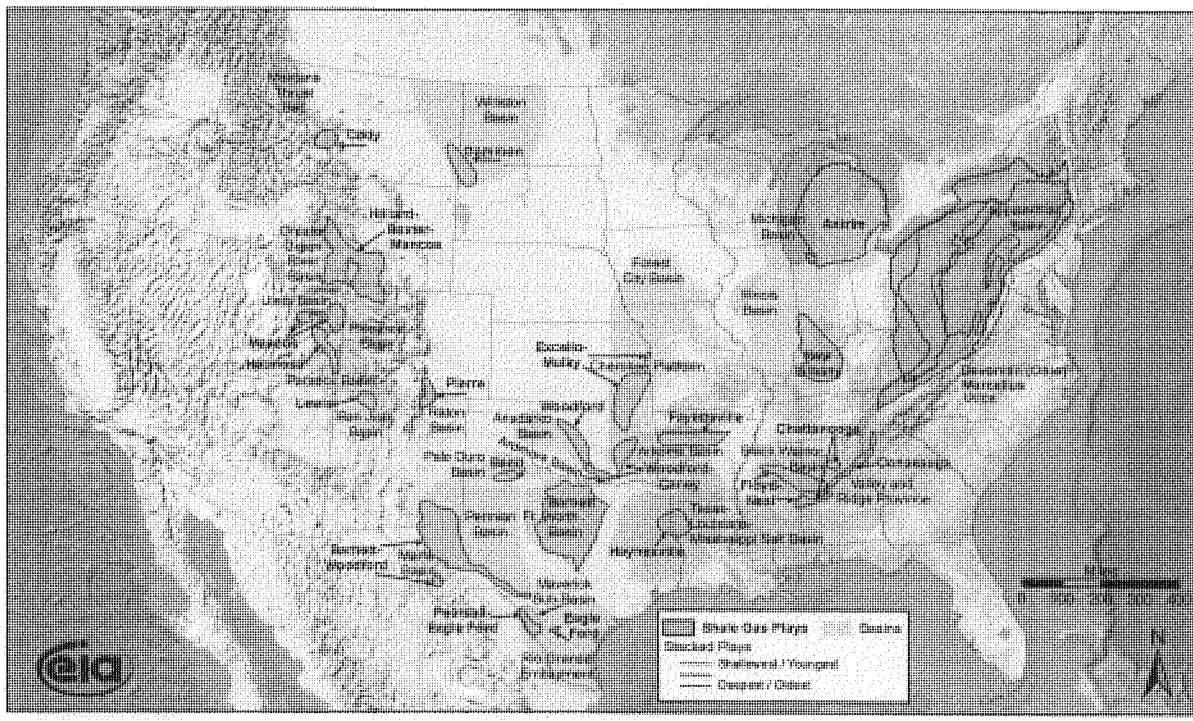
Advances in Efficiency and Price Demand Response

US Shale Gas

- Transformational Technology Breakthrough
- Collapsing Prices (consumers saved $100B)
- Replacing Coal Electricity Generation
  - Gas: 15% in 1988, 32% in 2Q 2012
  - Coal: 57% in 1988, 34.5% in 2Q 2012
  - Renewables: Only up 1%, mostly wind at night

Pending: Natural Gas Vehicles, LNG Exports?

Shale Gas Plays, Lower 48 States



Source: Energy Information Administration based on data from various published studies.
Updated: May 28, 2009

http://www.youtube.com/watch?v=LPfGoNvsqt0

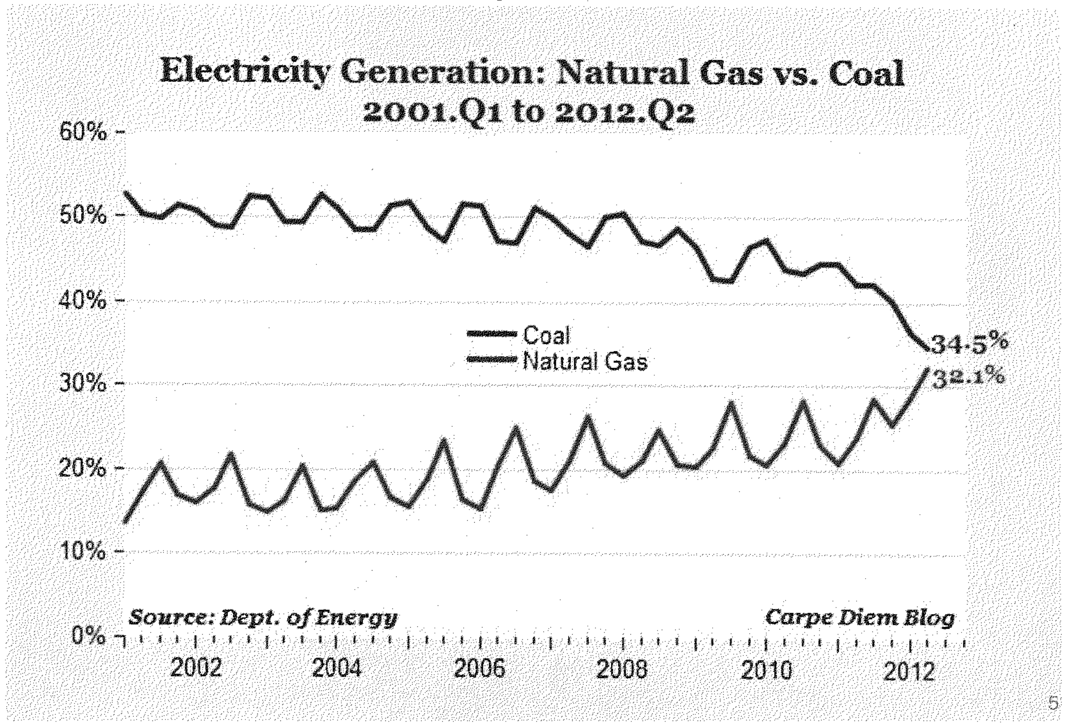
Contributing Policy Dynamics

9 Major Mandates	Supporting Incentives
Power Plant Air Pollution*	n/a
Vehicle Fuel Efficiency*	Tax Credits, Subsidies
Renewable Fuel*	Tax Credits (expired)
Lighting Efficiency*	Tax Credits, Subsidies
Appliance Efficiency	Rebates, Subsidies
Ozone Depleting Substances	n/a
Renewable Power* (30+ States)	Tax Credits, Emission Credits
Greenhouse Gases* (10 States)	n/a
Building Efficiency (State)	Tax Credits, Subsidies

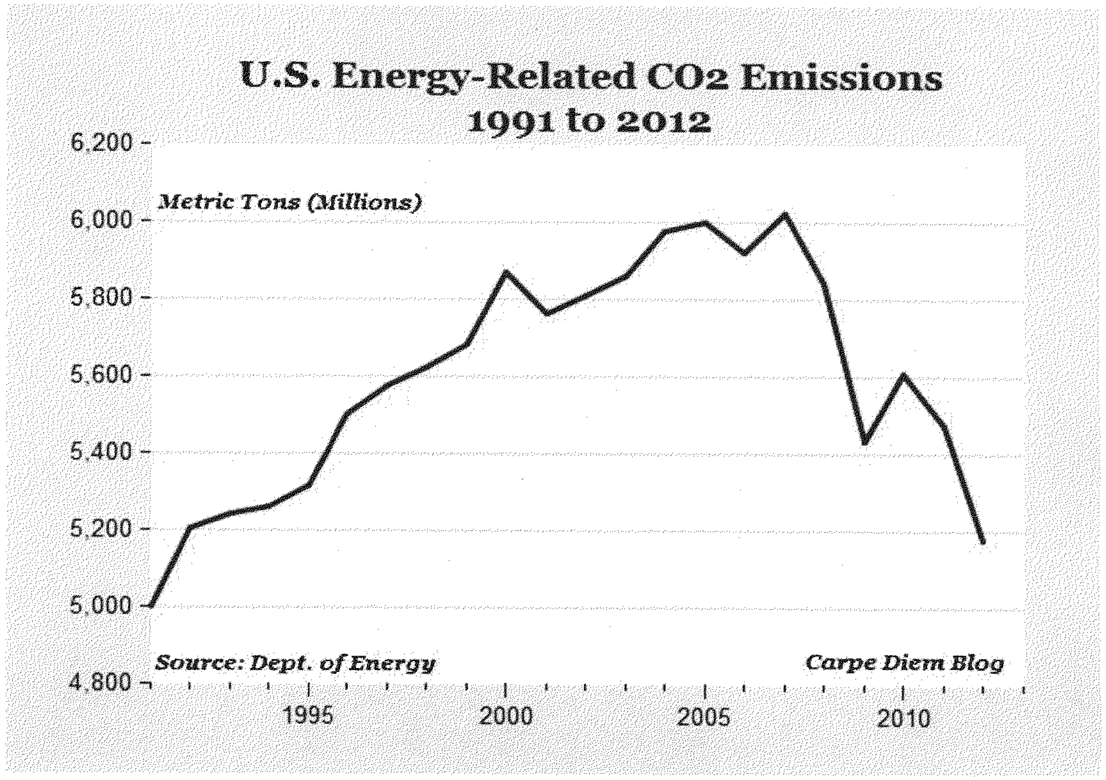
Pending: Clean Electricity Standard for Power Plants?
Economy-Wide "Cap and Trade" No Longer Plausible

* Uses market-based approach to varying degrees

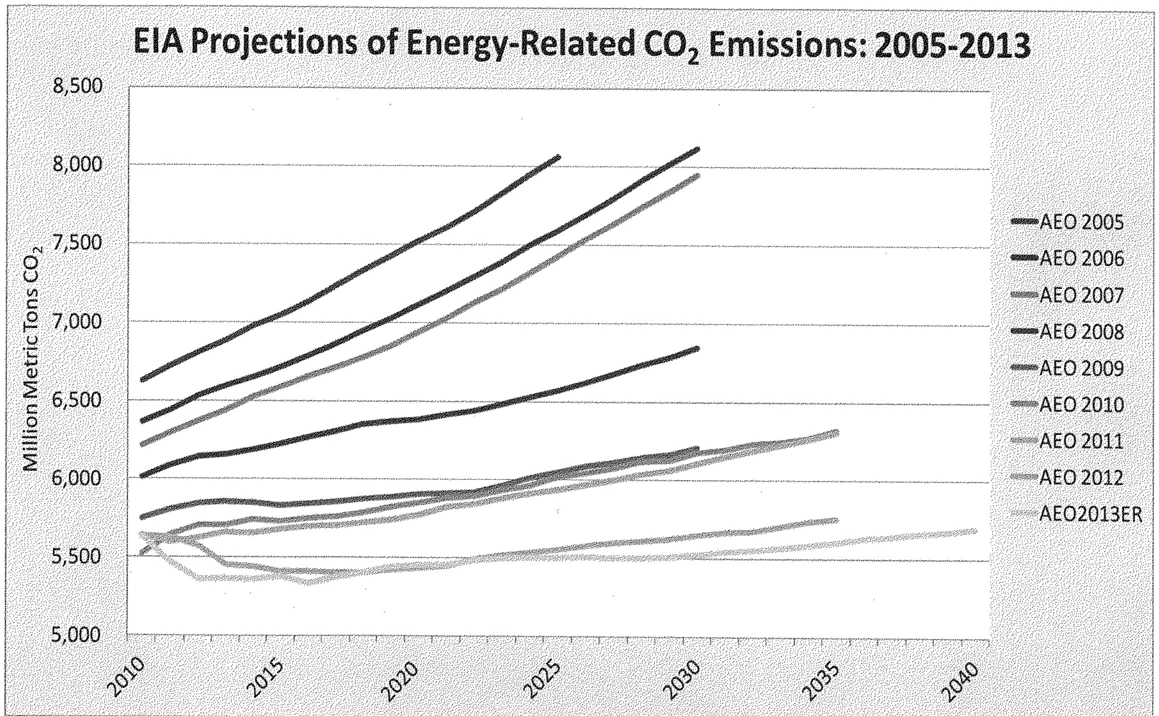
Gas Up and Coal Down Sharply in Electricity Generation



