S. HRG. 113–736

CLIMATE CHANGE: IT'S HAPPENING NOW

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

July 18, 2013

Printed for the use of the Committee on Environment and Public Works

Available via the World Wide Web: http://www.gpo.gov/fdsys

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COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

ONE HUNDRED THIRTEENTH CONGRESS
FIRST SESSION

C O N T E N T S

ADDITIONAL MATERIAL

CLIMATE CHANGE: IT'S HAPPENING NOW

THURSDAY, JULY 18, 2013

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Washington, DC.

The committee met, pursuant to notice, at 10 a.m. in room 406, Dirksen Senate Office Building, Hon. Barbara Boxer (chairman of the committee) presiding.

Present: Senators Boxer, Vitter, Carper, Cardin, Sanders, Whitehouse, Udall, Gillibrand, Hirono, Inhofe, Barrasso, Sessions, Wicker, and Fischer.

OPENING STATEMENT OF HON. BARBARA BOXER, U.S. SENATOR FROM THE STATE OF CALIFORNIA

Senator BOXER. The hearing will come to order.

I got a call from Senator Inhofe and he said he is pulled between his duties at the Armed Services Committee and here and that he would hope when he arrived, because he has to go back and forth, that he could be recognized, whatever the list is. I said it was fine with me and that I would ask unanimous consent at the time. I just wanted to mention that to everybody. And I told him what would a hearing on climate change be without him and I certainly was encouraging him to come.

So, today our hearing will focus on climate change and the serious threat it poses to our Nation. This is not a political hearing or a solutions hearing. It is a hearing where I hope we will listen to the experts.

The body of evidence, to me, and I think we will learn today appears to be overwhelming, the world's leading scientists agree and predictions of the impact of climate change are coming true before our eyes.

The issue has been a priority for me since I became Chairman of the Committee. How long ago was that? 2007. 2007. Because to me, climate change puts our environment and public health at risk and the long-term risks are enormous. And I remember that one of our first hearings at that time was about climate change.

I am going to talk about what the scientists then told us would be happening and people were looking at the scientists like this cannot be possible. But I will tell you what they said then and we can all judge as to whether or not what they said is coming true.

For example, Dr. Kevin Trenberth said it is very likely that hot extremes and heat waves will continue to become more frequent. He also said it is likely that tropical storms and hurricanes will become more intense and with much heavier rainfalls and thus the risk of flooding.

Dr. Howard Frumkin in 2009 said with climate change, an increase in the severity, duration and frequencies of extreme heat waves is expected. Admiral Dennis McGinn said on the most basic level climate change has the potential to create sustained natural and humanitarian disasters on a scale and frequency beyond those we see today.

So, in just a few short years since these predictions were made, we can just look at the window and see the evidence of climate change mounting around us. We can just look at what we are all voting for in terms of rebuilding our communities because of the intense weather.

I have a chart of the Rockaways in 2012. Superstorm Sandy resulted in the loss of life, wiped out entire communities and caused approximately $65 billion of damage. We all remember that. And I have a chart of an Alaskan village. The impacts of climate change are being felt. The Arctic has lost more than one-third of total sea ice volume over the last decade, making Alaskan Native villages increasingly vulnerable to erosion and storms.

And I will show you a chart of a California wildfire. These are raging. These are raging continually. Right now we have one in the county in which I live. We have seen large wildfires break out earlier in the season in California. Nineteen brave firefighters in Arizona tragically lose their lives. In 2012, New Mexico experienced the largest wildfire in State history. Colorado suffered the second large wildfire in State history. And Oregon has its largest wildfire since the 1860's.

According to NOAA, the National Oceanic Atmospheric Administration, over the past 2 years there have been 25 weather and climate disasters, each one costing more than $1 billion. And the second panel, which Senator Whitehouse requested and will chair, will look at the State of our oceans.

Climate change is real. This is what I believe. Human activities are the primary cause. That is what I believe. And the warming planet poses a significant risk to people and the environment. That is what I believe. And I believe all of that because the top scientists are telling us that.

Today we will be hearing from scientists and other experts who will tell us about the growing impacts associated with climate change. We have an amazing first panel. I will hold off introducing them until we have all made our opening statements.

And with that, I will call on Senator Vitter.

OPENING STATEMENT OF HON. DAVID VITTER, U.S. SENATOR FROM THE STATE OF LOUISIANA

Senator VITTER. Thank you, Chairman Boxer and members of our Committee who are here today and our panel of witnesses who will be discussing a number of very important issues as they relate to climate science and our National Energy Policy.

First let me say I think it is really unfortunate that we do not have any witnesses here from the Obama administration. Just weeks ago, President Obama announced a sweeping Climate Action Plan which will undoubtedly tighten the Federal Government's grip on our economy. It would have been very useful to hear from the Administration about how exactly they plan to implement this strategy. It also would have been useful to learn the exact the exact measurable benefits that the United States can expect from these actions.

In relation to that, I would just like to put into the record, Madam Chair, a letter to you specifically requesting we have witnesses as part of this discussion and also a letter to President Obama, both are from mid-July, requesting that he make available witnesses from his Administration about this climate action plan. And I ask unanimous consent to submit these for the record.

Senator BOXER. Without objection.

[The referenced information follows:]

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
WASHINGTON, DC 20510-6175

July 10, 2013

The Honorable Barbara Boxer
Chairman
Committee on Environment and Public Works
410 Dirksen Senate Office Bldg.
Washington, DC 20510-6175

Dear Chairman Boxer:

We want to express our interest in the global warming policy hearing entitled "Climate Change: It's Happening Now" that you have scheduled for July 18, 2013. This hearing is timely in light of the President's recent announcement of a "Climate Action Plan" at Georgetown University, where he committed to a "coordinated assault on a changing climate."[1] In his speech, the President highlighted a mere fraction of the federal actions being taken unilaterally by his Administration to address climate change. Because of the significant interest in and impacts of these actions, we request that you reconsider your decision to exclude the participation of government witnesses from the hearing.

The potential of these government actions to exacerbate the serious economic problems that currently persist justifies asking a panel of federal witnesses, charged with implementing the President's agenda, to testify as to the scope, purpose, and consequences of such unilateral action. Today, only 47% of Americans have a full time job,[2] the workforce participation rate is at its lowest level since the Carter Administration,[3] and the national unemployment rate has exceeded 7.5% for the longest period since the Bureau of Labor Statistics started tracking the national unemployment rate.[4] By the time President Obama leaves office, the federal debt will likely exceed $20 trillion, further frustrating America's future.

The American people should not be kept in the dark regarding the scope of the actions this Administration is taking under the guise of controlling our climate – actions that have the potential to negatively impact employment, job creation, and our national debt. These actions are being taken without China, India, and Russia – some of the world's largest carbon emitters – placing similar constraints on their economies.

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[1] President Barack Obama, Remarks by the President on Climate Change (June 25, 2013).
[2] News Release, U.S Dep't of Labor, Bureau of Labor Statistics, The Employment Situation-June 2013 (July 5, 2013) (*available at* http://www.bls.gov/news.release/pdf/empsit.pdf).
[3] U.S. Dep't of Labor, Bureau of Labor Statistics, Databases, Tables & Calculators by Subject, 1979-2013. (July 10, 2013) (*available at* http://data.bls.gov/pdq/SurveyOutputServlet)
[4] CONG. BUDGET OFF., U.S CONGRESS, PUB. NO. 4649, THE BUDGET AND ECONOMIC OUTLOOK: FISCAL YEARS 2013 TO 2023 (2013).

European nations continue to reconsider their own climate policies as their economies continue to suffer, interest in an international agreement further wanes, global warming continues to poll as one of the issues of least concern to our fellow Americans,[5] and global temperatures continue to fail to meet the climate model predictions of the last thirty years.[6] Enumerated below are just a few important reasons for including a panel of federal witnesses at the July 18 hearing:

1. The Environmental Protection Agency (EPA) has, without providing for public comment or peer review, adjusted upwards the Social Cost of Carbon (SCC)[7] to modify the accounting for benefits claims from regulatory actions. Regulation of greenhouse gases from new and existing sources is set to cripple numerous large scale manufacturing and energy projects across the nation, creating an environment in which foreign countries will become far more attractive for future investment, potentially undermining our economy.

2. For more than nine months, the Treasury Department stonewalled multiple transparency requests regarding internal work on the development of a carbon tax, as well as the sources of funding for international climate commitments that were negotiated behind closed doors.[8]

3. The Department of Interior continues to cut off access to minerals and other natural resources for energy development.[9] It also continues to craft multiple new layers of federal designations and bureaucracy certain to continue the decline in energy production on federal lands. It is critical that Congress has a clear understanding of how the Interior Department plans to utilize federal lands.

4. The Department of Energy's (DOE) "green" energy grant programs have been a disaster by any measure.[10] While the stimulus funds that went to now-bankrupt Solyndra received the most public notoriety, total federal stimulus spending cost $11.25 million for every permanent "green" job,[11] and the DOE Inspector General

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[5] *Climate Change and Financial Instability Seen as Top Global Threats*, PEW RESEARCH CTR. (June 24, 2013), http://www.pewglobal.org/2013/06/24/climate-change-and-financial-instability-seen-as-top-global-threats/#fn-27454-1.
[6] *Climate Science: A Sensitive Matter*, THE ECONOMIST, Mar. 30, 2013, http://www.economist.com/news/science-and-technology/21574461-climate-may-be-heating-up-less-response-greenhouse-gas-emissions.
[7] The White House, Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis, May 2013.
[8] Press Release, Republican Env't and Pub. Works Comm., Vitter: Still No Transparency at Treasury with Carbon Tax E-Mails (Jan. 14, 2013) (*available at* http://www.epw.senate.gov/public/index.cfm?FuseAction=Minority.PressReleases&ContentRecord_id=39ca37b0-a603-b2a4-5349-13e5ddf0a594.
[9] *IER Analysis: Oil and Gas Production Declines on Federal Lands in FY 2011*, INST. FOR ENERGY RESEARCH, Feb. 23, 2012, http://www.instituteforenergyresearch.org/2012/02/23/ier-analysis-oil-and-gas-production-declines-on-federal-lands-in-fy2011/.
[10] Steve Hargreaves, *Obama's Alternative Energy Bankruptcies*, CNN (Oct. 22, 1012, 11:16 PM), http://money.cnn.com/2012/10/22/news/economy/obama-energy-bankruptcies/index.html.
[11] *The Department of Energy Committed $11 Million Per Job*, INST. FOR ENERGY RESEARCH, May 8, 2013, http://www.instituteforenergyresearch.org/2013/05/08/does-11-million-jobs/.

has on more than one occasion found problems with efficiency and other federal grant programs.[12]

An Administration taking such sweeping actions on climate change should be ready to defend those actions before the Senate Environment and Public Works Committee. We are certain the President would accommodate the Chairman of this Committee in a request to have his Administration officials represent what he so proudly touts as being good for America. There seems to be little point in holding a hearing on climate change policy that excludes witnesses from our own federal government to explain the national climate change "policy" unilaterally established by this Administration. As our government sets in motion a litany of new actions with significant economic implications, we ask that you allow for Congressional oversight of federal policy decisions related to these attempts at controlling the climate.