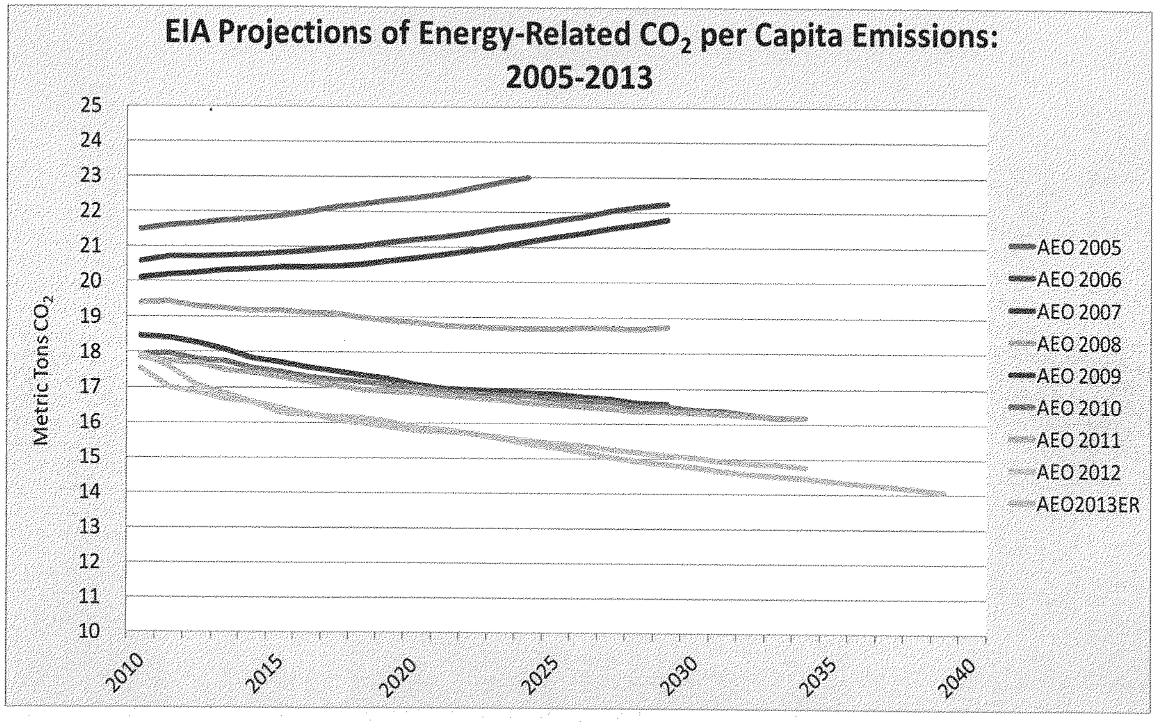
US Energy Emissions Returning to 1990 Levels



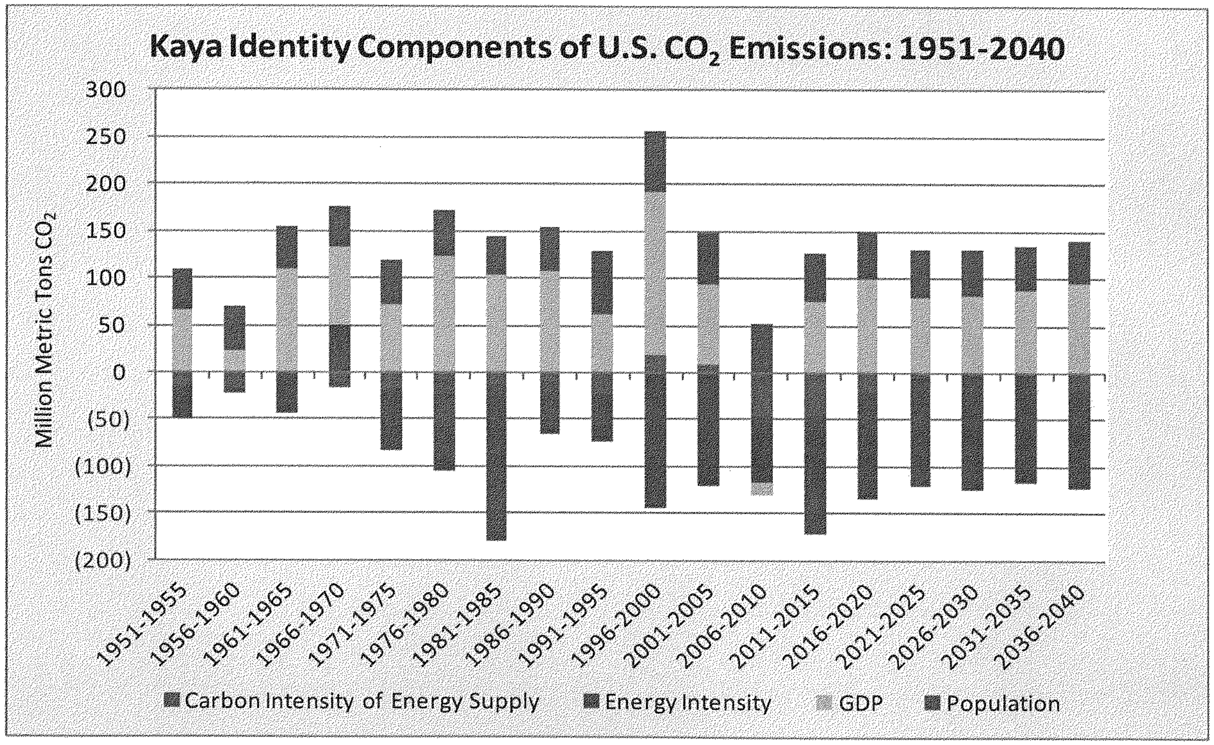
Results of Changing US Market and Policy



Results of Changing US Market and Policy



DECLINING TO FLAT KAYA IDENTITY



Impact of Carbon Prices on US Energy Costs

$20/ton adds about 20 cents to a gallon gasoline and 1 cent kwh to electricity

Energy Product	Additional Cost by Volume at:			Average 2011 Nominal Price	Percent Increase from 2011 at:		
	$20/Metric Ton CO_2	$50/Metric Ton CO_2	$100/Metric Ton CO_2		$20/Metric Ton CO_2	$50/Metric Ton CO_2	$100/Metric Ton CO_2
Distillate Fuel Oil (Residential) ($/gal)	$0.20	$0.51	$1.01	$3.66	5.5	13.9	27.7
Diesel (Transportation) ($/gal)	$0.20	$0.51	$1.01	$3.58	5.7	14.2	28.3
Motor Gasoline ($/gal)	$0.18	$0.44	$0.89	$3.42	5.2	13.0	25.9
Jet Fuel ($/gal)	$0.19	$0.48	$0.96	$3.04	6.3	15.7	31.5
Residual Fuel Oil (All Users) ($/gal)	$0.24	$0.59	$1.18	$2.64	8.9	22.3	44.7
Coal (Electric Power) ($/short ton)	$37.00	$92.51	$185.02	$46.38	79.8	199.5	398.9
Natural Gas (Residential) ($/tcf)	$1.08	$2.71	$5.42	$11.05	9.8	24.5	49.1
Natural Gas (Electric Power) ($/tcf)	$1.08	$2.71	$5.42	$4.87	22.3	55.7	111.3
Electricity (Ave. Price All Sectors) ($/kwh)	$0.011	$0.027	$0.055	$0.099	11.1	27.7	55.3

Sources: EIA, Documentation for Emissions of GHGs 2006, Table 6-1; EIA AEO 2013 Year-by-Year Reference Tables 8, 12, 13, 15 & 18.

International Situation: Formal Uncooperative UNFCCC Process

- 189 Countries—Only ~20 With Emission Share > 1%
- Represented by Foreign Affairs or Environment Officials
- Endless Re-Negotiation of Texts That Barely Change
- Unrealistic Expectations of Large New Wealth Transfers
- Relatively Small and Inconsequential Financing
- About 10,000 Conflict-Prone Stakeholders
- Business Participation Very Limited and Declining
- Massively Expensive Administrative Costs
- Withdrawal of Canada, Russia, Japan from KP

Durban Agreement: We Agree to Agree in Three Years on Agreed Actions Starting in Eight Years

International Situation: Informal Cooperative Processes

- Major Economies Forum (16 Nations + EU)
- Global Methane Initiative ("Methane to Markets")
- Global Alliance for Clean Cookstoves
- Global Partnership for Low Emission Development
- Global Gas Flaring Reduction Partnership
- Adaptation Partnership
- Climate and Clean Air Coalition to Reduce Short Lived Climate Pollutants
- Asia-Pacific Partnership Clean Development & Climate
- Other Regional, National, and Local Partnerships
- Traditional International Development Financing

International: Informal Cooperative Processes--"BizMEF"

Major Economies Business Forum
on Energy Security and Climate Change
www.majoreconomiesbusinessforum.org

ACCI
BUSA
BUSINESS UNITY SOUTH AFRICA
BUSINESSEUROPE
CBI
THE VOICE OF BUSINESS
CONFINDUSTRIA
USCIB
DI
Confederation of Danish Industry
MEDEF
CII
Confederation of Indian Industry
CNECC
China New Energy Chamber of Commerce
中华全国工商业联合会新能源商会
TUSIAD 40
IDEAS
KCCI
BISD
CNI
National Confederation of Industry
Brazil
一般社団法人
日本経済団体連合会
BusinessNZ
CANADIAN COUNCIL of CHIEF EXECUTIVES
CONSEIL CANADIEN des CHEFS D'ENTREPRISE
BDI
Industrieland Deutschland stärken.

Different Approaches Yield Different Results

UNFCC/Kyoto Protocol (1992/1997)	Montreal Protocol (1987)
Top down, economy-wide approach	Bottom up, sector specific approach
Single, inflexible short term targets	Multiple, flexible long term targets
No developing nation commitments	Developing nation commitments
Small and declining private sector role	Robust private sector engagement
Promises of major wealth transfers	No promise of major wealth transfers
No meaningful technical review process	Objective technical review process
No meaningful economic review process	Objective economic review process
Focused on international implementation	Focused on national implementation
Achieving less GHG reductions than KP	Achieving more GHG reductions than KP
Mostly Unsuccessful International Treaty	Mostly Successful International Treaty

Go "Back to the Future" and Rationalize Process

Original 1992 UNFCC Principles	Kyoto Protocol	Montreal Protocol
Cooperate as widely as possible	✗	✔
Share common responsibility; differentiate according each country's circumstances	✗	✔
Respect national sovereignty of environmental and development policies and priorities	✗	✔
Re-evaluate science, technology, and economics continually	✗	✔
Focus on actions producing net economic and environmental co-benefits	✗	✔
Pursue comprehensive approach at global, regional, national and local levels	✗	✔
Address all greenhouse gases, sources and sinks taking into account relative contribution	✗	✔
Coordinate actions to assure sustained economic growth and poverty eradication	✗	✔

On Climate Sensitivity

1. Revision of climate sensitivity

In the most recent IPCC 5th Assessment Report (AR5) completed in 2014, equilibrium climate sensitivity (climate sensitivity)[1] has been estimated as in the range of 1.5 to 4.5 °C and no best estimate for climate sensitivity can now be given "because of a lack of agreement".[2] The past history of climate sensitivity in the IPCC Assessment Reports is shown below.

IPCC Report	Published in	Climate Sensitivity	Best estimate
3rd Assessment R.	2001	1.5 – 4.5 °C	2.5 °C
4th Assessment R.	2007	2.0 – 4.5 °C	3.0 °C
5th Assessment R.	2014	1.5 – 4.5 °C	Not shown

Revision of the climate sensitivity directly affects future projection of temperature increases as well as emissions trajectories and costs to achieve, for example, the 2 °C target. In addition, it is clearly described in the 4th Assessment Report (AR4) that the best estimate figure of 3.0 °C was used to calculate emissions trajectory to achieve variety of stabilization goals shown in the Table SPM. 5[3]. In this sense, it is rather embarrassing that the best estimate was not shown in AR5 because of a lack of agreement.

2. Several points to be clarified in AR5

In AR5, same kind of the table on the relations between GHG concentration, temperature increase, necessary emissions reduction in 2050 and 2100, likelihood of staying below certain temperature levels, including 2 °C, over the 21st century etc. was presented[4] (see Table SPM.1 of the Working Group 3 of IPCC/AR5 shown in the next page).

[1] Equilibrium climate sensitivity is defined as the change in global mean surface temperature at equilibrium that is caused by a doubling of the atmospheric CO2 concentration (see page 16 of Summary for Policymakers of AR5 Working Group 1).
[2] See footnote 16 in page 16 of Summary for Policymakers of AR5 Working Group 1.
[3] See Table SPM.5 of Summary for Policymakers of AR4 Working Group 3.
[4] See Table SPM. 1 of Summary for Policymakers of AR5 Working Group 3.

Table SPM.1 | Key characteristics of the scenarios collected and assessed for WGIII AR5. For all parameters, the 10th to 90th percentile of the scenarios is shown. [illegible] [Table 6.3]

CO_2eq Concentrations in 2100 (ppm CO_2eq) Category label (concentration range)	Subcategories	Relative position of the RCPs	Cumulative CO_2 emissions (GtCO2): 2011–2050	2011–2100	Change in CO_2eq emissions compared to 2010 in (%): 2050	2100	Temperature change (relative to 1850–1900): 2100 Temperature change (°C)	Likelihood of staying below temperature level over the 21st century: 1.5 °C	2.0 °C	3.0 °C	4.0 °C
< 430	[illegible]										
450 (430–480)	Total range	RCP2.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	More unlikely than likely	Likely	Likely	Likely
500 (480–530)	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Unlikely	More likely than not		
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		About as likely as not		
550 (530–580)	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		More unlikely than likely		
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
(580–650)	Total range	RCP4.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
(650–720)	Total range		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		Unlikely	More likely than not	
(720–1000)	Total range	RCP6.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Unlikely		More unlikely than likely	
>1000	Total range	RCP8.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		Unlikely	Unlikely	More unlikely than likely

The footnote 7 to the above table clearly shows that "Temperature change in 2100 is provided for a <u>median estimate of the MAGICC calculations</u> (emphasis added)". But this table, as well as the whole report of the AR5, is silent as to what figure was used as median (or best estimate), reflecting the situation where best estimate was not agreed.

In chapter 6 of AR5/Working Group 3 report, there are sentences that it used the methods described by Rogelj et al. and Schaeffer et al. in calculating the likelihood of staying below certain temperature level[5]. In these two papers, the equilibrium climate sensitivity is employed based on the IPCC AR4 insight (likely range: 2.0–4.5 °C; best estimate: 3.0 °C). For example, Schaeffer et al, writes as the overall probability distribution of climate sensitivity is consistent with IPCC AR4, with a median estimate of 3 °C and a 76% chance of a value between 2 and 4.5 °C.[6]

Under these circumstances, and as impact of climate sensitivity is one of key

[5] "Several papers have introduced methods for probabilistic statements on temperature increase for emission scenarios [...]. For this assessment, the method described by Rogelj et al. (2012) and Schaeffer et al. (2014) is used, which employs the MAGICC model based on the probability distribution of input parameters from Meinshausen (2009) (see also Meinshausen et al., 2011c)." [Page 439, IPCC WG3 AR5 Chapter 6]

[6] "The model setup allows to derive a best-estimate and probability distribution for each of these variables, by running MAGICC6 600 times with different parameter sets for each emission scenario. Parameter sets were drawn randomly that allow the model to reproduce a series of observed time series of climate variables in terms of the overall median and uncertainty ranges, while the overall probability distribution of climate sensitivity is consistent with IPCC AR4 ,with a median estimate of 3 °C and a 76% chance of a value between 2 and 4.5 °C." [Schaeffer et al. (2014)]

issues in responding climate change, it is definitely necessary to firstly confirm and secondly make request to the MAGICC model key developers (Dr. Meinshausen and Dr. Wigley) and other key experts (such as Dr. Rigelj and Dr. Schaeffer) as shown in the last part of this paper (or rather indirectly to IPCC) the followings;

[Confirmation]

1. Should we understand that

a) the "median estimate" of MAGICC in footnote 7 of the Table SPM.1 corresponds to the equilibrium climate sensitivity of 3.0 °C, and

b) likelihood of staying below several temperature levels, such as likely, unlikely etc., shown in the Table SPM.1 (or probability of exceeding the target temperatures in Table 6.3 of Chapter 6, IPCC/AR5 WG3) are calculated by MAGICC model with the equilibrium climate sensitivity of the likely range 2.0–4.5 °C and the median of 3.0 °C, which is based on the IPCC AR4 insight?

2. As shown in the top page of this memo, IPCC/AR5(WG1) concluded that the likely range of equilibrium climate sensitivity is between 1.5 and 4.5 °C (not 2.0 and 4.5 °C). If the above understandings a) and b) are correct, can we understand that the temperatures and the probabilities exceeding the target temperatures are lower than those shown in the Table SPM.1 when the new insight on the climate sensitivity of the WG1 AR5 is taken into considerations?

[Requests]

1. Request the model developers of MAGICC (or IPCC) to recalculate the likelihood of staying below 2 °C relative to 1850-1900 for emission scenarios of Table SPM.1 (or probability of exceeding 2 °C in Table 6.3 of Chapter 6, IPCC/AR5 WG3) of IPCC/AR5 WG3, based on the new insight of IPCC AR5 where the equilibrium climate sensitivity was revised as between 1.5 and 4.5 °C.
2. Request the model developers of MAGICC (or IPCC) to recalculate the temperature for emission scenarios of Table SPM.1 (and Table 6.3), employing the equilibrium climate sensitivity of 2.5 °C, which was the "best estimate" of the likely range between 1.5 and 4.5 °C before the AR4.
3. If possible, request the model developers of MAGICC (or IPCC) to

recalculate the temperate for emission scenarios of Table SPM.1 (and Table 6.3) employing the equilibrium climate sensitivity of 1.5 and 4.5 °C.

References

Meinshausen M., N. Meinshausen, W. Hare, S. C. B. Raper, K. Frieler, R. Knutti, D. J. Frame, and M. R. Allen (2009). Greenhouse-gas emission targets for limiting global warming to 2 degrees C. Nature 458, 1158 – 1162. doi: 10.1038 / nature08017, ISSN: 1476-4687.

Meinshausen M., T. M. L. Wigley, and S. C. B. Raper (2011c). Emulating atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6 — Part 2: Applications. Atmospheric Chemistry and Physics 11, 1457 – 1471. doi: 10.5194 / acp-11-1457-2011, ISSN: 1680-7324.

Rogelj J., M. Meinshausen, and R. Knutti (2012). Global warming under old and new scenarios using IPCC climate sensitivity range estimates. Nature Climate Change 2, 248 – 253. doi: 10.1038 / nclimate1385, ISSN: 1758-678X.

Schaeffer M., L. Gohar, E. Kriegler, J. Lowe, K. Riahi, and D. Van Vuuren (2014). Mid- and long-term climate projections for fragmented and delayedaction scenarios. Technological Forecasting and Social Change [in Press]. doi: 10.1016 / j.techfore.2013.09.013.

[Information for key authors]

J. Rogelj: Institute for Atmospheric and Climate Science, ETH Zurich, Universitätstrasse 16, 8092 Zürich, Switzerland

M. Meinshausen: PRIMAP Group, Earth System Analysis, Potsdam Institute for Climate Impact Research (PIK), PO Box 60 12 03, 14412 Potsdam, Germany

T. M. L. Wigley: National Center for Atmospheric Research (NCAR), Boulder, CO, USA

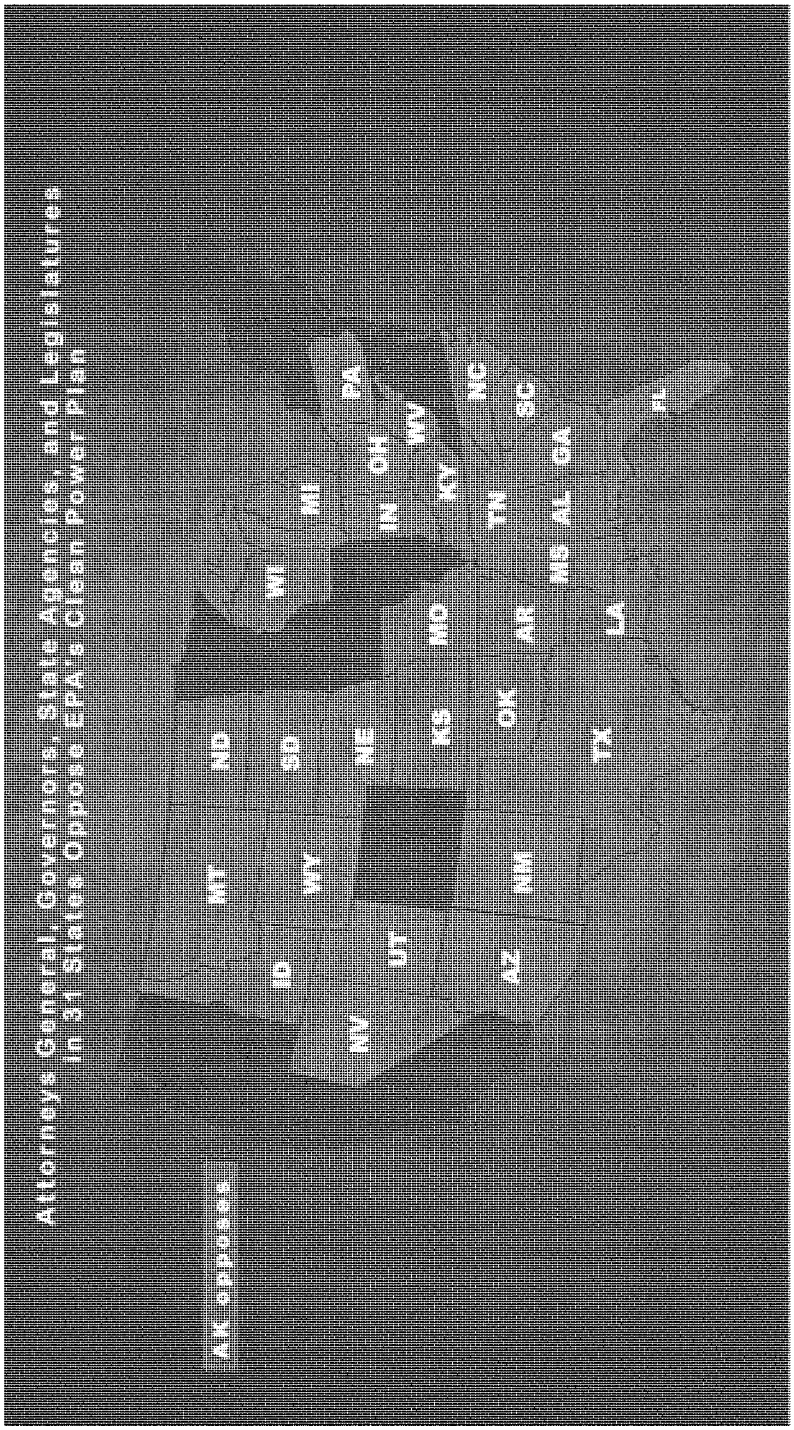
M Schaeffer, Climate Analytics, Germany, and Wageningen University, The Netherlands

FYI, the following is the enlarged copy of Table SPM.1 and its footnote 7.

Table SPM.1 | Key characteristics of the scenarios collected and assessed for WGIII AR5. For all parameters, the 10th to 90th percentile of the scenarios is shown.[1,2] [Table 6.3]

<table>
<tr><th rowspan="3">CO_2eq Concentrations in 2100 [ppm CO_2eq]
Category label (concentration range)[9]</th><th rowspan="3">Subcategories</th><th rowspan="3">Relative position of the RCPs[5]</th><th colspan="2" rowspan="2">Cumulative CO_2 emissions[3] [$GtCO_2$]</th><th colspan="2" rowspan="2">Change in CO_2eq emissions compared to 2010 in [%][4]</th><th colspan="5">Temperature change (relative to 1850–1900)[5,6]</th></tr>
<tr><th rowspan="2">2100 Temperature change [°C][7]</th><th colspan="4">Likelihood of staying below temperature level over the 21st century[8]</th></tr>
<tr><th>2011–2050</th><th>2011–2100</th><th>2050</th><th>2100</th><th>1.5 °C</th><th>2.0 °C</th><th>3.0 °C</th><th>4.0 °C</th></tr>
<tr><td>< 430</td><td colspan="11">Only a limited number of individual model studies have explored levels below 430 ppm CO_2eq</td></tr>
<tr><td>450 (430–480)</td><td>Total range[1,10]</td><td>RCP2.6</td><td>550–1300</td><td>630–1180</td><td>−72 to −41</td><td>−118 to −78</td><td>1.5–1.7 (1.0–2.8)</td><td>More unlikely than likely</td><td>Likely</td><td rowspan="6">Likely</td><td rowspan="8">Likely</td></tr>
<tr><td rowspan="2">500 (480–530)</td><td>No overshoot of 530 ppm CO_2eq</td><td></td><td>860–1180</td><td>960–1430</td><td>−57 to −42</td><td>−107 to −73</td><td>1.7–1.9 (1.2–2.9)</td><td rowspan="6">Unlikely</td><td>More likely than not</td></tr>
<tr><td>Overshoot of 530 ppm CO_2eq</td><td></td><td>1130–1530</td><td>990–1550</td><td>−55 to −25</td><td>−114 to −90</td><td>1.8–2.0 (1.2–3.3)</td><td>About as likely as not</td></tr>
<tr><td rowspan="2">550 (530–580)</td><td>No overshoot of 580 ppm CO_2eq</td><td></td><td>1070–1460</td><td>1240–2240</td><td>−47 to −19</td><td>−81 to −59</td><td>2.0–2.2 (1.4–3.6)</td><td rowspan="3">More unlikely than likely[12]</td></tr>
<tr><td>Overshoot of 580 ppm CO_2eq</td><td></td><td>1420–1750</td><td>1170–2100</td><td>−16 to 7</td><td>−183 to −86</td><td>2.1–2.3 (1.4–3.6)</td></tr>
<tr><td>(580–650)</td><td>Total range</td><td rowspan="2">RCP4.5</td><td>1260–1640</td><td>1870–2440</td><td>−38 to 24</td><td>−134 to −50</td><td>2.3–2.6 (1.5–4.2)</td></tr>
<tr><td>(650–720)</td><td>Total range</td><td>1310–1750</td><td>2570–3340</td><td>−11 to 17</td><td>−54 to −21</td><td>2.6–2.9 (1.8–4.5)</td><td rowspan="2">Unlikely</td><td>More likely than not</td></tr>
<tr><td>(720–1000)</td><td>Total range</td><td>RCP6.0</td><td>1570–1940</td><td>3620–4990</td><td>18 to 54</td><td>−7 to 72</td><td>3.1–3.7 (2.1–5.8)</td><td rowspan="2">Unlikely[11]</td><td>More unlikely than likely</td></tr>
<tr><td>>1000</td><td>Total range</td><td>RCP8.5</td><td>1840–2310</td><td>5350–7010</td><td>52 to 95</td><td>74 to 178</td><td>4.1–4.8 (2.8–7.8)</td><td>Unlikely[11]</td><td>Unlikely</td><td>More unlikely than likely</td></tr>
</table>

Footnote 7. Temperature change in 2100 is provided for a median estimate of the MAGICC calculations, which illustrates differences between the emissions pathways of the scenarios in each category. The range of temperature change in the parentheses includes in addition the carbon cycle and climate system uncertainties as represented by the MAGICC model [see 6.3.2.6 for further details]. The temperature data compared to the 1850 - 1900 reference year was calculated by taking all projected warming relative to 1986 - 2005, and adding 0.61 ° C for 1986 - 2005 compared to 1850 - 1900, based on HadCRUT4 [see WGI Table SPM.2].