Sincerely,

David Vitter
Ranking Member
Environment and Public Works

James Inhofe
United States Senate

John Barrasso
United States Senate

Jeff Sessions
United States Senate

Mike Crapo
United States Senate

Roger Wicker
United States Senate

John Boozman
United States Senate

Deb Fischer
United States Senate

[12] THE DEP'T OF ENERGY, OFF. OF INSPECTOR GEN., OFF. OF AUDITS AND INSPECTIONS, OAS-RA-11-14, THE DEPARTMENT OF ENERGY'S WEATHERIZATION ASSISTANCE PROGRAM FUNDED UNDER THE AMERICAN RECOVERY AND REINVESTMENT ACT FOR THE COMMONWEALTH OF VIRGINIA (2011), *available at* http://energy.gov/sites/prod/files/OAS-RA-11-14.pdf

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
WASHINGTON, DC 20510-6175

July 15, 2013

The Honorable Barack Obama
President
The White House
1600 Pennsylvania Avenue NW
Washington, DC 20500

Dear President Obama:

As you are aware, last week my fellow Environment and Public Works Committee Republicans and I sent a letter to Senator Boxer requesting the presence of federal witnesses at this Thursday's hearing entitled "Climate Change: It's Happening Now." I am requesting your active participation in providing representatives of your Administration that Senator Boxer has failed to include. This hearing is timely in light of your recent announcement of a "Climate Action Plan" at Georgetown University, where you committed to a "coordinated assault on a changing climate."[1] In this speech, you highlighted a mere fraction of the federal actions being taken unilaterally by your Administration to address climate change.

To date, Chairman Barbara Boxer has refused to invite any government witnesses to participate in this hearing. Although she assured the press that she will have a panel of government witnesses at another hearing later in the year, I remain uncertain of her commitment to fulfilling that promise. Her similar agreement to hold a hearing on the U.S. Environmental Protection Agency's budget, which has traditionally been an item of regular order for the Committee, has failed to come to fruition.

The potential for your climate plan to exacerbate the serious economic problems that currently persist justifies providing a panel of federal witnesses who are charged with implementing your agenda, to testify as to the scope, purpose, and consequences of such unilateral action. Today, only 47% of Americans have a full time job,[2] the workforce participation rate is at its lowest level since the Carter Administration,[3] and the national unemployment rate has exceeded 7.5% for the longest period since the Bureau of Labor Statistics started tracking it.[4] At the end of your second term in office, the federal debt will likely exceed $20 trillion, further frustrating America's future.

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[1] President Barack Obama, Remarks by the President on Climate Change (June 25, 2013).
[2] News Release, U.S Dep't of Labor, Bureau of Labor Statistics, The Employment Situation-June 2013 (July 5, 2013) (*available at* http://www.bls.gov/news.release/pdf/empsit.pdf).
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[4] CONG. BUDGET OFF., U.S CONGRESS, PUB. NO. 4649, THE BUDGET AND ECONOMIC OUTLOOK: FISCAL YEARS 2013 TO 2023 (2013).

The American people should not be kept in the dark regarding the scope of the actions your Administration is taking under the guise of controlling our climate – actions that have the potential to negatively impact employment, job creation, and our national debt. These actions are being taken without China, India, and Russia – some of the world's largest carbon emitters – placing similar constraints on their economies.

European nations continue to reconsider their own climate policies as their economies continue to suffer, interest in an international agreement further wanes, global warming continues to poll as one of the issues of least concern to our fellow Americans,[5] and global temperatures continue to fail to meet the climate model predictions of the last thirty years.[6] Enumerated below are just a few important reasons for including a panel of federal witnesses at the July 18 hearing:

1. Your Interagency Working Group (IWG), without providing for public comment or peer review, and ignoring OMB guidance, adjusted upwards the Social Cost of Carbon (SCC)[7] to modify the accounting for benefits claims from regulatory actions. Regulation of greenhouse gases from new and existing sources is set to cripple numerous large scale manufacturing and energy projects across the nation, creating an environment in which foreign countries will become far more attractive for future investment, potentially undermining our economy.

2. For more than nine months, the Treasury Department stonewalled multiple transparency requests regarding internal work on the development of a carbon tax, as well as the sources of funding for international climate commitments that were negotiated behind closed doors.[8]

3. The Department of Interior continues to cut off access to minerals and other natural resources for energy development.[9] It also continues to craft multiple new layers of federal designations and bureaucracy certain to continue the decline in energy production on federal lands. It is critical that Congress has a clear understanding of how the Interior Department plans to utilize federal lands.

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[6] *Climate Science: A Sensitive Matter*, THE ECONOMIST, Mar. 30, 2013, http://www.economist.com/news/science-and-technology/21574461-climate-may-be-heating-up-less-response-greenhouse-gas-emissions.

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[9] *IER Analysis: Oil and Gas Production Declines on Federal Lands in FY 2011*, INST. FOR ENERGY RESEARCH, Feb. 23, 2012, http://www.instituteforenergyresearch.org/2012/02/23/ier-analysis-oil-and-gas-production-declines-on-federal-lands-in-fy2011/.

4. The Department of Energy's (DOE) "green" energy grant and loan programs have been a disaster by any measure.[10] While the stimulus funds that went to now-bankrupt Solyndra received the most public notoriety, total federal stimulus spending cost $11.25 million for every permanent "green" job,[11] and the DOE Inspector General has on more than one occasion found problems with efficiency and other federal grant and loan programs.[12]

An Administration taking such sweeping actions on climate change should be ready to defend those actions before the Senate Environment and Public Works Committee. I am certain Chairman Boxer would accommodate the President of the United States in a request to have his Administration officials represent what he so proudly touts as being good for America. There seems to be little point in holding a hearing on climate change policy that excludes witnesses from our own federal government who could explain the national climate change "policy" unilaterally established by your Administration. As our government sets in motion a litany of new actions with significant economic implications, I ask that you encourage Congressional oversight of federal policy decisions related to these attempts at controlling the climate.

Sincerely,

David Vitter

David Vitter
Ranking Member

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[11] *The Department of Energy Committed $11 Million Per Job*, INST. FOR ENERGY RESEARCH, May 8, 2013, http://www.instituteforenergyresearch.org/2013/05/08/does-11-million-jobs/.

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Senator VITTER. Former Administrator Lisa Jackson testified before this Committee that U.S. action alone will not impact the climate. So, this begs a few questions, starting with have things changed so drastically in the last 4 years that now U.S. action alone can control the climate?

The hearing is entitled Climate Change: It's Happening Now. I would also note it is interesting that it is not Global Warming: It's Happening Now. Maybe it is because given the earth's stagnant temperature for the last 15 years, a fact that is currently confounding climate scientists and modeling experts that predicted otherwise, that would have been an inconvenient title.

The unique thing about the title of the hearing is that I think it could have been true and accurate and appropriate not only now but 50 years ago, and 500 years ago, and 5,000 years ago because climate change is happening, it is always happening, and there are many significant influences that are making it happen.

Just a cursory glance at recent scientific literature shows that influences, major influences on climate, include solar activity, solar cycles, ocean currents, cosmic rays and greenhouse gases that occur naturally as well as those emitted from many countries including those who have no plans on regulatory change like China, India and Russia. These are factors impacting our climate over which we have little or no control.

As the President unilaterally implements his regulatory agenda, I believe it is important to note what the Obama campaign does not want us to talk about. And I think it is very interesting. This was outlined in email last month by Ken Berlin, a Chair of President Obama's energy and environment team. And we have that detailed email and talking point memo here and I would like unanimous consent to submit this for the record.

Senator BOXER. Without objection.

[The referenced information follows:]

---------- Forwarded message ----------
From: **Ken Berlin, Energy & Environment Team**
Date: Mon, Jun 24, 2013 at 8:27 PM
Subject: TOMORROW: President Obama to deliver historic speech on climate change

Note: This is talking and interview points distributed by the institutionalized Obama Campaign staff to their insiders, commentators and pundits. Most notable is the chart of "do's and don'ts" which instruct their followers to steer away from mention of facts and instead use poll-tested words and points. Who is Ken Berlin? http://www.coalitionforgreencapital.com/ken-berlin.html

As you have probably heard, President Obama is going to give an historic speech on climate change tomorrow. According to press reports, he will make a commitment to reduce carbon emissions from both new and existing power plants. He will also announce his intention for the US to take the lead in international climate negotiations and will emphasize that we have an obligation to future generations to address climate change, that climate change is harming the country now, and that addressing climate change will be a plus for the economy.

The President's proposals will be bitterly attacked. Speaker Boehner has already said that setting standards to reduce emissions from existing power plants would be "absolutely crazy." The Energy and Environment Team is therefore asking you, as a leader in the energy or environment community, to support publicly the President's positions as individuals and or though any organization with which you are affiliated. To help you to begin thinking about this, I have included a set of talking points and supporting resources below. Tomorrow, we will send you our press release, as well as a form press release and a form letter to the editor that you can use to inform your own statements on the speech.