Attorneys General, Governors, State Agencies, and Legislatures
In 31 States Oppose EPA's Clean Power Plan
AK opposes
MT
ND
SD
WY
NE
ID
UT
NV
AZ
NM
KS
OK
TX
MO
AR
LA
WI
MI
IN
OH
KY
TN
MS
AL
GA
SC
NC
WV
PA
FL

THE WALL STREET JOURNAL.

http://www.wsj.com/articles/the-state-electricity-revolt-1428621436

REVIEW & OUTLOOK

The State Electricity Revolt

A promising way to resist Obama's federal climate coercion.

April 9, 2015 7:17 p.m. ET

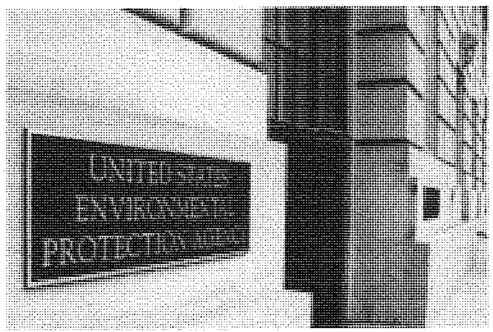
Health care, Wall Street, the Internet—by the time President Obama leaves office, there may not be much of the economy left for his successor to take over. The better news is that his attempt to do the same to the energy industry is meeting heavy resistance in the states.

The Environmental Protection Agency is finishing a rule—expected in June or July—that requires the states to meet carbon-reduction targets by reorganizing their "production, distribution and use of electricity," as the EPA puts it. This is an unprecedented federal usurpation of what has been a state responsibility since the invention of the modern steam turbine in the 1880s.

States are normally allowed as much as three years to comply with EPA mandates that are far less complex than this one. But the EPA will instruct them to submit implementation plans by summer 2016 and make interim progress as soon as 2020. The rule is intended to impress the greendees of the Paris climate conference this year, so Mr. Obama can announce a global climate deal.

The plan hangs on an obscure section of the 44-year-old Clean Air Act. That law's section 111(d) was well understood but the EPA has published a new interpretation of these several hundred words that runs 1,200 pages. No less a dean of legal liberalism than Harvard's Larry Tribe is stunned by this attempt to nationalize U.S. electric generation.

States will be told to meet the targets using four "building blocks." The first is uncontroversial: improving the efficiency of fossil-fuel power plants and installing pollution-control technology like smokestack scrubbers. But for the first time the EPA is also telling states to roam "outside the fence line" of power plants to force coal and



EPA offices in Washington, D.C. *PHOTO: GETTY IMAGES*

eventually natural gas to shut down, mandate quotas for renewables like wind and solar, and impose energy conservation.

The problem is that the federal government has no legal power outside the fence line. Last year the D.C. Circuit Court of Appeals slapped down the Federal Energy Regulatory Commission's bid to claim authority over "demand response" on the electric grid.

Thus the EPA is trying to coerce the states into doing what it can't do itself. Most will need to pass new laws or rush through new rules to comply, jammed into a single year. The EPA wants to embed policy changes that a Republican President couldn't reverse and deny Governors and legislatures the time to think through the consequences. But some states are thinking, and they may tell the agency: *No mas*.

Under the cooperative federalism of the Clean Air Act, states are invited to draw up implementation plans for EPA approval. But they have no legal obligation to do so, because the feds cannot commandeer the states. The EPA can pursue a fallback federal plan if it doesn't like what states do. But there is good reason for the states to band together, refuse to participate, and thus call the EPA's bluff.

In particular, states would avoid making themselves complicit in dangerous behavior. Virtually everyone who understands the electric grid, from state utility commissions to the regional transmission operators, warns that the EPA's ambitions threaten reliability. These apolitical organizations think brownouts or cascading blackouts are possible.

To take one example, the northeast blackout of 2003 cost about $13 billion, and the New York Independent Systems Operator now reports that the EPA's reductions "cannot be sustained while maintaining reliable electric service to New York City." It calls the plan "inherently unreasonable" that "no amount of flexibility can fix." This is not Texas talking.

The section 111(d) rewrite will be litigated for years or decades and almost certainly resolved by the Supreme Court. The 2016 White House budget requests $52 million merely to hire lawyers to defend this single rule. It would be prudent for states to postpone cooperation until the lawsuits shake out, rather than spend billions of dollars now that may turn out to be unnecessary.

We also know from ObamaCare that the feds do not have the bandwidth to successfully reconstruct part of the economy without state participation. A mass state-by-state boycott, though risky, could limit some of the damage by overloading the EPA's limited resources and personnel.

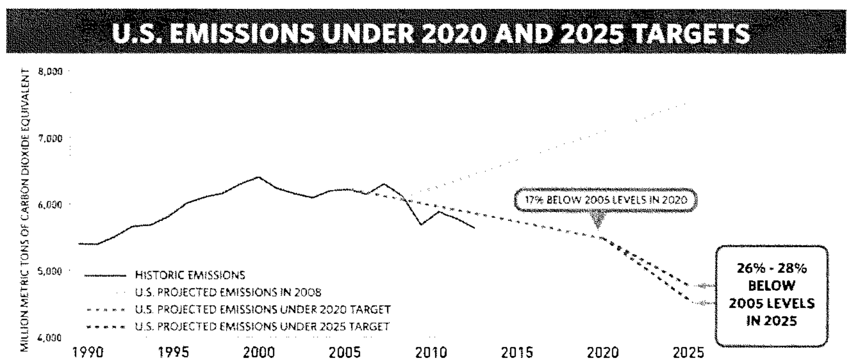
More to the point, the states ought to decline to lend political legitimacy to an extraordinary abuse of federal power. The EPA is not merely exercising the lawmaking that belongs to Congress but frustrating democratic accountability. If the EPA causes a blackout, then voters should understand that the EPA is the cause, not a Governor.

***

Senate Majority Leader Mitch McConnell is urging Governors to wait before cooperating, and the irony is that the White House is assailing him for "interfering" with state deliberations. The truth is that the EPA is attempting to steal state sovereignty in order to dominate everything from power plants to ceiling fans. The EPA's imperiousness is creating the case for noncooperation. States can only protect their energy futures by declining to do the EPA's dirty work.

The United States is pleased to communicate its intended nationally determined contribution, as well as information to facilitate the clarity, transparency, and understanding of the contribution.

The United States is strongly committed to reducing greenhouse gas pollution, thereby contributing to the objective of the Convention. In response to the request in Lima to communicate to the secretariat its intended nationally determined contribution towards achieving the objective of the Convention as set out in its Article 2—the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system—the United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26-28 per cent below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%.



The target is fair and ambitious. The United States has already undertaken substantial policy action to reduce its emissions, taking the necessary steps to place us on a path to achieve the 2020 target of reducing emissions in the range of 17 percent below the 2005 level in 2020. Additional action to achieve the 2025 target represents a substantial acceleration of the current pace of greenhouse gas emission reductions. Achieving the 2025 target will require a further emission reduction of 9-11% beyond our 2020 target compared to the 2005 baseline and a substantial acceleration of the 2005-2020 annual pace of reduction, to 2.3-2.8 percent per year, or an approximate doubling.

Substantial global emission reductions are needed to keep the global temperature rise below 2 degrees Celsius, and the 2025 target is consistent with a path to deep decarbonization. This target is consistent with a straight line emission reduction pathway from 2020 to deep, economy-wide emission reductions of 80% or more by 2050. The target is part of a longer range, collective effort to transition to a low-carbon global economy as rapidly as possible.

The target reflects a planning process that examined opportunities under existing regulatory authorities to reduce emissions in 2025 of all greenhouse gases from all sources in every economic sector. A number of existing laws, regulations, and other domestically mandatory measures are relevant to the implementation of the target, which we detail in the information provided.

Party: United States of America

Intended nationally determined contribution
The United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26%-28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%.

****

Information provided in order to facilitate clarity, transparency, and understanding
Scope and coverage: *Gases*: The U.S. target covers all greenhouse gases included in the 2014 Inventory of United States Greenhouse Gas Emissions and Sinks: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). *Sectors*: The U.S. target covers all IPCC sectors. *Percentage of total greenhouse gas emissions:* The United States intends to account for 100 percent of U.S. greenhouse gas emissions and removals for the base year 2005 as published in the Inventory of United States Greenhouse Gas Emissions and Sinks, on a net-net basis.
Quantifiable information on the reference point, time frames, assumptions and methodological approaches including those for estimating and accounting for anthropogenic greenhouse gas emissions and removals: *Timeframe and reference point:* The U.S. target is for a single year: 2025. The base year against which the target is measured is 2005.

Accounting approach for land sector:

The United States intends to include all categories of emissions by sources and removals by sinks, and all pools and gases, as reported in the Inventory of United States Greenhouse Gas Emissions and Sinks; to account for the land sector using a net-net approach; and to use a "production approach" to account for harvested wood products consistent with IPCC guidance. The United States may also exclude emissions from natural disturbances, consistent with available IPCC guidance.

There are material data collection and methodological challenges to estimating emissions and removals in the land sector. Consistent with IPCC Good Practice, the United States has continued to improve its land sector greenhouse gas reporting, which involves updating its methodologies. The base year and target for the U.S. INDC were established on the basis of the methodologies used for the land sector in the 2014 Inventory of United States Greenhouse Gas Emissions and Sinks and the United States 2014 Biennial Report.

Metric:

The United States intends to use 100-year global warming potential (GWP) values to calculate CO_2 equivalent totals. The United States intends to report emissions totals using Fourth Assessment Report values, and will consider future updates to GWP values from the IPCC.

Use of markets:

At this time, the United States does not intend to utilize international market mechanisms to implement its 2025 target.

Domestic laws, regulations, and measures relevant to implementation:

Several U.S. laws, as well as existing and proposed regulations thereunder, are relevant to the implementation of the U.S. target, including the Clean Air Act (42 U.S.C. §7401 et seq.), the Energy Policy Act (42 U.S.C. §13201 et seq.), and the Energy Independence and Security Act (42 U.S.C. § 17001 et seq.).

Since 2009, the United States has completed the following regulatory actions:

- Under the Clean Air Act, the United States Department of Transportation and the United States Environmental Protection Agency adopted fuel economy standards for light-duty vehicles for model years 2012-2025 and for heavy-duty vehicles for model years 2014-2018.
- Under the Energy Policy Act and the Energy Independence and Security Act, the United States Department of Energy has finalized multiple measures addressing buildings sector emissions including energy conservation standards for 29 categories

of appliances and equipment as well as a building code determination for commercial buildings.

- Under the Clean Air Act, the United States Environmental Protection Agency has approved the use of specific alternatives to high-GWP HFCs in certain applications through the Significant New Alternatives Policy program.

At this time:

- Under the Clean Air Act, the United States Environmental Protection Agency is moving to finalize by summer 2015 regulations to cut carbon pollution from new and existing power plants.
- Under the Clean Air Act, the United States Department of Transportation and the United States Environmental Protection Agency are moving to promulgate post-2018 fuel economy standards for heavy-duty vehicles.
- Under the Clean Air Act, the United States Environmental Protection Agency is developing standards to address methane emissions from landfills and the oil and gas sector.
- Under the Clean Air Act, the United States Environmental Protection Agency is moving to reduce the use and emissions of high-GWP HFCs through the Significant New Alternatives Policy program.
- Under the Energy Policy Act and the Energy Independence and Security Act, the United States Department of Energy is continuing to reduce buildings sector emissions including by promulgating energy conservation standards for a broad range of appliances and equipment, as well as a building code determination for residential buildings.