We are trying to gather information on all actions taken in support of the President and therefore we would deeply appreciate it if you could let us know what actions you take in response to tomorrow's speech. Please send us your activities via email to ofaeeteam@gmail.com.

Thanks,

Ken Berlin

Chair, Energy and Environment Team

Message Guidance – President Obama's Climate Change Action Plan

Core Message: President Obama has presented a broad and common sense plan for meeting our obligation to protect future generations from climate change. Americans are feeling the impacts of climate change already from destructive and deadly storms like Hurricane Sandy, droughts, and wild fires. President Obama's decision to take action to cut carbon pollution from power plants is particularly important since there are no current limits on carbon pollution from power plants even though they are its biggest source.

A simple 3-part message formulation should be used for maximum effect with general audiences.

1. We have a moral obligation to act.
2. Communities all over America are already being harmed.
3. The president's climate plan is full of common sense solutions including first-ever limits on carbon pollution from power plants.

Short interview-ready formulation:

1. We have a moral obligation to future generations to leave them a planet that's not polluted and damaged by carbon pollution.
2. Climate Change is already harming Americans all over the country. Cleaning up after climate-driven disasters last year cost the average taxpayer over $1,100. (Or cost taxpayers nearly $100 billion, one of the largest non-defense discretionary budget items in 2012.)
3. That's why we applaud President Obama's climate plan, which is full of common-sense solutions, starting with his call for the EPA to limit the carbon pollution from power plants. While we set limits for arsenic, mercury and lead, we let power plants release as much carbon pollution as they want. It's time to set a limit on pollution that affects public health, and that's why it's so important that the President is rising to the challenge.

Variations:

1. Moral obligation:

a. "We have a moral obligation to future generations to leave them a planet that's not polluted and damaged" – 93% agree, including 67% who strongly agree (Benenson Strategy Group for the League of Conservation Voters, 2/12/13)

b. "Just like our parents and grandparents handed us a better planet, we need to be responsible stewards of the earth" – 55% agree (Benenson Strategy Group for the League of Conservation Voters, 2/12/13)

c. "We have an obligation to future generations to do something about the issue of climate change. We need to make sure that this is not a problem that we simply pass on to future generations to deal with because it will just keep getting more expensive and painful if we put it off. – 65% say fairly important/very important reason government should act (Hart Research Associates for CAC, 1/29/13)

2. How Americans are already being harmed by Climate Change

a. **Extreme Weather**: In 2012, there were 3,527 monthly weather records broken for heat, rain, and snow in the US, according to information from the National Climatic Data Center — including a line of powerful storms in 2012 that killed 15 people and left millions without power [http://www.nrdc.org/health/extremeweather/]

b. **Drought**: By the end of August 2012, nearly 63% of the United States was experiencing drought conditions, with over 2,000 counties declared drought disaster areas. [http://www.ncdc.noaa.gov/sotc/national/2012/8]

c. **Flooding**: Hurricane Sandy, which left 131 dead and destroyed approximately 380,000 homes, created a storm surge that broke the all-time record in New York Harbor. The U.S. Geological Survey says that it has measured "the highest levels of flooding ever recorded in the state of Illinois. And the US Department of Agriculture says that 43% of this year's corn crop is in fair to very poor condition because of excessive rain. [http://www.climatecentral.org/news/statistics-show-just-how-intense-hurricane-sandy-was-15196; http://www.chicagonow.com/chicago-weather-watch/2013/04/great-midwest-flood-2013/; http://abcnews.go.com/Business/story?id=5181112&page=1#.Uclac6WyfzJ]

d. **Wildfires**: In November of 2012, the average size of wildfires in the US was the largest on record for any January through November period, nearly doubling the previous decade's average. These wildfires destroyed 9.2 million acres of land and hundreds of homes. [http://www.predictiveservices.nifc.gov/intelligence/intelligence.htm]

e. **Heat Waves**: By July 3, 2012, more than 40,000 daily heat records had been broken around the country, and the number of heat-related deaths predicted has jumped from the current annual rate of around 700 to between 3,000 and 5,000 by 2050. [http://www.cdc.gov/media/releases/2013/p0606-extreme-heat.html]

f. **Coastal Vulnerabilities**: In the last 80 years, Louisiana has lost a Delaware-sized amount of land to coastal erosion — equivalent to the loss of a football field every 38 minutes. [http://www.coastalmasterplan.louisiana.gov/whats-at-stake/coastal-crisis/]

g. **Costs**: At $100 billion, paying for climate disruption was one of the largest non-defense discretionary annual budget items in 2012. [http://www.nrdc.org/globalwarming/files/taxpayer-climate-costs-IP.pdf]

3. What we need to do to solve this problem:

a. Limiting carbon pollution from power plants seems so reasonable that 57 percent of voters believe that there are already significant limits on the greenhouse gases that have been linked to global warming that power plants are allowed to emit. (Benenson Strategy Group for the League of Conservation Voters, 2/12/13)

b. Power plants are the biggest source of dangerous carbon pollution in the U.S. Directing the EPA to set power plant carbon pollution standards is the strongest possible action the President can take to address the impacts of climate change.

c. In an era of heightened skepticism about the role of government, it is notable that a 51 percent majority of voters say that government should be doing more. (Hart Research Associates for CAC, 1/29/13)

Additional messages:

The president's action has strong public support

- Millions of Americans support action to cut industrial carbon pollution from power plants. EPA was inundated with more than 3.2 million comments in support of action to curb carbon pollution from all power plants.

- Poll after poll shows that a majority of Americans want climate action now. Nearly two-thirds of voters (65%) support "the President taking significant steps to address climate change now" (Benenson Strategy Group for the League of Conservation Voters, 2/12/13)

Cleaning up power plants is a common-sense step

- Just as the EPA protects our health from arsenic, mercury and lead, the EPA can protect our health from dangerous carbon pollution.
- In fact, the EPA could cut carbon pollution from America's power plants by a quarter (26 percent) by 2020, saving Americans between $26 to $60 billion in saved lives, reduced illnesses, and climate change avoided, for less than $4 billion. And most of that $4 billion would be invested in new technologies and clean energy, putting Americans to work.

The costs of inaction are great

- Industrial carbon pollution was just measured at the highest levels in human history. The costs of inaction are already apparent: more destructive and deadly extreme weather; rising global temperatures; life-threatening diseases; and skyrocketing costs for disaster recovery.
- Superstorm Sandy and 24 other extreme weather events over 2011-2012 caused damage in excess of $1 billion each $188 billion total — and left more than 1,100 people dead.

Opponents are anti-science

- Opponents of action to cut industrial carbon pollution ignore and deny the science that tells us it is time to act. The anti-science gang is backed by corporate polluters.
- The polluters deny the science to protect their profits and the politicians deny the science to protect their political careers.
- The era of delay and denial is over.

Clean air is good for the economy

- Taking action to avert the worst effects of climate change, such as investing in renewable energy and energy efficiency, will create jobs and a more resilient economy.
- Since 1970, every $1 in investment in compliance with Clean Air Act standards has produced $4-8 in economic benefits.

Do's and Don'ts

DO	DON'T
…talk about our climate change harming Americans now and our obligation to future generations to address climate change…	…lead with straight economic arguments
…use "cutting carbon pollution from power plants"	…use "regulations to control greenhouse gas emissions from power plants"
…discuss the real health impacts including asthma attacks and extreme weather events…	…over promise on the impacts taking action will have
…remind audiences that this is latest in a series of steady and responsible steps the administration has taken	…overstate the magnitude of the action being taken
…discuss the impacts – carbon pollution is bad for the health of our kids and our planet…	…debate the validity or consensus of the science that is already settled
…discuss that we are already cutting mercury, arsenic, and other toxics but polluters now can release unlimited carbon pollution…	…talk about the need to "regulate" industry and shut down power plants
…use "industrial carbon pollution" to define the threat as "harming our health and our planet"…	…use "carbon footprint" or "greenhouse gases" or "emissions" to define the threat
…inform audiences about the nature of the problem, who is at fault, and what can be done	…debate the increase in electricity rates. Instead pivot to health & clean air message
…discuss modernizing and retooling power plants and innovation that will create green jobs	…try to suggest net job increases
…cite health professionals such as doctors, nurses and health experts	…rely on statistics without the supporting argument of public health verifiers
…make big corporate polluters responsible, bad actors by explaining about their behavior and motives	…rely on a recognition that local utilities or the coal industry are bad actors without explanation

SUPPORTING RESOURCES

EPA: "Fossil Fuel-Fired Power Plants Are Responsible For…40 Percent Of Man-Made

Carbon Dioxide Emissions." According to the Environmental Protection Agency, "Electricity generation is the dominant industrial source of air emissions in the United States today. Fossil fuel-fired power plants are responsible for 67 percent of the nation's sulfur dioxide emissions, 23 percent of nitrogen oxide emissions, and 40 percent of man-made carbon dioxide emissions." [EPA, Clean Energy, accessed 6/18/13]

NRDC: Electricity Generating Power Plants Emit Roughly 2.4 Billion Tons Of CO2 Each Year. According to the Natural Resource Defense Council, "Nothing is more important than reducing carbon dioxide (CO2) emissions from the largest industrial source of pollution: electricity-generating power plants. In the United States these plants emit about 2.4 billion tons of CO2 each year, roughly 40 percent of the nation's total emissions." [NRDC, December 2012]

2013: Obama At Second Inaugural Address: "We Will Respond To The Threat Of Climate Change, Knowing That The Failure To Do So Would Betray Our Children And Future Generations." At his second inaugural address president Obama said, "We, the people, still believe that our obligations as Americans are not just to ourselves, but to all posterity. We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations. Some may still deny the overwhelming judgment of science, but none can avoid the devastating impact of raging fires, and crippling drought, and more powerful storms. The path towards sustainable energy sources will be long and sometimes difficult. But America cannot resist this transition; we must lead it. We cannot cede to other nations the technology that will power new jobs and new industries – we must claim its promise. That's how we will maintain our economic vitality and our national treasure – our forests and waterways; our croplands and snowcapped peaks. That is how we will preserve our planet, commanded to our care by God. That's what will lend meaning to the creed our fathers once declared." [President Obama, Second Inaugural Address, 1/21/13]

2012 Obama: "I Am A Firm Believer That Climate Change Is Real, That It Is Impacted By Human Behavior, And Carbon Emissions… We've Got An Obligation To Future Generations To Do Something About It." According to an article in Reuters, "President Barack Obama said he plans to work with Congress in his second term to curb human-aggravated climate change, but not at the expense of the U.S. economy. 'I am a firm believer that climate change is real, that it is impacted by human behavior, and carbon emissions,' Obama said at a televised news conference on Wednesday. 'And as a consequence, I think we've got an obligation to future generations to do something about it.'" [Reuters, 11/14/12]

2013 Obama: "If Congress Won't Act Soon To Protect Future Generations, I Will." During his 2013 State of the Union Address President Obama said, "The good news is, we can make meaningful progress on this issue while driving strong economic growth. I urge this Congress to pursue a bipartisan, market-based solution to climate change, like the one John McCain and Joe Lieberman worked on together a few years ago. But if Congress won't act soon to protect future generations, I will. I will direct my Cabinet to come up with executive actions we can take, now and in the future, to reduce pollution, prepare our communities for the consequences of climate change, and speed the transition to more sustainable sources of energy." [2013 State of the Union Address, 2/12/13]

2013: Carbon Dioxide Levels Reached 400 Parts Per Million; Highest Level In 3 Million Years. According to an article in the New York Times, "The level of the most important heat-trapping gas in the atmosphere, carbon dioxide, has passed a long-feared milestone, scientists reported, reaching a concentration not seen on the earth for millions of years. The costs of inaction are already apparent: more destructive and deadly extreme weather; rising global temperatures; life-threatening diseases; and skyrocketing costs for disaster recovery. Scientific instruments showed that the gas had reached an average daily level above 400 parts per million — just an odometer moment in one sense, but also a sobering reminder that decades of efforts to bring human-produced emissions under control are faltering. The best available evidence suggests the amount of the gas in the air has not been this high for at least three million years, before humans evolved, and scientists believe the rise portends large changes in the climate and the level of the sea." [New York Times, 5/10/13]

- **Report: "Burning Of Fossil Fuels Has Caused A 41 Percent Increase In The Heat-Trapping Gas Since The Industrial Revolution."** According to an article in the New York Times, "From studying air bubbles trapped in Antarctic ice, scientists know that going back 800,000 years, the carbon dioxide level oscillated in a tight band, from about 180 parts per million in the depths of ice ages to about 280 during the warm periods between. The evidence shows that global temperatures and CO2 levels are tightly linked. For the entire period of human civilization, roughly 8,000 years, the carbon dioxide level was relatively stable near that upper bound. But the burning of fossil fuels has caused a 41 percent increase in the heat-trapping gas since the Industrial Revolution, a mere geological instant, and scientists say the climate is beginning to react, though they expect far larger changes in the future." [New York Times, 5/10/13]

Center For American Progress: Extreme Storms Cost $188 Billion From 2011-2012. According to the Center for American Progress, "From 2011 to 2012 these 25 "billion-dollar damage" weather events in the United States are estimated to have caused up to $188 billion in total damage. The two costliest events were the September 2012 drought—the worst drought in half a century, which baked nearly two-thirds of the continental United States—and superstorm Sandy, which battered the northeast coast in late October 2012. The four recently added disastrous weather events were severe tornadoes and thunderstorms." [Center for American Progress, 2/12/13]

2011-2012: Extreme Weather Events Responsible For 1,105 U.S. Deaths. According to the National Oceanic and Atmospheric Administration there were 25 billion dollar climate disasters in 2011 and 2012 that were responsible for 1,105 deaths. In 2011, 728 people in the U.S. were killed by extreme weather; in 2012 extreme weather was responsible for 377 deaths. [National Oceanic and Atmospheric Administration, Billion-Dollar Weather/Climate Disasters, accessed 6/18/13]

New York Times: "Some Of The Mightiest Players In The Oil, Gas And Coal Industries Are Financing An Aggressive Effort To Defeat [President Obama]" According to an article in the New York Times, "Some of the mightiest players in the oil, gas and coal industries are financing an aggressive effort to defeat [President Obama], or at least press him to adopt policies that are friendlier to fossil fuels. And the president's former allies in promoting wind and solar power and caps on greenhouse gases? They are disenchanted and sitting on their wallets. This year's campaign on behalf of fossil fuels includes a surge in political contributions to Mitt Romney, attack ads questioning Mr. Obama's clean-energy agenda, and television spots that are not overtly partisan but criticize administration actions like new air pollution rules and the delay of the Keystone XL oil pipeline from Canada." [New York Times, 9/13/12]

- **Fossil Fuel Advocates Outspent Clean-Energy 4 To1 On Television Ads In 2012.** According to an article in the New York Times, "With nearly two months before Election Day on Nov. 6, estimated spending on television ads promoting coal and more oil and gas drilling or criticizing clean energy has exceeded $153 million this year, according to an analysis by The New York Times of 138 ads on energy issues broadcast this year by the presidential campaigns, political parties, energy companies, trade associations and third-party spenders. That tally is nearly four times the $41 million spent by clean-energy advocates, the Obama campaign and Democratic groups to defend the president's energy record or raise concerns about global warming and air pollution. The Times rated presidential campaign and national policy ads by whether they promoted fossil fuels or pushed clean energy and conservation, regardless of their sponsors, using ad and spending data compiled by Kantar Media, a company that tracks television advertising." [New York Times, 9/13/12]

Chronicle Of Higher Education: "The Republican Party Platform... Unambiguously Calls For Expanding The Production And Use Of The Fossil Fuels That Drive Climate Change." According to the Chronicle of Higher Education, "Why have scientists fled the Republican Party? The obvious answer is that the Republican Party has spurned science. Consider Mitt Romney's shifting position on climate change. As governor of Massachusetts in 2004, he laid out a plan for protecting the state's climate. As presidential candidate, he has said that climate change is real, but has questioned whether humans are causing it. His stance is consistent with the Republican Party platform, which unambiguously calls for expanding the production and use of the fossil fuels that drive climate change. In 2009, Paul Ryan accused climate scientists of 'clear efforts to use statistical tricks to distort their findings and intentionally mislead the public on the issue of climate change,' echoing false accusations leveled against climatologists at the University of East Anglia." [Chronicle of Higher Education, 11/5/12]

Center For Media And Democracy: Republican Backed American Legislative Exchange Council Proposals "Would Destroy Environmental Regulations... Corporate Lobbyists And Special Interests Vote As Equals With Elected Representatives On Templates To Change Our Laws." According to the non-profit Center for Media and Democracy, "On American Legislative Exchange Council task forces, corporate lobbyists and special interests vote as equals with elected representatives on templates to change our laws, behind closed doors with no press or public allowed to see the votes or deliberations. ALEC legislation benefits corporate profits at the expense of our environment and our health by making it easier for polluters to spoil our water and our air and by pushing climate change denial. ALEC proposals would destroy environmental regulations and health safeguards, eliminate clean energy competition, allow drilling on protected lands, and curtail recycling." [Center for Media and Democracy, accessed 6/18/13]

Investments To Comply With The Clean Air Act Have Generated $4 To $8 In Economic

Benefits For Every $1 Spent On Compliance. According to a report by the Political Economy Research Institute at the University of Massachusetts and Ceres, "Since 1970, investments to comply with the Clean Air Act have provided $4 to $8 in economic benefits for every $1 spent on compliance, according to the nonpartisan Office of Management and Budget. Since the passage of the Clean Air Act Amendments in 1990, U.S average electricity rates (real) have remained flat even as electric utilities have invested hundreds of billions of dollars to cut their air pollution emissions." [Political Economy Research Institute at the University of Massachusetts and Ceres, Employment Effects Under Planned Changes to the EPA's Air Pollution Rules, February 2011]

NRDC: Cost Of Climate Related Appropriations "Amounted To Over $1100 Per Taxpayer." According to the Natural Resources Defense Council, "Spending related to storms includes appropriated funds for the Federal Emergency Management Agency (FEMA) as well as emergency supplemental appropriations following major disasters, such as Superstorm Sandy. It also includes the National Flood Insurance Program, which is supposed to be self-supporting, but is increasingly under water. Drought-related spending includes the federal crop insurance program as well as the government's share of higher food costs…The true scorekeepers of climate risk —the insurance industry—realizes it can't win when the dice are increasingly loaded with carbon pollution, so it's walking away from the table, leaving taxpayers holding the bag. Last year that cost amounted to over $1100 per taxpayer, and we can expect to see even higher costs in future as CO2 concentrations continue to soar past 400 parts per million." [Natural Resources Defense Council, 5/14/13]

NRDC: Climate Disruption Budget Nearly $100 Billion. According to the Natural Resources Defense Council, "Despite the lengthy debate on the federal budget in Congress, climate change rarely gets mentioned as a deficit driver. Yet paying for climate disruption was one of the largest non-defense discretionary budget items in 2012. Indeed, when all federal spending on last year's droughts, storms, floods, and forest fires are added up, the U.S. Climate Disruption Budget was nearly $100 billion." [Natural Resources Defense Council, 5/14/13]

2012: "3,527 Monthly Weather Records Broken For Heat, Rain, And Snow In The US." According to the Natural Resources Defense Council, "Climate change increases the risk of many types of record-breaking extreme weather events that threaten communities across the country. In 2012, there were 3,527 monthly weather records broken for heat, rain, and snow in the US, according to information from the National Climatic Data Center (NCDC). That's even more than the 3,251 records smashed in 2011—and some of the newly-broken records had stood for 30 years or more." [Natural Resources Defense Council, accessed 6/21/13]