In addition, since 2008 the United States has reduced greenhouse gas emissions from Federal Government operations by 17 percent and, under Executive Order 13693 issued on March 25th 2015, has set a new target to reduce these emissions 40 percent below 2005 levels by 2025.

Relationship with inventory:

This approach, and the definitions and metrics used, are fully consistent with our greenhouse gas inventory. The United States intends to continue to improve its greenhouse gas inventory over time, and may incorporate these improvements into its intended nationally determined contribution accordingly. Additional information on the greenhouse gas inventory, including calculations, models, data sources, and references can be found here:

www.epa.gov/climatechange/ghgemissions/usinventoryreport.html#about

ENVIRONMENT REPORT

Making Plans for the Paris Climate Conference

What needs to be done to ensure the upcoming COP 21 conference in Paris is a success? **Yamaguchi Mitsutsune**, Visiting Professor at the University of Tokyo, comments.

On 12 November 2014, China, the world's largest greenhouse gas (GHG) emitter, and the United States, the world's second largest greenhouse gas emitter, agreed to combat global climate change (GHG reduction/control targets). This is the so-called U.S.-China Joint Announcement on Climate Change. According to this announcement, the United States intends to achieve an economy-wide target of reducing GHG emissions by 26% to 28% below its 2005 level by the year 2025. China intends to achieve the peaking of CO_2 emissions around 2030, and increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030.

These two countries, which had no obligation until then to reduce/control GHG emissions, even announced their resolve to play a leading role in building a global agreement at the twenty-first session of the Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC), which is scheduled to be held in Paris in December 2015.

Combined with the EU's resolution to reduce its GHG emissions by 40% below its 1990 level in 2030, the impact of this bilateral commitment is extremely significant, and there are some who are already optimistic that an ambitious agreement involving the participation of all countries will be reached at the conference in Paris. It is noteworthy that the U.S.-China Joint Announcement stipulated that the two nations are mindful of the 2 degree goal, which is the internationally agreed de facto target for limiting the increase of the temperature below two degrees above the pre-industrial level.

The top-down approach applied for the Kyoto Protocol set the upper limit of global GHG emissions and allocated emissions allowances to each country, though limited to industrialized countries, with the aim of achieving collective target. Unfortunately, this model did not work properly. Based on previous experience, many think it is certain that a new agreement, if any, in Paris will be based on a bottom-up approach in which each country pledges its own specific target. In this case, each country will make a pledge to achieve an ambitious target, while taking into consideration its individual situation. However, it is quite likely that even an aggregation of those targets will fall far short of the 2 degree target. If this gap is excessively large, it will become clear that the target will fail within a few short years, and a global awareness of climate change will suffer, potentially undermining the effectiveness of response measures. We must consider what needs to be done to make the Paris conference a success in these circumstances.

The Emergence of the Overshoot Scenario and the Disappearance of the 50% Global GHG Reduction Target

First and foremost, global leaders must recognize that scientific findings about climate change have changed. Global GHG emissions continued to increase even after 1997 when countries all around the world agreed on the Kyoto Protocol. The emissions ultimately reached 49 Gt in 2010, along with a significant increase in emissions in emerging economies. The IPCC Fourth Assessment Report (AR4), which was published in 2007, specified the range of temperature increases corresponding to multiple levels of GHG concentration, and the percentage of emissions reduction in 2050 to realize this range. The report states that the GHG concentration to achieve the 2 degree target will be about 450 ppm CO_2-equivalent. To realize this target, the report claims global emissions need to be reduced by 50–85% below 2000 levels by the year 2050. In response to this estimate by the IPCC, the international community has intended to reduce GHG emissions by 50% by 2050 (the "50% Global GHG Reduction Target toward 2050") to achieve the 2 degree target. For this target, it is necessary to note that the designated GHG concentration and the targeted upper limit for temperature increase were based on the assumption that they would eventually stabilize at these levels. However, as a result of a recent drastic rise in global emissions, it has become impossible to draw scenarios, especially for the ambitious 2 degree target, in which the GHG concentration and the temperature gradually increase toward stabilization. Subsequently, this simulation was replaced by the "overshoot scenario," which predicts that the GHG concentration (or possibly temperature) will have exceeded the targeted level by 2100 and then decline to a certain level (overshoot scenario). In fact, the IPCC Fifth Assessment Report (AR5), which was published in 2014, specified rigid targets based on this scenario. Consequently, in the AR5 the 2 degree target has been changed from the eventual 2 degree stabilization set in the AR4 to a target of preventing the temperature from rising more than two degrees by 2100.

In accordance with this estimate, **Table 1** shows the percentage of 2050 emissions reduction (relative to the base year of 2010) needed to achieve the 2 degree target based on the AR5 scenario, and the likelihood of achieving the respective targets. (The author edited the table based on Table SPM.1 and Table 6.3 in AR5 to make it simple for readers' convenience.) When the AR5 was announced, many media reports claimed it would be necessary to reduce GHG emissions by 41–72% by the year 2050 to achieve the 2 degree target. This corresponds to a 28–66% reduction if compared with emissions of the year 2000 as was done in AR4 (see the parenthesized numbers in Table 1). In AR5, the above estimate was based on the assumption that the likelihood of achievement probability would be greater than 66%. If we allow to lower the likelihood of achieving the target to 33–66%, the target can be attained with emissions reductions of at least 8–47% below the 2000 levels. This is the amount of reductions required based on the latest scientific findings. It is essential for world leaders to understand that the 50% global GHG reduction by 2050 is unnecessary when assessing the pledges made by each country at the Paris conference.

Table 1: Concentration, Increase in Temperature, and the Percentage of Emissions Reduction Required to Achieve Targets

CO_2eq Concentrations in 2100 (CO_2-eq) Category label (Conc. Range)	Subcategories	Change in CO_2-eq emissions (in %)		Likelihood of staying below 2°C over the 21st century (relative to 1850–1900)
		2050 compared to 2010	2050 compared to 2000	
450 (430 – 530)	Total range	-72 to -41	(-66 to -28)	66 – 100%
500 (480 – 530)	No overshoot of 530 ppm CO_2eq.	-57 to -42	(-47 to -29)	> 50 – 100%
	Overshoot of 530 ppm CO_2eq.	-55 to -25	(-47 to -8)	33 – 66%

Note: The table above was edited on the basis of multiple charts drawn up by IPCC/AR5. The percentage of 2050 emissions reduction required to achieve targets compared to 2000 (the parenthesized numbers in the table) is based on the author's calculations.

Table 2: Changes in Climate Sensitivity and Best Estimate in IPCC Reports

IPCC Report	Published in	Climate sensitivity	Best estimate
1st Assessment R.	1990	1.5 – 4.5 °C	2.5 °C
2nd Assessment R.	1995	1.5 – 4.5 °C	2.5 °C
3rd Assessment R.	2001	1.5 – 4.5 °C	2.5 °C
4th Assessment R.	2007	2.0 – 4.5 °C	3.0 °C
5th Assessment R.	2014	1.5 – 4.5 °C	Not shown

Can the U.S.-China Joint Announcement on Climate Change Achieve the 2 Degree Target?

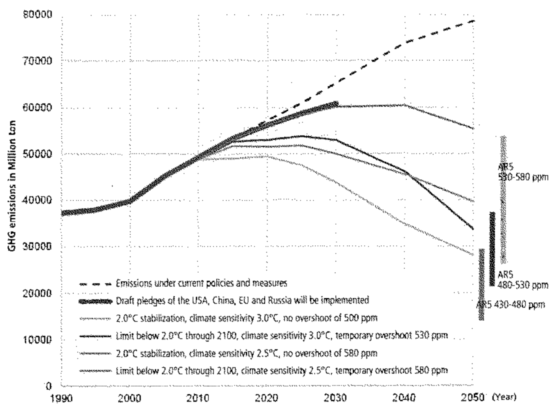
The biggest challenge in tackling climate change is uncertainty. Factors of uncertainty include the effect and cost of mitigation/adaptation and the damage caused by climate change. In addition, the uncertainty of climate sensitivity poses one of the greatest challenges. Climate sensitivity (strictly speaking, Equilibrium Climate Sensitivity) means an increase in global mean surface temperature caused by a doubling of the atmospheric CO_2 concentration. The AR4 specified the likely range of climate sensitivity is 2 to 4.5 degrees, but the AR5 lowered the figure to 1.5 to 4.5 degrees. For reference, **Table 2** shows the changes in climate sensitivity and the best estimates in IPCC Assessment Reports.

Considering the remarkable uncertainty that exists in the relationship between the CO_2 concentration and the increase in temperature, it is conceivable that there will be a huge range in the CO_2 concentration needed to achieve such as the 2 degree target, which in turn makes it more difficult for the entire world to implement measures. This is why the percentage of emissions reduction required to achieve targets is often calculated by using the best estimate of climate sensitivity. As shown in Table 2, the best estimate specified in the AR4 was 3 degrees. The percentage of emissions reduction required to achieve the 2 degree target was also calculated by applying this best estimate in AR4. On the other hand, the AR5 did not provide a best estimate because experts failed to reach a consensus. As a result, the AR5 did not present a specific figure for the best estimate to be used in similar calculations. However, the AR5 must have used a certain figure of climate sensitivity to calculate the figure in **Table 1**. The author will avoid giving a detailed explanation due to the limit on the length of this paper, but if we carefully read the AR5 and refer to its source materials, we find that the AR5 used 3 degrees for climate sensitivity. It is illogical, however, that while providing no best estimate in AR5 to use the best estimate of AR4, i.e. 3 degrees, without giving a clear-cut explanation. The question here is what level the best estimate will be now and how much influence does it have?

The IPCC has continued to rely upon the literatures of the Atmosphere-Ocean General Circulation Model (AOGCM) to estimate climate sensitivity. The application of this model shows that both climate sensitivity and the best estimate are the same as those specified in the AR4. However, this model cannot properly account for the hiatus in the temperature increase that has continued since 1998. In the meantime, an increasing number of literatures based on the observed warming since pre-industrialization show both climate sensitivity and its best estimate are rather lower. The AR5 reflects this estimate by presenting a lower figure for climate sensitivity. Although, as mentioned above, the AR5 did not provide a specific figure for the best estimate, it is logical to speculate that best estimate is lower than 3 degrees. [For example, a climate sensitivity of 1.25 to 2.45 degrees (17% to 83% range) and a median estimate of 1.64 degrees were presented in "The implications for climate sensitivity of the AR5 forcing and heat uptake estimates" (Lewis. N. and Curry. J., (2014), *Climate Dynamics*, DOI 10.1007/s00382-014-2342-y).]

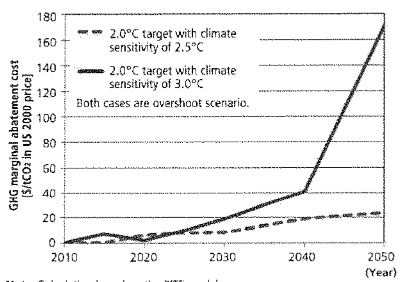
Given the uncertainty of climate sensitivity, is the U.S.-China Joint Announcement compatible with the 2 degree target? In addition to the United States and China, as of this time the EU (40% reduction below its 1990 level by the year 2030) and Russia (25–30% reduction below its 1990 level by the year 2030) have announced their pledges towards 2030 (the target year of 2025 is for the United States only). **Figure 1** illustrates the relationship between global GHG emissions in 2030

Figure 1: The U.S.-China Joint Announcement on Climate Change and the Likelihood of Achieving the 2 Degree Target



Source: RITE

Figure 2: Carbon Price to Achieve the 2 Degree Target (2010 to 2050)



Note: Calculation based on the RITE model

that takes into account the above four (provisional) emission pledges, the Global EmissionsTrajectory based on the four pledges — GET4Ps — and the achievement of the 2 degree target. The bold red line in the figure indicates the GET4Ps. Please note that China's peak GHG emissions in 2030 was estimated as 15 Gt.

Figure 1 also presents a total of four emission trajectories towards 2050 on the basis of the simulated climate sensitivity of 3 and 2.5 degrees, with a focus on the classification of the 2 degree stabilization scenario and the 2 degree overshoot scenario. The simulation shows that only the 2 degree overshoot scenario in which climate sensitivity is 2.5 degrees and the GHG concentration temporarily overshoots 580 ppm (green line), is compatible with the GET4Ps. This suggests that if climate sensitivity is 3 degrees, pledges in the U.S.-China Joint Announcement are completely inadequate for achieving the 2 degree target. However, if climate sensitivity is 2.5 degrees, the target might just be achievable if we overlook a considerable level of overshoot. It should be noted, however, that in this case we must reduce global emissions rather drastically after 2050.