CDC/Red Cross: 117 Deaths Associated With Hurricane Sandy. According to the Center for Disease Control, "To characterize deaths related to Sandy, CDC analyzed data on 117 hurricane-related deaths captured by American Red Cross (Red Cross) mortality tracking during October 28 - November 30, 2012. This report describes the results of that analysis, which found drowning was the most common cause of death related to Sandy, and 45% of drowning deaths occurred in flooded homes in Evacuation Zone A." [Center for Disease Control, 5/24/13]

New York Times Estimate: 380,000 Homes Destroyed Or Damaged By Hurricane Sandy. According to the New York Times City Room Blog, a total of 380,000 housing unties were destroyed or damaged by Hurricane Sandy. 305,000 were in New York, 72,000 in New Jersey, and 3,000 in Connecticut. [New York Times, City Room Blog, 11/27/12]

2013: USGS Measured Record Flooding In Illinois. According to the United States Geological Survey, "At least ten USGS streamgages in Illinois that have more than 20 years of record, have measured the highest flood levels ever recorded. More record levels are expected as flooding moves downstream. USGS crews are expected to track the movement of the floodwaters down the Illinois River, the Rock Rivers, and major tributaries over the next few days. Many of the Illinois River floodwaters are expected to exceed records and may result in major flooding that overtop levees. There are 53 USGS streamgages currently at or above flood levels as a result of the rains that began on Tuesday, April 16 [2013]." [USGS, 4/23/13]

2012 Wildfires Burned 9.2 Million Acres In The US. According to the National Oceanic and Atmospheric Administration, "Wildfires burned over 9.2 million acres across the U.S. in 2012. This is the 3rd highest annual total since the year 2000. The most damaging wildfires occurred in the western states (CO, ID, WY, MT, CA, NV, OR, WA). Colorado experienced the most costly wildfires (e.g., Waldo Canyon fire) where several hundred residences were destroyed. Total Estimated Costs: $1.0 Billion; 8 Deaths." [NOAA, Billion-Dollar US Weather/Climate Disasters 1980-2012, accessed 6/21/13]

By July 2012: 40,113 Warm Temperature Records Set Or Tied. According to Inside Climate News, "For the year-to-date, there have been 40,113 warm temperature records set or tied, compared to just 5,835 cold records. (These figures, compiled by the National Climatic Data Center, are preliminary.) In other words, the warm temperature records have been outnumbering cold records by about 7-to-1." [Inside Climate News, 7/2/12]

State Of Louisiana: "Every 38 Minutes, A Football Field Sized Parcel Of Louisiana's Wetlands Is Taken Over By Water." According to the State of Louisiana, "The wetlands of Louisiana are disappearing at a high rate. Every 38 minutes, a football field sized parcel of Louisiana's wetlands is taken over by water. The U.S. Geological Survey estimates that if present trends continue, the state will have lost 2,400 square miles of land between 1932 and 2050 (USGS, 2003). That's an area about 25 times the size of Washington, D.C. Across the region, communities are being threatened, jobs are being lost, and habitats are vanishing." [State of Louisiana, Coastal Protection and Restoration, accessed 6/21/13]

- **Louisiana Could Lose 2,400 Square Miles Of Wetland By 2050.** According to the State of Louisiana, "The U.S. Geological Survey estimates that if present trends continue, the state will have lost 2,400 square miles of land between 1932 and 2050 (USGS, 2003). That's an area about 25 times the size of Washington, D.C. Across the region, communities are being threatened, jobs are being lost, and habitats are vanishing." [State of Louisiana, Coastal Protection and Restoration, accessed 6/21/13]

Plan To Cut Emissions 26 Percent Could Save $60 Billion. According to the Center for American Progress, "The Natural Resources Defense Council, or NRDC, an environmental advocacy organization, recently released a plan to unlock the Clean Air Act's potential to curb carbon pollution from existing power plants. The plan would cut emissions from existing power plants by 26 percent by 2020. It would operate by: Considering individual state baseline pollution levels. Establishing separate targets for oil/gas and coal-based power plants, crediting plants for energy efficiency and renewable energy modifications. Generally creating a flexible approach for states and power plants to meet carbon pollution limits. The plan achieves climate protection and public health benefits, grossing between $26 billion and $60 billion in 2020 for a net benefit between 6 times and 15 times more than the cost of the plan." [Center for American Progress, 2/14/13; NRDC, Using the Clean Air Act to Sharply Reduce Carbon Pollution from Existing Power Plants, Creating Clean Energy Jobs, Improving Americans' Health, and Curbing Climate Change, December 2012

- **Plan Would Cost $4 Billion.** According to the Natural Resources Defense Council, "The plan would cut CO2 pollution from America's power plants by 26 percent from 2005 levels by 2020 and 34 percent by 2025. The price tag: about $4 billion in 2020. But the benefits— in saved lives, reduced illnesses, and climate change avoided —would be $25 billion to 60 billion, 6 to 15 times greater than the costs. For Americans' health and welfare, for the nation's economy, and for the health of the planet, we can't afford not to curb the carbon pollution from existing power plants." [NRDC, Using the Clean Air Act to Sharply Reduce Carbon Pollution from Existing Power Plants, Creating Clean Energy Jobs, Improving Americans' Health, and Curbing Climate Change, December 2012]

CDC: "If Current Emissions Hold Steady, Excess Heat-Related Deaths In The U.S. Could Climb From An Average Of About 700 Each Year Currently, To Between 3,000 And 5,000 Per Year By 2050." According to the Center for Disease Control, "Climate change will bring more heat waves to the U.S. Increases in the number of people living in cities, as well as population aging, will further increase heat-related health risks. Studies suggest that, if current emissions hold steady, excess heat-related deaths in the U.S. could climb from an average of about 700 each year currently, to between 3,000 and 5,000 per year by 2050." [CDC, Heat Waves, accessed 6/21/13]

Senator VITTER. Specifically, as outlined very clearly in this email, the President and his team do not want anyone to discuss "straight economic arguments.' Well, I think on behalf of the American people we should absolutely talk about the economic impacts of these policies and have an honest discussion about that.

They do not want to talk about "regulations to control greenhouse gas emissions from power plants.' I think we should absolutely talk about these very significant and very economically detrimental regulations.

They do not want to talk about, or they do not want to "overpromise on impacts taking action will have.' Again, maybe the reason is, as Lisa Jackson herself testified, such action would have no impact given that we in the United States alone do not control impacts on climate.

They do not want to "debate the validity or consensus of the science that has already settled.' I am interested in discussing exactly what part of science is settled in light of facts like climate models being wrong for the last 15 years regarding temperature and the fact that none of White House Science Advisor John Holdren's predictions on climates have come true, very dramatic predictions, just have not come true.

They do not want to talk about "the need to regulate industry and shut down power plants.' If I can ask for unanimous consent for one additional minute?

Senator BOXER. I cannot do that because we have got everybody here to speak, we have got two panels. But if you could finish in a minute, it would be great.

Senator VITTER. That is exactly what I asked for. Thank you.

They do not want to talk about "the need to regulate industry and shut down power plants.' And certainly no none should "debate the increase in electricity rates.' Well, again, we think these are very important issues that should be discussed for the benefit of the American people.

So, I look forward to this discussion. I look forward to digging down into the science, what exactly it suggests and does not suggest, and I certainly look forward to talking about economic impacts on the American people as they face very, very tough times.

Thank you, Madam Chairman.

[The prepared statement of Senator Vitter follows:]

STATEMENT OF HON. DAVID VITTER, U.S. SENATOR FROM THE STATE OF LOUISIANA

Thank you, Chairman Boxer, the members of our Committee who are here today, and our panel of witnesses who will be discussing a number of very important issues as they relate to climate science and our national energy policy.

It is unfortunate we don't have any witnesses here from the Obama administration. Just weeks ago, President Obama announced a sweeping climate action plan, which will undoubtedly tighten the Federal Government's grip on our economy. It would have been very useful to hear from the Administration how exactly they plan to implement this strategy. It would also have been helpful to learn the exact measurable benefits that the United States can expect from these actions.

Former Administrator Lisa Jackson testified before this Committee that U.S. action alone will not impact the climate. This begs a few questions: Have things changed so drastically in the last 4 years that now U.S. action alone can control the climate? Are we now able to determine what weather events will happen and which ones won't?

This hearing is entitled "Climate Change: It's Happening Now." I would note that it has not been titled "Global Warming: It's Happening Now." Maybe that would have been too ironic given the Earth's stagnant temperature for the past 15 years, a fact that is currently confounding climate scientists and modeling experts who predicted otherwise.

The unique thing about the title of our hearing is that we could have been holding this hearing 50 years ago, 500 years ago, 5 thousand years ago, or 5 million years ago, and it would have been just as accurate a statement. The climate has always and will always be changing because there are influences on our climate that will always be outside Congress's control.

Just a cursory glance at recent scientific literature shows that influences on our climate include: solar activity; solar cycles; ocean currents; cosmic rays; and greenhouse gases that occur naturally as well as those emitted from other countries such as China, India, and Russia. These are factors impacting our climate over which we have little or no control.

As the President unilaterally implements his regulatory agenda, I believe it is important to note what the Obama campaign does not want us to talk about. This was outlined in an email last month by Ken Berlin, a chair of President Obama's Energy & Environment Team. Specifically, President Obama does not want anyone to discuss:

- "Straight economic arguments." I think the economic impacts of these policies are imperative to an honest discussion.
- "Regulations to control greenhouse gas emissions from power plants." I think we absolutely should talk about the regulations so the American public can know exactly what the Administration has planned.
- "Over promise on the impacts taking action will have." Maybe the reason is because Lisa Jackson said such action would have no impact, and I think that is something we should discuss.
- "Debate the validity or consensus of the science that is already settled." I am interested in discussing exactly what part of the science is settled in light of the fact that climate models have been wrong for the last 15 years and that none of White House Science Advisor John Holdren's predictions on climate have come true.
- "The need to regulate industry and shut down power plants." I, on the other hand, think that is exactly what the Administration is doing and I think we should talk about the impacts of shutting down power plants, putting our fellow Americans out of work, and increasing the price of energy for those that can least afford it.
- No one should "Debate the increase in electricity rates" and should "instead pivot to health & clean air message." We should discuss the increase in electricity rates and, if we are going to discuss health, let's focus on the health effects of higher unemployment or the benefits to plant life from increased CO_2 .

President Obama would like his supporters to "suggest net job increases" from all these new regulations and mandates. Perhaps because the reality is that all evidence actually suggests the President's agenda will be horrible economic policy over the long-term. So any assertion of net job increase is a flat out lie.

Today, only 47 percent of Americans have a full time job, the workforce participation rate is at its lowest level since the Carter administration, and the national unemployment rate has exceeded 7.5 percent for the longest period since the Bureau of Labor Statistics started tracking it. At the end of President Obama's second term in office, the Federal debt will likely exceed $20 trillion, further frustrating America's future.

Policy and economic decisions surrounding the issue of climate change should be based on being honest with our fellow Americans. That starts with being honest about the economic impacts of regulatory actions, avoiding sensationalism when it comes to the science, and taking a retrospective look at the models, predictions and claims over the last 30+ years to assess what impacts we can truly measure and what claims under the guide of "science" have been inaccurate.

Senator BOXER. Thank you, Senator.

I ask unanimous consent to place in the record two documents that refute what you said about temperatures remaining stagnant, one from the EPA, one from Climate Central.

[The referenced information follows:]

U.S. and Global Temperature

This indicator describes trends in average surface temperature for the United States and the world.

Background

Temperature is a fundamental measurement for describing the climate, and the temperature in particular places can have wide-ranging effects on human life and ecosystems. For example, increases in air temperature can lead to more intense heat waves, which can cause illness and death, especially in vulnerable populations. Annual and seasonal temperature patterns also determine the types of animals and plants that can survive in particular locations. Changes in temperature can disrupt a wide range of natural processes, particularly if these changes occur more quickly than plant and animal species can adapt.

Concentrations of heat-trapping greenhouse gases are increasing in the Earth's atmosphere (see the Atmospheric Concentrations of Greenhouse Gases indicator on p. 16). In response, average temperatures at the Earth's surface are rising and are expected to continue rising. However, because climate change can shift the wind patterns and ocean currents that drive the world's climate system, some areas experience more warming than others, and some might experience cooling.

About the Indicator

This indicator examines U.S. and global surface temperature patterns from 1901 to the present. U.S. surface measurements come from weather stations on land, while global surface measurements also incorporate observations from buoys and ships on the ocean, thereby providing data from sites spanning much of the surface of the Earth. For comparison, this indicator also displays satellite measurements that can be used to estimate the temperature of the Earth's lower atmosphere since 1979.

This indicator shows anomalies, which compare recorded annual temperature values against a long-term average. For example, an anomaly of +2.0 degrees means the average temperature was 2 degrees higher than the long-term average. This indicator uses the average temperature from 1901 to 2000 as a

(Continued on page 25)

Figure 1. Temperatures in the Contiguous 48 States, 1901–2011

This figure shows how annual average temperatures in the contiguous 48 states have changed since 1901. Surface data come from land-based weather stations. Satellite measurements cover the lower troposphere, which is the lowest level of the Earth's atmosphere (see diagram on p. 23). "UAH" and "RSS" represent two different methods of analyzing the original satellite measurements. This graph uses the 1901 to 2000 average as a baseline for depicting change. Choosing a different baseline period would not change the shape of the data over time.

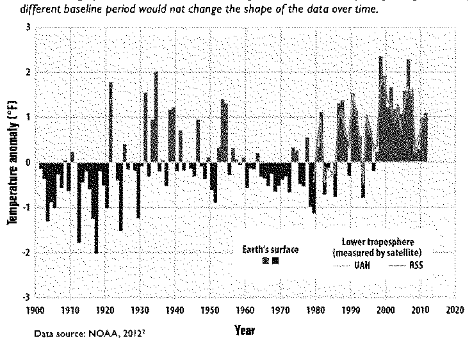


Figure 2. Temperatures Worldwide, 1901–2011

This figure shows how annual average temperatures worldwide have changed since 1901. Surface data came from a combined set of land-based weather stations and sea surface temperature measurements. Satellite measurements cover the lower troposphere, which is the lowest level of the Earth's atmosphere (see diagram on p. 23). "UAH" and "RSS" represent two different methods of analyzing the original satellite measurements. This graph uses the 1901 to 2000 average as a baseline for depicting change. Choosing a different baseline period would not change the shape of the data over time.

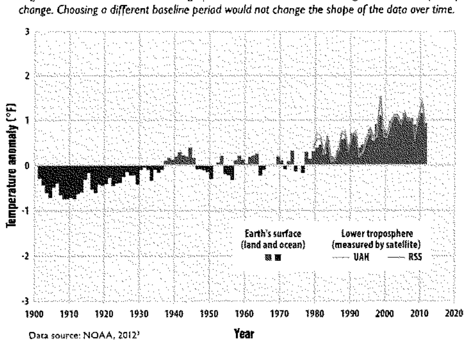
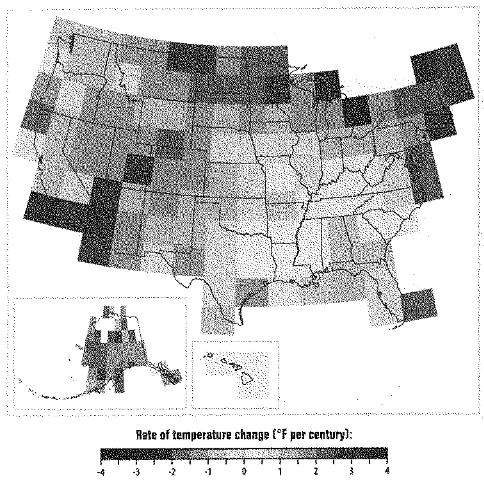


Figure 3. Rate of Temperature Change in the United States, 1901–2011

This figure shows how annual average air temperatures have changed in different parts of the United States since the early 20th century (since 1901 for the contiguous 48 states, 1905 for Hawaii, and 1918 for Alaska).



Data source: NOAA, 2012[4]

Key Points

- Since 1901, the average surface temperature across the contiguous 48 states has risen at an average rate of 0.13°F per decade (1.3°F per century) (see Figure 1). Average temperatures have risen more quickly since the late 1970s (0.31 to 0.45°F per decade). Seven of the top 10 warmest years on record for the contiguous 48 states have occurred since 1990.
- Worldwide, 2001–2010 was the warmest decade on record since thermometer-based observations began. Global average surface temperature has risen at an average rate of 0.14°F per decade since 1901 (see Figure 2), similar to the rate of warming within the contiguous 48 states. Since the late 1970s, however, the United States has warmed faster than the global rate.
- Some parts of the United States have experienced more warming than others (see Figure 3). The North, the West, and Alaska have seen temperatures increase the most, while some parts of the Southeast have experienced little change. However, not all of these regional trends are statistically significant.

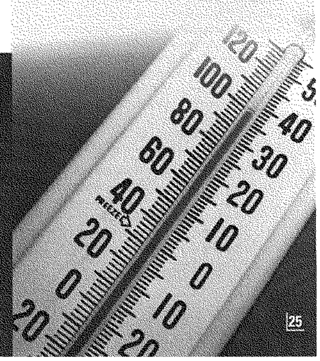
baseline for comparison. Annual anomalies are calculated for each weather station, starting from daily and monthly average temperatures. Anomalies for broader regions have been determined by dividing the country (or the world) into a grid, averaging the data for all weather stations within each cell of the grid, and then averaging the grid cells together (for Figures 1 and 2) or displaying them on a map (Figure 3). This method ensures that the results are not biased toward regions that happen to have many stations close together.

Indicator Notes

Data from the early 20th century are somewhat less precise than more recent data because there were fewer stations collecting measurements at the time, especially in the Southern Hemisphere. However, the overall trends are still reliable. Where possible, the data have been adjusted to account for any biases that might be introduced by station moves, development (e.g., urbanization) near the station, changes in instruments and times of measurement, and other changes.

Data Sources

The data for this indicator were provided by the National Oceanic and Atmospheric Administration's National Climatic Data Center, which maintains a large collection of climate data online at: www.ncdc.noaa.gov/oa/ncdc.html. Surface temperature anomalies were calculated based on monthly values from a network of long-term monitoring stations. Satellite data were analyzed by two independent groups—the Global Hydrology and Climate Center at the University of Alabama in Huntsville (UAH) and Remote Sensing Systems (RSS)—resulting in slightly different trend lines.



The Economist

Climate science

A sensitive matter

The climate may be heating up less in response to greenhouse-gas emissions than was once thought. But that does not mean the problem is going away

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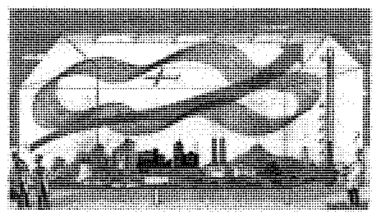
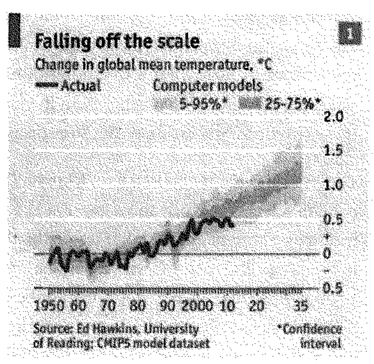


OVER the past 15 years air temperatures at the Earth's surface have been flat while greenhouse-gas emissions have continued to soar. The world added roughly 100 billion tonnes of carbon to the atmosphere between 2000 and 2010. That is about a quarter of all the CO_2 put there by humanity since 1750. And yet, as James Hansen, the head of NASA's Goddard Institute for Space Studies, observes, "the five-year mean global temperature has been flat for a decade."