According to an estimate presented by the Research Institute of Innovative Technology for the Earth (RITE), a Japanese think tank, if climate sensitivity merely changes from 3 to 2.5 degrees, the marginal abatement cost (carbon price) in 2050 in overshoot scenarios will fall from 171 to 24 dollars/tCO_2, a reduction of nearly 86% (see **Figure 2**). This demonstrates that, under the lower climate sensitivity, achieving the 2 degree target will become feasible and that international cooperation will be able to maintain momentum towards the aim of achieving reduction targets even after the conference in Paris.

Conclusion

To secure the participation of all countries by accepting their ambitious pledges will be of paramount importance in the negotiations at the conference in Paris. It is also necessary to secure compatibility with the 2 degree target in view of previous negotiation processes. To this end, the international community should share a common recognition of the latest scientific findings for achieving the 2 degree target (reducing GHG emissions by at least 8% to 28% below the 2000 level by the year 2050). Moreover, it is essential for experts to reexamine best estimate, including the post-AR5 literatures, on the basis of recognition that if the climate sensitivity is 2.5 degrees, it will be possible to achieve the 2 degree target.

In addition, the pledges each country makes need to be sufficiently ambitious and convincing in terms of efficacy and equity. In closing, the author would like to stress the significance of establishing various indexes for ex-ante and ex-post evaluation of pledges.

Note: This paper was written following my series of discussions with Dr. Kaya Yoichi, RITE President, and Dr. Akimoto Keigo, RITE System Analysis Group Leader. I would like to express my sincere gratitude to them for their helpful suggestions.

YAMAGUCHI Mitsutsune is a visiting professor at the University of Tokyo and a special advisor for the Research Institute of Innovative Technology for the Earth (RITE)

Subject: India to add 103 GW of coal fired power

India to add 103 gigawatts of coal power

Clean coal capacity is expected to increase by approximately 103 Gigawatts (GW) between 2016 and 2025, as the country seeks to meet its electricity demand. Coal is India's primary source of energy for it accounts for more than half of the country's energy needs. It will remain predominate to the country's energy mix with the power sector making for the majority of coal consumption. In 2014, coal was the leading source of power generation with 160 GW, accounting for 59% of installed capacity and this is expected to almost double by 2025, according to GlobalData. While India's clean coal installations are in the nascent stages, many recent ultra-mega power projects have adopted supercritical (SC) technology, while future SC and ultra-supercritical installations will drive capacity additions over the forecast period. India's increasing population and industrialisation, improved standard of living and robust economic growth are all pushing up its demand for electricity, said Sowmyavadhana Srinivasan, GlobalData's senior analyst covering power. "Between 2013 and 2014, India experienced a deficit of 4.5% in terms of the electricity supply available to fulfill peak demand. "The country is not fully electrified and is subject to a large number of power cuts and power reliability uncertainties. In order to resolve this, India urgently requires many new installations, with coal a significant contributor," he said. However, the growth in India's clean coal market could be limited by fluctuations in the international coal market and the domestic government's increased emphasis on the use of cleaner fuels for power generation. India has a policy that most mega power plants have to secure coal imports internationally, said Srinivasan, and this means that if there is a shift in the international coal community, it will affect the coal power plants in India, which adds to the risks involved with setting them up. "Furthermore, under the National Action Plan on Climate Change (NAPCC), India aims to generate 15% of its electricity from renewable sources by 2020. As a consequence, alternative energy sources, such as wind and solar power, may impact the adoption of clean coal technologies," he said. According to the U.S Energy Information Administration (EIA), in 2014 the Indians had approximately 5.7 billion barrels of proven oil and 47 trillion cubic feet of natural gas reserves. Over the years, domestic production has not kept pace with demand, thus the country heavily relies on crude oil and liquefied natural gas (LNG) imports. It is the fourth largest energy consumer in the world after China, the United States and Russia.

http://www.aogdigital.com/component/k2/item/4676-india-to-add-103-gigawatts-of-coal-power

IEA Clean Coal Centre, Park House, 14
Northfields, London, SW18 1DD. United Kingdom
Tel +44 (0)20 8877 6280 mail@iea-coal.org sales@iea-coal.org

NEGOTIATIONS:

India's prime minster says his country won't be pressured into emission cuts

Published: Tuesday, April 7, 2015

Indian Prime Minister Narendra Modi announced yesterday that his country will not allow foreign pressure to determine its carbon emissions reduction plans. Rather, India will carve its own path in addressing climate change by focusing on clean energy and traditional methods, he said.

Later this year, representatives of nations will gather in Paris to discuss strategies to limit global warming. As one of the largest global economies, India's role in addressing climate change will be a factor to whether or not the Paris talks are considered successful.

"The world guides us on climate change, and we follow them? The world sets the parameters, and we follow them? It is not like that," said Modi. "We can lead the world."

India is the world's third-largest greenhouse gas emitter. The government plans to increase emissions as it works to alleviate poverty in the country.

So far, Modi has emphasized a need for cleaner energy rather than emissions cuts. He has also developed ambitious plans for renewable energy production and suggested using traditional methods to reduce energy consumption, like turning off streetlights when the moon is full (Kalra/Wilkes, **Reuters**, April 6). -- **MV**

DOCUMENT SUBMITTED BY DR. MARGO THORNING

ACCF CENTER FOR POLICY RESEARCH SPECIAL REPORT | FEBRUARY 2015

U.S. COAL PLANT FINANCING POLICY: A THREAT TO LONG-TERM U.S. INTERESTS IN THE DEVELOPING WORLD

BY GEORGE DAVID BANKS[1]

The role of the federal government in the international financing of coal plants has become controversial in recent years. Some policymakers as well as environmental activists oppose the use of any public funds for any overseas coal plant, including highly-efficient units, while some fiscal conservatives want an end to all government financing of exports and projects. At the same time, the developing world is seeking financial assistance from the United States and other major economies to provide basic electricity access, which is indispensable to poverty eradication and improvements in environmental quality and health care. Current U.S. policy—backed by a number of European countries—places unrealistic conditions on power generation projects in developing countries. As a result, other nations, some of which openly seek to displace U.S. influence, are moving to fill the gap, putting at risk long-term U.S. interests. Ironically, U.S. policy, if adopted by major Western suppliers, would result in an increase in greenhouse gas emissions as developing countries deployed older, less efficient coal technology from non-OECD sources.

Setting the Scene

Today, U.S. foreign policy prioritizes climate change mitigation over expanding access to affordable and reliable energy in developing countries—as demonstrated by the Obama Administration's push to eliminate most financing of overseas coal plants.[2] The White House has moved to limit U.S. funds for coal projects, lobbied other developed countries to join its position, and leveraged U.S. influence in multilateral development banks to achieve this goal. These efforts have the indirect effect of imposing a carbon cap on poor countries, despite U.S. recognition, as a party to the United Nations Framework Convention on Climate Change (UNFCCC), that developing countries have the right to increase their greenhouse gas (GHG) emissions to meet social and economic needs.[3]

On the political right, some fiscal conservatives oppose government-backed financing of overseas projects and exports (e.g., reauthorization of the Export-Import Bank of the United States (Ex-Im)), citing the unreasonable risk of default, the availability of private financing, and opposition to corporate welfare.[4] Although most free market advocates support the use of coal, overseas coal projects would suffer collateral damage by shutting down the very institutions that would help fund them. Locking the doors of Ex-Im and

[1] Dave Banks is Executive Vice President at the American Council for Capital Formation (ACCF).

[2] Some Democrats on Capitol Hill have also been very active in limiting coal investments in the developing world. In 2009, Senate Democrats required the Overseas Private Investment Corporation (OPIC) to reduce the GHG impact of its portfolio an additional 30 percent in 10 years and 50 percent in 15 years – on top of a previous court settlement that resulted in a commitment to reduce GHG emissions by 20 percent by 2018. As a result, OPIC annual investment in the power sector, in practice, is limited to the equivalent of one 280 megawatt natural gas-fired simple cycle power project, according to an unpublished industry estimate.

[3] The UNFCCC also embraces the principle of a "supportive and open international economic system" that results in economic development in all parties, particularly in developing economies, thereby increasing the resilience of those countries to climate impacts. The type of restrictions on coal plant financing promoted by the United States in poor countries does not appear consistent with this principle or its spirit. See Principle 5 at http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

[4] Goldfarb, Zachary and Holly Yeager, "Long-Building Conservative Anger at Export-Import Bank Reaches Boiling Point," Washington Post, June 28, 2014 at http://www.washingtonpost.com/business/economy/long-building-conservative-anger-at-export-import-bank-reaches-boiling-point/2014/06/27/cce4a87a-fe01-11e3-b1f4-8e77c632c07b_story.html.

George David Banks is Executive Vice President for The American Council for Capital Formation Center for Policy Research. ACCF Center for Policy Research brings together academics, policymakers, business leaders and the media to focus on important new research on economic, tax, energy and regulatory policies. For more information about the Center or for copies of this special report, please contact the ACCF, 1001 Connecticut Avenue, N.W., Suite 620, Washington D.C. 20036; telephone: 202.293.5811; email: info@accf.org; website: www.accf.org.

the Overseas Private Investment Corporation (OPIC) would threaten development goals in poor countries—where private capital markets are not well established.

U.S. policymaking across the political spectrum is certainly influenced by the fact that most Americans take electricity for granted and have little understanding of how power is produced and how it is delivered to their homes. Many also lack the appreciation for the plight of the developing world, which suffers from inadequate access to the electricity needed to provide clean water, health care services, and sanitation.

The International Energy Agency (IEA) reports that 1.3 billion people remain without electricity (about 20 percent of the global population—the majority of which are located in Sub-Saharan Africa and developing Asia, particularly in rural areas.[5] In addition, 2.8 billion people use solid fuels to cook in their home stoves (e.g., dung, biomass, and coal), a practice that produces harmful particulate emissions, resulting in the estimated global loss of 370,000 lives (roughly the population of New Orleans) and 9.9 million disability-adjusted life years in 2010.[6] More recently, the World Health Organization has argued that the lack of reliable electricity at health treatment facilities proved to be a major barrier to containment of the Ebola outbreak.[7] In general, the poorest of the poor countries, which account for 12 percent of the world's population, only consume about 1 percent of global energy.

Investments in on- and off-grid electrification, including generation, transmission, and distribution, are desperately needed in those countries, particularly to electrify rural communities and increase power consumption levels in urban zones. Distributed generation and renewable energy technologies are part of the answer, given the lack of grid infrastructure. However, coal-fired generation, which can provide affordable baseload electricity 24/7, is indispensable to attracting industry and manufacturing that requires a dependable supply of power.[8]

Unfortunately, much of the developing world suffers from the lack of private capital markets, which necessitates government or multilateral-backed financing. Few energy infrastructure projects actually can win private financing in these markets for a variety of reasons – most notably because of political, devaluation, and regulatory hazards. Accordingly, multilateral development banks play a critical role. In 2009, those institutions accounted for more than $3 billion spent to provide impoverished countries access to electricity –around 34 percent of total funding for that effort.[9]

U.S. International Position Linked to Domestic Policy Concerns

In June 2013, President Barrack Obama announced that the United States would no longer provide public funding for construction of new coal fired power plants overseas, except under very limited circumstances.[10] In his speech rolling out his Climate Action Plan (CAP), the President emphasized the U.S. obligation to be a global leader in reducing carbon emissions, challenging Americans to innovations that would usher in a clean energy economy for the United States and the rest of the world.[11] The following month, the World Bank—in which the United States has the largest voting share—joined the White House in its coal ban, favoring instead to finance cleaner natural gas and hydro plants.[12]

In the autumn of 2013, the U.S. Treasury Department issued detailed guidance implementing the CAP, reinforcing the coal ban and laying out the specifics on the limited circumstances under which international financing of new coal plants would be considered. Moving forward, the United

[5]See http://www.iea.org/publications/worldenergyoutlook/resources/energydevelopment/accesstoelectricity/. For example, only about 31 percent of the Sub-Saharan population has access to electricity. Nearly 600 million people live without it.

[6]Chafe, Zoe, Michael Brauer, Zbigniew Klimont et al, "Household Cooking with Solid Fuels Contributes to Ambient PM2.5 Air Pollution and the Burden of Disease," Environmental Health Perspectives at http://ehp.niehs.nih.gov/1206340/.

[7]See http://www.who.int/csr/disease/ebola/overview-august-2014/en/.

[8]Nuclear power is also baseload generation, but most developing countries are not good candidates for a commercial nuclear program because of the significant capital costs, as well as required regulations for safety, security, and non-proliferation. Of course, political risk and insecurity, which is a challenge in many poor countries, creates a strong argument against nuclear deployment in those countries.