Temperatures fluctuate over short periods, but this lack of new warming is a surprise. Ed Hawkins, of the University of Reading, in Britain, points out that surface temperatures since 2005 are already at the low end of the range of projections derived from 20 climate models (see chart 1). If they remain flat, they will fall outside the models' range within a few years.

The mismatch between rising greenhouse-gas emissions and not-rising temperatures is among the biggest puzzles in climate science just now. It does not mean global warming is a delusion. Flat though they are, temperatures in the first decade of the 21st century remain almost 1°C above their level in the first decade of the 20th. But the puzzle does need explaining.

The mismatch might mean that—for some unexplained reason—there has been a temporary lag between more carbon dioxide and higher temperatures in 2000-10. Or it might be that the 1990s, when temperatures were rising fast, was the anomalous period. Or, as an increasing body of research is suggesting, it may be that the climate is responding to higher concentrations of carbon dioxide in ways that had not been properly understood before. This possibility, if true, could have profound significance both for climate science and for environmental and social policy.

The insensitive planet

The term scientists use to describe the way the climate reacts to changes in carbon-dioxide levels is "climate sensitivity". This is usually defined as how much hotter the Earth will get for each doubling of CO_2 concentrations. So-called equilibrium sensitivity, the commonest measure, refers to the temperature rise after allowing all feedback mechanisms to work (but without accounting for changes in vegetation and ice sheets).

Carbon dioxide itself absorbs infra-red at a consistent rate. For each doubling of CO_2 levels you get roughly 1°C of warming. A rise in concentrations from preindustrial levels of 280 parts per million (ppm) to 560ppm would thus warm the Earth by 1°C. If that were all there was to worry about, there would, as it were, be nothing to worry about. A 1°C rise could be shrugged off. But things are not that simple, for two reasons. One is that rising CO_2 levels directly influence phenomena such as the amount of water vapour (also a greenhouse gas) and clouds that amplify or diminish the temperature rise. This affects equilibrium sensitivity directly, meaning doubling carbon concentrations would produce more than a 1°C rise in temperature. The second is that other things, such as adding soot and other aerosols to the atmosphere, add to or subtract from the effect of CO_2. All serious climate scientists agree on these two lines of reasoning. But they disagree on the size of the change that is predicted.

The Intergovernmental Panel on Climate Change (IPCC), which embodies the mainstream of climate science, reckons the answer is about 3°C, plus or minus a degree or so. In its most recent assessment (in 2007), it wrote that "the equilibrium climate sensitivity...is likely to be in the range 2°C to 4.5°C with a best estimate of about 3°C and is very unlikely to be less than 1.5°C. Values higher than 4.5°C cannot be excluded." The IPCC's next assessment is due in September. A draft version was recently leaked. It gave the same range of likely outcomes and added an upper limit of sensitivity of 6°C to 7°C.

A rise of around 3°C could be extremely damaging. The IPCC's earlier assessment said such a rise could mean that more areas would be affected by drought; that up to 30% of species could be at greater risk of extinction; that most corals would face significant biodiversity losses; and that there would be likely increases of intense tropical cyclones and much higher sea levels.

New Model Army

Other recent studies, though, paint a different picture. An unpublished report by the Research Council of Norway, a government-funded body, which was compiled by a team led by Terje Berntsen of the University of Oslo, uses a different method from the IPCC's. It concludes there is a 90% probability that doubling CO_2 emissions will increase temperatures by only 1.2-2.9°C, with the most likely figure being 1.9°C. The top of the study's range is well below the IPCC's upper estimates of likely sensitivity.

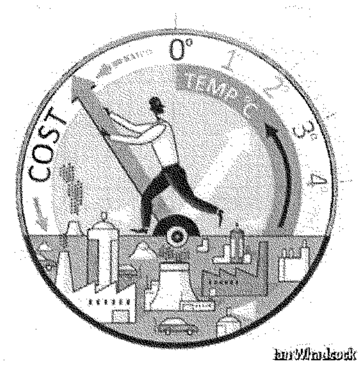
This study has not been peer-reviewed; it may be unreliable. But its projections are not unique. Work by Julia Hargreaves of the Research Institute for Global Change in Yokohama, which was published in 2012, suggests a 90% chance of the actual change being in the range of 0.5-4.0°C, with a mean of 2.3°C. This is based on the way the climate behaved about 20,000 years ago, at the peak of the last ice age, a period when carbon-dioxide concentrations leapt. Nic Lewis, an independent climate scientist, got an even lower range in a study accepted for publication: 1.0-3.0°C, with a mean of 1.6°C. His calculations reanalysed work cited by the IPCC and took account of more recent temperature data. In all these calculations, the chances of climate sensitivity above 4.5°C become vanishingly small.

If such estimates were right, they would require revisions to the science of climate change and, possibly, to public policies. If, as conventional wisdom has it, global temperatures could rise by 3°C or more in response to a doubling of emissions, then the correct response would be the one to which most of the world pays lip service: rein in the warming and the greenhouse gases causing it. This is called "mitigation", in the jargon. Moreover, if there were an outside possibility of something catastrophic, such as a 6°C rise, that could justify drastic interventions. This would be similar to taking out disaster insurance. It may seem an unnecessary expense when you are forking out for the premiums, but when you need it, you really need it. Many economists, including William Nordhaus of Yale University, have made this case.

If, however, temperatures are likely to rise by only 2°C in response to a doubling of carbon emissions (and if the likelihood of a 6°C increase is trivial), the calculation might change. Perhaps the world should seek to adjust to (rather than stop) the greenhouse-gas splurge. There is no point buying earthquake insurance if you do not live in an earthquake zone. In this case more adaptation rather than more mitigation might be the right policy at the margin. But that would be good advice only if these new estimates really were more reliable than the old ones. And different results come from different models.

One type of model—general-circulation models, or GCMs—use a bottom-up approach. These divide the Earth and its atmosphere into a grid which generates an enormous number of calculations in order to imitate the climate system and the multiple influences upon it. The advantage of such complex models is that they are extremely detailed. Their disadvantage is that they do not respond to new temperature readings. They simulate the way the climate works over the long run, without taking account of what current observations are. Their sensitivity is based upon how accurately they describe the processes and feedbacks in the climate system.

The other type—energy-balance models—are simpler. They are top-down, treating the Earth as a single unit or as two hemispheres, and representing the whole climate with a few equations reflecting things such as changes in greenhouse gases, volcanic aerosols and global temperatures. Such models do not try to describe the complexities of the climate. That is a drawback. But they have an advantage, too: unlike the GCMs, they explicitly use temperature data to estimate the sensitivity of the climate system, so they respond to actual climate observations.



Ian Whadcock

The IPCC's estimates of climate sensitivity are based partly on GCMs. Because these reflect scientists' understanding of how the climate works, and that understanding has not changed much, the models have not changed either and do not reflect the recent hiatus in rising temperatures. In contrast, the Norwegian study was based on an energy-balance model. So were earlier influential ones by Reto Knutti of the Institute for Atmospheric and Climate Science in Zurich; by Piers Forster of the University of Leeds and Jonathan Gregory of the University of Reading; by Natalia Andronova and Michael Schlesinger, both of the University of Illinois; and by Magne Aldrin of the Norwegian Computing Centre (who is also a co-author of the new Norwegian study). All these found lower climate sensitivities. The paper by Drs Forster and Gregory found a central estimate of 1.6°C for equilibrium sensitivity, with a 95% likelihood of a 1.0-4.1°C range. That by Dr Aldrin and others found a 90% likelihood of a 1.2-3.5°C range.

It might seem obvious that energy-balance models are better: do they not fit what is actually happening? Yes, but that is not the whole story. Myles Allen of Oxford University points out that energy-balance models are better at representing simple and direct climate feedback mechanisms than indirect and dynamic ones. Most greenhouse gases are straightforward: they warm the climate. The direct impact of volcanoes is also straightforward: they cool it by reflecting sunlight back. But volcanoes also change circulation patterns in the atmosphere, which can then warm the climate indirectly, partially offsetting the direct cooling. Simple energy-balance models cannot capture this indirect feedback. So they may exaggerate volcanic cooling.

This means that if, for some reason, there were factors that temporarily muffled the impact of greenhouse-gas emissions on global temperatures, the simple energy-balance models might not pick them up. They will be too responsive to passing slowdowns. In short, the different sorts of climate model measure somewhat different things.

Clouds of uncertainty

This also means the case for saying the climate is less sensitive to CO_2 emissions than previously believed cannot rest on models alone. There must be other explanations—and, as it happens, there are: individual climatic influences and feedback loops that amplify (and sometimes moderate) climate change.

Begin with aerosols, such as those from sulphates. These stop the atmosphere from warming by reflecting sunlight. Some heat it, too. But on balance aerosols offset the warming impact of carbon dioxide and other greenhouse gases. Most climate models reckon that aerosols cool the atmosphere by about 0.3-0.5°C. If that underestimated aerosols' effects, perhaps it might explain the lack of recent warming.

Yet it does not. In fact, it may actually be an overestimate. Over the past few years, measurements of aerosols have improved enormously. Detailed data from satellites and balloons suggest their cooling effect is lower (and their warming greater, where that occurs). The leaked assessment from the IPCC (which is still subject to review and revision) suggested that aerosols' estimated radiative "forcing"—their warming or cooling effect—had changed from minus 1.2 watts per square metre of the Earth's surface in the 2007 assessment to minus $0.7W/m^2$ now: ie, less cooling.

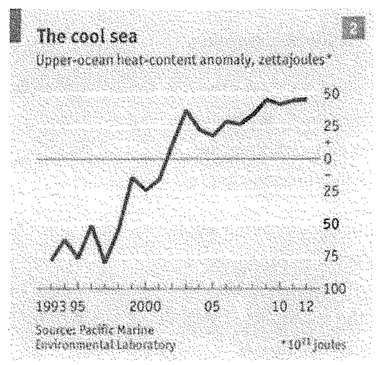
One of the commonest and most important aerosols is soot (also known as black carbon). This warms the atmosphere because it absorbs sunlight, as black things do. The most detailed study of soot was published in January and also found more net warming than had previously been thought. It reckoned black carbon had a direct warming effect of around

1.1W/m 2. Though indirect effects offset some of this, the effect is still greater than an earlier estimate by the United Nations Environment Programme of 0.3-0.6W/m 2.