[9]"Energy for All – Financing Access for the Poor," International Energy Agency and the Organization for Economic Cooperation and Development, October 2011, pg. 13. See http://www.iea.org/papers/2011/weo2011_energy_for_all.pdf

[10]"Today, I'm calling for an end of public financing for new coal plants overseas - (applause) – unless they deploy carbon-capture technologies, or there's no other viable way for the poorest countries to generate electricity. And I urge other countries to join this effort." – President Barrack Obama, June 25, 2013. See http://www.whitehouse.gov/the-press-office/2013/06/25/remarks-president-climate-change

[11]See http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf. "Leading Global Sector Public Financing Towards Cleaner Energy: Under this Administration, the United States has successfully mobilized billions of dollars for clean energy investments in developing countries, helping to accelerate their transition to a green, low-carbon economy. Building on these successes, the President calls for an end to U.S. government support for public financing of new coal plants overseas, except for (a) the most efficient coal technology available in the world's poorest countries in cases where no other economically feasible alternative exists, or (b) facilities deploying carbon capture and sequestration technologies. As part of this new commitment, we will work actively to secure the agreement of other countries and the multilateral development banks to adopt similar policies as soon as possible."

[12]See http://www.worldbank.org/en/news/feature/2013/07/16/world-bank-group-direction-for-energy-sector and "Toward a Sustainable Energy Future for All: Directions for the World Bank Group's Energy Sector" at http://documents.worldbank.org/curated/en/2013/07/18016002/toward-sustainable-energy-future-all-directions-world-bank-group%C2%92s-energy-sector.

States would only consider coal financing for the world's poorest countries, with no other economically feasible alternatives, or for facilities deploying carbon capture and storage (CCS), *which is not even commercially available.*[13]

The U.S. Export-Import Bank (Ex-Im) then revised its guidelines in December, eliminating support for high carbon intensity projects, except for the poorest.[14] The Bank's new guidelines were amended soon afterward by Congress, including the addition of more poor countries to the list (See Table 1).[15] Expectedly, Republican lawmakers were criticized by a number of environmental organizations for this act.[16]

With its focus on climate policy, the Obama Administration has redefined the primary purpose of U.S. international financing for energy projects – from access to reliable and affordable energy to climate mitigation. This shift was best exemplified in December 2013 when the United States—albeit unsuccessfully—opposed Asian Development Bank (ADB) funding for a *supercritical* coal-fired plant in Pakistan.[17] In overcoming U.S. disapproval, ADB officials claimed that the power plant would help address acute power shortages of up to 20 hours per day and save the Pakistani economy $535 million by replacing imported oil with coal. Power shortages cost the Pakistani economy an estimated 2 percent of its annual economic growth.[18]

Energy security and development goals do not appear to be major concerns of the White House. Administration officials have aggressively lobbied other developed countries to restrict international coal financing. The United Kingdom, Denmark, Finland, Iceland, Norway and Sweden joined the U.S. position quickly, followed late last year by France and Germany.[19,20] However, U.S. efforts to persuade other major developed economies outside of Europe have stalled. In July 2014, Japan announced that it would increase its support for coal-fired power plants in developing countries, arguing that U.S. policy would force those nations to deploy cheaper, more polluting technologies. That month, Tokyo's Japan Bank for International Cooperation (JBIC) approved a $200 million-credit line to Vietnam to purchase Japanese coal pollution-control technology.[21] Australia has also opposed U.S. efforts, given the importance of coal exports to the Australian economy.[22]

Few proponents for funding overseas coal plants actually question the need to impose certain environmental conditions—such as the need to install highly-efficient technology to mitigate greenhouse gas emissions and traditional pollutants. However, these requirements should take into account the circumstances of the country in question, including ambient environmental conditions and coal quality (i.e., not all coal projects should be ultra-supercritical). The determination should also consider what current feedstock a coal plant would be displacing, including solid fuels and petroleum. **Furthermore, carbon capture and storage (CCS) technology should not be imposed as a standard on *any* part of the developing world, including India, which has roughly 300 million people without access to electricity.**

It is doubtful, however, that the Obama Administration will voluntarily take a more practical approach because of overriding domestic policy goals. As part of the implementation of the President's Climate Action Plan, the Environmental Protection Agency (EPA) has put forward a regulatory proposal covering carbon dioxide emissions from new power plants. That plan would require carbon capture and storage (CCS) on all new coal plants built in the United States.

The Administration is already under pressure from Republicans and a number of Democrats to drop the CCS standard for new U.S. plants. In May of 2014, seven Democratic Senators, citing the commercial unavailability of CCS, re-

[13] See http://www.treasury.gov/press-center/press-releases/Pages/jl2195.aspx and http://www.treasury.gov/resource-center/international/development-banks/Documents/CoalGuidance_2013.pdf.
[14] See http://www.exim.gov/newsandevents/releases/2013/EXPORT-IMPORT-BANK-BOARD-ADOPTS-REVISED-ENVIRONMENTAL-GUIDELINES-TO-REDUCE-GREENHOUSE-GAS-EMISSIONS.cfm and "Supplemental Guidelines for High Carbon Intensity Projects" at http://www.exim.gov/newsandevents/releases/2013/SUPPLEMENTAL-GUIDELINES-FOR-HIGH-CARBON-INTENSITY-PROJECTS.cfm
[15] Adragna, Anthony, "Climate Agenda Intact with Limited Riders in Appropriations Bill, White House Says," Bloomberg, January 15, 2014 at http://www.bloomberg.com/news/2014-01-15/climate-agenda-intact-with-limited-riders-in-appropriations-bill-white-house-says.html. Specifically, the provision would prevent Ex-Im and the Overseas Private Investment Corporation "from blocking coal-fired or other power-generation projects that increase the export of U.S. goods or services or prevent the loss of U.S. jobs."
[16] See http://blog.nwf.org/2014/01/dirty-business-congress-seeks-to-export-u-s-fossil-fuels-and-carbon-pollution/ and http://switchboard.nrdc.org/blogs/jschmidt/spending_bill_shouldnt_change.html.
[17] Fortunately, the plant was approved by the ADB. See http://www.adb.org/news/pakistan/adb-provides-900-million-jamshoro-power-project. Although restrictions on U.S. Ex-Im financing for coal-related exports to Pakistan were relaxed by Republican lawmakers, the White House can still oppose development bank funding.
[18] Blocking funding to the plant would have reduced Pakistan's access to affordable power that is needed for job creation, increasing the odds of political instability – a risk that the United States should seek to reduce, particularly given Pakistan's nuclear weapons stockpile. See http://www.law360.com/articles/494317/pakistan-secures-900m-loan-for-coal-power-plant.
[19] See http://www.ebrd.com/pages/sector/powerenergy/the-switch-from-coal.shtml and http://www.bna.com/netherlands-joins-bid-n17179889127/.
[20] See http://www.new-york-un.diplo.de/Vertretung/newyorkvn/en/__pr/speeches-statements/2014/20140923-hendricks-un-climate-summit.html?archive=3759636 and http://www.reuters.com/article/2014/11/27/us-france-energy-coal-idUSKCN0JB17120141127.
[21] Iwata, Mari, "Japan to Step Up Support for Overseas Use of Coal," Wall Street Journal, July 23, 2014 at http://online.wsj.com/articles/japan-to-step-up-support-for-overseas-use-of-coal-1406114037
[22] In 2012-13, coal accounted for 13 percent of total goods and services exported by Australia. See http://www.minerals.org.au/resources/coal/exports.

quested that President Obama support a standard in the near term that could be achieved by high-efficiency coal technologies.[23] Proponents for the efficiency standard also argue that a CCS requirement would irreparably damage U.S. investments and research and development in coal combustion, thus undermining the longer term goal of commercializing and exporting cleaner coal technologies.

The White House is probably concerned that adopting an energy efficiency standard for overseas coal plants would strengthen opposition to the President's domestic plan for CCS. The stakes are definitely high for proponents of future carbon regulation. If EPA carbon regulation survives legal challenges and makes it to the next round of U.S. GHG emissions cuts, the Agency will need the CCS standard for natural gas to force a fuel switch to zero emissions sources.[24] In the end, the courts may reject the CCS standard in the EPA proposal, which could force the Agency to support an efficiency standard for new U.S. coal plants. In turn, this development would obviously have a major impact on U.S. international financing policy of coal projects.

Developing Countries Need Coal-Fired Generation

Electricity investments in the developing world mainly seek to achieve three goals: to provide affordable power to people who do not have *any* access, to increase current consumption levels to achieve modern usage, or to generate affordable and reliable electricity to attract industry and power public buildings (e.g., schools and hospitals). According to a joint study by the IEA and the Organization for Economic Cooperation and Development (OECD), the world will spend an average of $14 billion annually between now and 2030 to provide access to modern power services, which will still leave nearly 1 billion people without electricity. To close this gap, the IEA and OECD propose an additional $34 billion spending in energy infrastructure per year by 2030, for a total investment of about $1 trillion.[25]

The IEA and the OECD acknowledge that meeting this universal objective would require on-grid, mini-grid and off-grid solutions. **Of the on-grid power generation, the study estimates that over 60 percent would be delivered using fossil fuels, predominantly coal—resulting in a global increase of GHG emissions by an estimated 0.7 percent by 2030.** Some part of this growth in emissions would be offset by fuel switching from solid fuels to electric stoves *(i.e., reduction in global warming particulates)* and reduced deforestation *(i.e., increased sequestration).*[26] In comparison, China's carbon pollution will increase substantially in the same timeframe—to a point where its level surpasses the combined total of the countries of the OECD.[27]

Table 1 (see next page) illustrates the vast disparity in electricity consumption between the countries that oppose coal plant financing and energy-poor countries, including those that are viewed by the Obama Administration as being too wealthy to be considered for efficient coal plants. As a point of reference, developing country household access to 250 kWh per year can provide electric light for five hours per day, the usage of one floor fan, and the charge for one cell phone. Increasing to 500 kWh allows for the addition of an efficient refrigerator, a second cell phone, and an appliance, such as small television or computer.[28]

The White House's Power Africa campaign, launched in the summer of 2013, targets six of the continent's poorest countries—Ethiopia, Ghana, Kenya, Liberia, Nigeria, and Tanzania—and seeks to add 10,000 megawatts of clean energy generation capacity. Washington has committed to more than $7 billion of public funding over a five-year period, leveraging it with $18 billion in private sector funding from a variety of U.S. and global companies.[30,31] With collaboration from a dozen U.S. government agencies, African governments, and private sector investment, the initiative is assisting with on-grid, mini-grid and off-grid projects fueled by wind, solar, geothermal, and biomass energy.[32] Consistent with the President's Climate Action Plan, none of the support will involve construction of coal

[23]See http://www.heitkamp.senate.gov/public/_cache/files/e14328e8-94a5-4b6a-8c18-10b154f9e30/S-21-nsps-letter.pdf.
[24]EPA and environmental activists will seek U.S. reductions in greenhouse gases that they feel are necessary to avoid abrupt climate change – at least an 80 percent reduction by 2050. Because of the emissions profile of natural gas, the 2050 goal cannot be met as long as natural gas plays a dominant role in the American economy.
[25]The "additional $34 billion" was derived from subtracting $14 billion from the IEA/OECD estimate that universal access would require $48 billion annually. Ibid, Energy for All, pg. 7.
[26]Ibid, pg. 27.
[27]The Obama Administration recognized this reality in its November 2014 agreement with Beijing. See http://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change.
[28]Ibid, Energy for All, pg. 12.
[29]CIA World Fact Book 2013: http://www.photius.com/rankings/energy/electricity_consumption_per_capita_2013_0.html.
[30]On August 5, 2014 at the US-Africa Business Forum, President Obama announced an increased financial commitment of public and private sector funding, and tripled the power connections target to 60 million households and businesses. http://www.whitehouse.gov/the-press-office/2014/08/05/remarks-president-us-africa-business-forum and See http://www.usaid.gov/powerafrica/partners/private-sector
[31]As a point of reference, the ABD provided $900 million to help build the 600 megawatt supercritical coal plant in Pakistan. Supercritical coal plants typically run around 70 percent of the time, while wind power has a capacity rate of about 15 to 30 percent. Thus, 10,000 megawatts of wind power capacity – at best – would be roughly equivalent to 2,000 to 4,000 megawatts of supercritical coal-fired generation capacity.
[32]See http://www.whitehouse.gov/the-press-office/2013/06/30/fact-sheet-power-africa.

TABLE 1: SELECT COUNTRIES, ELECTRICITY CONSUMPTION, 2013 (KWH PER CAPITA)

Countries Supporting Severe Restrictions on Coal Plant Investments	Ex-Im List of Poorest Countries (Coal Plant Investments Allowed in Limited Circumstances)	Countries Added to the Ex-Im List by Republican Lawmakers in 2014
Norway (23,538)	Bangladesh (216)	Vietnam (1,103)
Sweden (13,961)	Cote d'Ivoire (162)	India (529)
United States (12,391)	Congo, Republic (128)	Bolivia (612)
Germany (6,753)	Cambodia (117)	Sri Lanka (431)
Netherlands (6,419)	Congo, Dem. Rep. (89)	Pakistan (368)
Denmark (5,848)	Ethiopia (40)	Cameroon (250)
United Kingdom (5,167)	Eritrea (39)	Nigeria (103)

[29]

TABLE 2: U.S. GOVERNMENT AGENCY FINANCIAL COMMITMENTS FOR POWER AFRICA

Federal Agency	Funding	Type of Commitment
U.S. Agency for International Development (USAID)	$285 million	Technical and regulatory assistance, grants and risk mitigation
Millennium Challenge Corporation (MCC)	Up to $1 billion	Investments in infrastructure, reform, and capacity
Overseas Private Investment Corporation (OPIC)	Up to $1.5 billion	Financing, loan guarantees, and political risk insurance
U.S. Export-Import Bank (Ex-Im)	Up to $5 billion	Potential loan guarantees

[33]

plants, despite the recommendations of development policy experts from the IEA and OECD.

One year later, criticism is spreading that Power Africa is *powerless* in providing real help to Africa. Detractors argue that President Obama's plan and focus on intermittent renewable energy sources will not deliver the type of consistent, baseload power that African countries need to build an industrial economy. Certain practical goals, such as increasing access to refrigeration and consistent operation of machinery for manufacturing, cannot be achieved solely with renewable power generation.

African governments understand fully that fossil fuel exploitation is essential to meeting those basic needs. **At the August 2014 U.S.-Africa Leader Summit, African senior officials were vocal in opposing the U.S. position. Tanzanian Minister of Power Sospeter Muhongo argued that his country would build coal plants, "Why shouldn't we use coal when there are other countries where their [carbon pollution] per capita is so high?. . . We will just go ahead."** Nigeria's Minister of Power Chinedu Ositadinma Nebo agreed, "I think Africa should be allowed to develop its coal potential. This is very critical."[34]

[33] "Power Africa: Annual Report July 2014" See http://www.usaid.gov/sites/default/files/documents/1860/USAID_PowerAfrica_AR_July2014.pdf
[34] Friedman, Lisa, "Africa Needs Fossil Fuels to End Energy Apartheid," ClimateWire, August 5, 2014.

In response to African government concerns, World Bank President Jim Kim appears to have taken a more nuanced position, despite the Bank's formal position on coal plant financing. Kim announced at the Summit in August, "Where the only option is coal, we have said that we're going to have to look at that, and look at that seriously." On the ability of renewables to meet Africa's basic power needs, he further commented, "The minute it gets there, we will be the first to celebrate. But it's not there yet."[35]

U.S. Policy Opens Up Opportunities for Foreign Competitors

The U.S. position is unlikely to gain much traction outside of Europe for one incredibly important reason: the climate agenda is not a top political priority in most other areas of the world.[36] In fact, developing countries are likely to surmise that the motivation behind U.S. policy is to limit their economic growth or worse yet—to offset the growth of carbon dioxide emissions in the United States and the European Union.[37] In the best-case scenario, poor countries will ascertain that Washington policymakers are simply removed from reality or insensitive to their needs. In either case, developing nations are likely to seek funding for coal projects from bilateral sources and other development banks not under the influence of the United States and its coalition partners.

China and Russia, in particular, will be eager to exploit this gap by offering financing at better terms and with fewer environmental conditions. Beijing and Moscow both seek to realign the global financial system, which they view as a relic of Bretton Woods and providing unwarranted influence to the West. Moreover, affordable and reliable energy resources that are often politically incorrect in Washington, including coal and hydro, will become increasingly important as the world further industrializes. **By financing power projects that can last decades, China and Russia both will gain greater political influence in the developing world, which will increase in geopolitical importance over the course of this century.**

Recent research indicates that China is by far the largest funder of overseas coal projects in developing countries (See Table 3). Last year, Beijing approved a deal to finance a 1,320 megawatt coal plant in Bangladesh—one of the countries most cited as being vulnerable to climate impacts.[38] And even in the EU's backyard, China is building coal power. A Chinese consortium won a bid in 2014 to build a 450 megawatt plant in Bosnia, a country hoping to achieve EU membership. China's Ex-Im Bank plans to finance 85 percent of the $1 billion project, including contracts with European equipment providers, Alstom and Siemens.[39]

China is also pursuing the creation of multilateral financing mechanisms that give it greater control over decision making, in contrast with its limited influence in the World Bank and Asian Development Bank. In this effort, Beijing is focusing on infrastructure development, in part because of lessons learned from its own economic development history. According to the World Bank, a 10 percent increase in infrastructure investment contributes to 1 percent GDP growth in developing countries.[40] Unencumbered by carbon restrictions, it is expected that China's new initiatives will provide substantial funding for coal projects in poor countries.

Last year, the BRICS group (Brazil, Russia, India, China, and South Africa) agreed to create the New Development Bank (NDB), headquartered in Shanghai, China, to be in operation by 2016.[41] Focusing primarily on infrastructure projects, the NDB will have initial starting capital of $50 billion, increased over time to $100 billion. Although the Bank will focus on BRICS projects initially, the NDB plans to fund projects in low and middle income countries as well.

In addition to the NDB, China, joined by 20 other countries in November 2014, launched another $50 billion development bank—the Asian Infrastructure Investment Bank (AIIB).[42] Widely viewed as a rival to the World Bank

[35] See http://www.eenews.net/special_reports/global_climate_debate/stories/1060004061/print

[36] A number of environmental activists will dispute this point, relying in particular on statements from small island developing states (SIDS). However, SIDS climate change policy is defined largely by Western environmental groups. In fact, it is not uncommon to find environmental activists representing SIDS in the international climate negotiations. See http://www.worldwatch.org/node/6360

[37] This narrative may be fed in particular by Germany's recent actions to bring new coal plants on line. See http://www.bloomberg.com/news/2014-06-26/germany-s-new-coal-plants-push-power-glut-to-4-year-high.html

[38] "China, Bangladesh Sign Power Plant Deal," Xinhua, April 29, 2014 at http://english.people.com.cn/90883/8613419.html

[39] "Chinese Group Wins Approval for Bosnia Power Plant," Reuters, July 24, 2014 at http://www.reuters.com/article/2014/07/24/bosnia-energy-china-idUSL6N0PZ4W520140724

[40] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTINFRA/0,,contentMDK:23136175~menuPK:8497173~pagePK:64168445~piPK:64168309~theSitePK:8430730,00.html

[41] Sharkov, Damien, "Russia, China, India Ready to Launch Rival to World Bank," Newsweek, July 9, 2014 at http://www.newsweek.com/russia-china-india-ready-launch-rival-world-bank-258058

[42] See Perlez, Jane, "U.S. Opposing China's Answer to World Bank," New York Times, October 9, 2014 at http://www.nytimes.com/2014/10/10/world/asia/chinas-plan-for-regional-development-bank-runs-into-us-opposition.html and http://www.reuters.com/article/2014/11/05/us-china-aiib-idUSKCN0IP08U20141105.

and Asian Development Bank (ABD), the AIIB will focus on infrastructure development as well. The high level of interest across the region indicates that governments believe that a new bank is needed because existing multilateral banks have not been able to provide adequate low-cost financing for infrastructure creation.[43] Certainly, carbon conditions pushed aggressively by the United States have raised concerns that Western development banks have lost focus in helping provide developing countries the energy systems they actually want and need.

TABLE 3: SELECT COUNTRIES, PUBLIC FINANCING OF OVERSEAS COAL POWER PLANTS IN ASIA (2007 TO 2013)[44]

Country	Billions (U.S. Dollars)
China	$13.1 to $20.6
Japan	$7.66
South Korea	$4.3
Germany	$3.66
France	$1.71
United States	$1.46

44

The United States, despite its reported diplomatic efforts to undermine the Asian Infrastructure Development Bank, cannot stop China and other countries from creating new financial institutions nor can Washington stop those governments from funding overseas coal plants. More importantly, the United States *should* not block Beijing's desire to provide more money for infrastructure development, given the enormous gap between the capital that is currently available and what is required, particularly for global access to electricity and modern energy usage.

Obstructing China only reinforces the belief in impoverished countries that the United States has no real understanding of poverty issues and will do anything to preserve its own influence, even to the detriment of the world's poor. This insensitivity has associated political costs, likely resulting in greater resentment towards the United States and declining U.S. influence in large parts of the world relative to China and other BRICS countries.

Finding the Right Balance

Washington should take caution in imposing climate policies on poor countries, particularly those that are built on a mythology in which renewable energy systems can replace baseload generation in economic development. While developing countries benefit from deployment of distributed generation, especially in rural areas, they also need coal units to reduce power shortages in urban zones and to help attract factories that require reliable power.

Climate activists argue that the United States has a moral responsibility to reduce its greenhouse gas emissions—in part to save poor countries from climate impacts. While developing countries would agree with that statement, they would argue that the greater moral responsibility is for Washington to help improve their quality of life—even if that means building coal plants in poor countries and offsetting those emissions by further reducing carbon pollution in the industrialized world. Further, they would emphasize that increasing access to electricity enhances resilience to climate impacts—a point reflected in the UNFCCC.

Given their influence in multilateral development banks, the United States and its partners in Europe can undoubtedly slow down the deployment of coal plants, but they cannot stop them. Beijing and other governments will continue to fund coal projects throughout the developing world, and they will earn political goodwill for it. Over time, poor countries will learn to go to the Chinese and others first when discussing energy infrastructure—if they have not already—leaving the United States and its climate allies on the sidelines.

This development will have negative implications for the environment. IEA Executive Director Maria van der Hoeven recently warned that too many inefficient coal plants are being built in Africa and Asia already, necessitating greater investment in highly efficient plants in those areas.[45] **Chinese displacement of Japanese boiler technology exports, for example, would have a non-trivial impact on greenhouse gas emissions. According to research at the University of Tokyo, roughly 35 percent of**

[43] "India likely to join Asian Infrastructure Bank," Sidhartha, October 6, 2014 at http://timesofindia.indiatimes.com/business/india-business/India-likely-to-join-Asian-infrastructure-bank/articleshow/44435632.cms

[44] Data taken from Takahiro Ueno, Mike Yanagi, and Jane Nakano. "Quantifying Chinese Public Financing for Foreign Coal Power Plants," GraSPP Working Paper Series, University of Tokyo, November 2014, pg. 14 - 18

[45] See http://www.eenews.net/climatewire/stories/1060010525.

[46] Takahiro Ueno, Mike Yanagi, and Jane Nakano. "Quantifying Chinese Public Financing for Foreign Coal Power Plants," GraSPP Working Paper Series, University of Tokyo, November 2014, pg. 22 and 23.

boiler technology supplied by Chinese manufacturers to Asian markets after 2007 was supercritical, compared to 62 percent exported by Japanese firms.[46] Accordingly, U.S. efforts to obtain an OECD consensus on severely limiting coal financing for the sake of climate mitigation, if successful, would actually result in an increase in GHG emissions over the longer term—an unintended but foreseeable consequence.

Fortunately, there is time for a policy correction that protects long-term U.S. interests. The Obama Administration should abandon the requirement of carbon capture and storage (CCS) on any coal plant in the developing world—choosing instead a flexible efficiency standard. Washington should also weigh the positive environmental and health benefits of coal generation when new builds result in energy efficiency upgrades or fuel switching from oil or solid fuels, such as wood and charcoal. Reducing dependence on solid fuels not only reduces potent, short-lived global warming agents but also saves lives. If needed to produce a carbon neutral transaction, the United States should consider attaching domestic or foreign offset requirements, including land use and forests, to a new coal plant.

For their part, fiscal conservatives should support a role for the U.S. government in helping finance infrastructure, including power projects, where there is a heightened perception of risk, private capital markets are not well developed, and U.S. national interests are at stake. Unmistakably, U.S. taxpayers face a real risk in the U.S. financing of these projects. There remains a strong public policy argument to back electricity investments, however. A more prosperous world, fueled by affordable power, reduces the probability of conflict, humanitarian crises, terrorism, and instability—issues about which the United States and its public cares deeply. In this effort, both Ex-Im and OPIC can be important U.S. foreign policy tools if used correctly.[47]

The United States still has substantial leverage that it can use to promote its objectives. Developing countries need U.S. assistance, particularly from its private sector which offers knowledge, training, transparency, and world-class technology. Washington, however, cannot overplay its hand; it must seek a balance—in coordination with other creditors, including China and Russia—that weighs economic development goals, including global energy access, and the need to improve air quality and health systems in the developing world.

[47] The ability to provide government financing can determine if a U.S. company's bid is even competitive. According to an industry survey, some procurement tenders give up to 30 percent weight to government backed financing in evaluation of bids.