All this makes the recent period of flat temperatures even more puzzling. If aerosols are not cooling the Earth as much as was thought, then global warming ought to be gathering pace. But it is not. Something must be reining it back. One candidate is lower climate sensitivity.

A related possibility is that general-circulation climate models may be overestimating the impact of clouds (which are themselves influenced by aerosols). In all such models, clouds amplify global warming, sometimes by a lot. But as the leaked IPCC assessment says, "the cloud feedback remains the most uncertain radiative feedback in climate models." It is even possible that some clouds may dampen, not amplify global warming—which may also help explain the hiatus in rising temperatures. If clouds have less of an effect, climate sensitivity would be lower.

So the explanation may lie in the air—but then again it may not. Perhaps it lies in the oceans. But here, too, facts get in the way. Over the past decade the long-term rise in surface seawater temperatures seems to have stalled (see chart 2), which suggests that the oceans are not absorbing as much heat from the atmosphere.



As with aerosols, this conclusion is based on better data from new measuring devices. But it applies only to the upper 700 metres of the sea. What is going on below that—particularly at depths of 2km or more—is obscure. A study in *Geophysical Research Letters* by Kevin Trenberth of America's National Centre for Atmospheric Research and others found that 30% of the ocean warming in the past decade has occurred in the deep ocean (below 700 metres). The study says a substantial amount of global warming is going into the oceans, and the deep oceans are heating up in an unprecedented way. If so, that would also help explain the temperature hiatus.

Double-A minus

Lastly, there is some evidence that the natural (ie, non-man-made) variability of temperatures may be somewhat greater than the IPCC has thought. A recent paper by Ka-Kit Tung and Jiansong Zhou in the *Proceedings of the National Academy of Sciences* links temperature changes from 1750 to natural changes (such as sea temperatures in the Atlantic Ocean) and suggests that "the anthropogenic global-warming trends might have been overestimated by a factor of two in the second half of the 20th century." It is possible, therefore, that both the rise in temperatures in the 1990s and the flattening in the 2000s have been caused in part by natural variability.

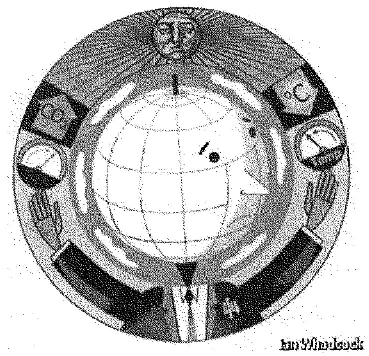
So what does all this amount to? The scientists are cautious about interpreting their findings. As Dr Knutti puts it, "the bottom line is that there are several lines of evidence, where the observed trends are pushing down, whereas the models are pushing up, so my personal view is that the overall assessment hasn't changed much."

But given the hiatus in warming and all the new evidence, a small reduction in estimates of climate sensitivity would seem to be justified: a downwards nudge on various best estimates from 3°C to 2.5°C, perhaps; a lower ceiling (around 4.5°C), certainly. If climate scientists were credit-rating agencies, climate sensitivity would be on negative watch. But it would not yet be downgraded.

Equilibrium climate sensitivity is a benchmark in climate science. But it is a very specific measure. It attempts to describe what would happen to the climate once all the feedback mechanisms have worked through; equilibrium in this sense takes centuries—too long for most policymakers. As Gerard Roe of the University of Washington argues, even if climate sensitivity were as high as the IPCC suggests, its effects would be minuscule under any plausible discount rate because it operates over such long periods. So it is one thing to ask how climate sensitivity might be changing; a different question is to ask what the policy consequences might be.

For that, a more useful measure is the transient climate response (TCR), the temperature you reach after doubling CO_2 gradually over 70 years. Unlike the equilibrium response, the transient one can be observed directly; there is much less controversy about it. Most estimates put the TCR at about 1.5°C, with a range of 1-2°C. Isaac Held of America's National Oceanic and Atmospheric Administration recently calculated his "personal best estimate" for the TCR: 1.4°C, reflecting the new estimates for aerosols and natural variability.

That sounds reassuring: the TCR is below estimates for equilibrium climate sensitivity. But the TCR captures only some of the warming that those 70 years of emissions would eventually generate because carbon dioxide stays in the atmosphere for much longer.



As a rule of thumb, global temperatures rise by about 1.5°C for each trillion tonnes of carbon put into the atmosphere. The world has pumped out half a trillion tonnes of carbon since 1750, and temperatures have risen by 0.8°C. At current rates, the next half-trillion tonnes will be emitted by 2045; the one after that before 2080.

Since CO_2 accumulates in the atmosphere, this could increase temperatures compared with pre-industrial levels by around 2°C even with a lower sensitivity and perhaps nearer to 4°C at the top end of the estimates. Despite all the work on sensitivity, no one really knows how the climate would react if temperatures rose by as much as 4°C. Hardly reassuring.

From the print edition: Science and technology

I want to reiterate. We did get a letter asking for the Obama administration to be here and I responded that this is a committee of experts and we will do this. But as you know, we have been without a head of the EPA for the longest time in history. We are about to solve that, thank goodness, thank you. And then we will have someone who is going to carry out those rules.

Now, we are going to go with the early bird rule, which is what the Committee asked to do. So, I am going to tell you who is going where with an exception for James Inhofe which, he is going to be called on when he arrives, when it is the Republican's turn.

So, ours are Boxer, Cardin, Whitehouse, Hirono, Sanders and Carper. The Republicans are Vitter, Barrasso, Sessions, Fischer and Wicker.

So, with that I will call on Senator Cardin.

OPENING STATEMENT OF HON. BENJAMIN L. CARDIN, U.S. SENATOR FROM THE STATE OF MARYLAND

Senator CARDIN. Well, thank you Madam Chair and I would ask consent that my full statement be included in the record.

Senator BOXER. Without objection.

Senator CARDIN. And Madam Chair, let me thank you for calling this hearing. I was listening to the Ranking Member and I very much agree that we need to have Administration before this Committee. But I think it is refreshing that we have a hearing with the experts. We all want to be judged by the best science and I think this hearing gives us a chance to talk about the science of climate which I think is our responsibility. I applaud you for convening this hearing.

Madam Chair, I also want to thank you for making the arrangements yesterday for the naming of the EPA building in honor of William Jefferson Clinton. It was an incredible day. We all talk about the fact that we can have respect for our environment and we can grow our economy and create jobs.

But I think President Clinton said it best yesterday in that we cannot have a growing economy and create jobs unless we have a pro-environment agenda. If you do not respect our environment, you cannot grow the economy. And I think that was at least every telling to many of us and that is why we are so concerned about what is happening with global climate change.

Let me just give you the example in Maryland. In 2007, Maryland decided to pass the toughest power plant emission laws on the East Coast of the United States. And the result was a $1 billion investment in the Brandon Shores Coal Fired Power Plant. It created thousands of jobs. And Maryland has some of the cleanest burning power plants in the Nation. It was the right thing to do. The people of Maryland have benefited both from their environment and from their economy.

But it is not enough because we are downwind from many other States. We need national policies to deal with these issues. And I applaud President Obama and the action he has taken with the authority that he has as President and the agencies involved to take action to clean up our environment through reduced carbon emissions and to deal with greenhouse gas problems.

As the Chairman pointed out, this is an urgent situation. The wildfire photo that you showed was taken just 6 weeks ago. This is a current crisis that we are facing every day. Where we are here, we have experienced record numbers of heat days. Last summer, we had the largest number of above 95 degrees in the history of recordkeeping. So we see it every day.

I am honored to represent the State of Maryland and my colleagues on this Committee have heard me talk about the Chesapeake Bay many time. Sea level rising is occurring. It is having a devastating impact on the people of Maryland and on this region. It is urgent that we act and we act now.

President Obama was right to act. But we have a responsibility, as Members of Congress, to act, to pass the policies that will make this Nation safer. The interesting thing is, the same policy that will make us more secure by developing our own energy sources will create the jobs of the future, good paying jobs, grow our economy, will also protect our environment for future generations.

We should take advantage of the opportunity now. And it should be judged by best science. And that is why this hearing is so important to the work of the Committee.

Thank you, Madam Chair.

[The prepared statement of Senator Cardin follows:]

STATEMENT OF HON. BENJAMIN L. CARDIN, U.S. SENATOR FROM THE STATE OF MARYLAND

Thank you for holding this hearing, Madam Chairman. I appreciate the opportunity to come together today to talk about such a critical, timely issue. Today we will hear not only from the scientists who will explain to us how our climate and our oceans are changing. We will also hear from experts in policy and business who will tell us what we should be doing about these disturbing trends.

This climate crisis is already happening, and the extreme weather that we have been experiencing as a nation makes it clear. Just last month, Colorado experienced the most destructive wildfire in the history of the state; spreading to 100 square miles, it destroyed five hundred homes—all fueled by forests full of trees that are completely dried out from the ongoing drought.

This is a tragic repeat of last summer's deadly wildfire season in our western states, also exacerbated by historic drought conditions. According to the National Oceanic and Atmospheric Administration, 2012 was the hottest year globally on record. There was a deadly wildfire season in our western states last summer. Right here in Washington, the summer of 2012 brought us the longest recorded streak of 95-degree-plus days, and a resulting multi-day power outage that crippled the Washington area. In my home State of Maryland, hundreds of thousands of people were without power for days. Being without air-conditioning during a heat wave, without heat during a blizzard, without refrigeration for days at a time is no mere inconvenience—it is a public health issue. We must act to ensure the health and safety of our communities.

These extreme weather events and increased temperatures are not theoretical. They are happening to us right now. When those of us in this hearing room leave the building today, we will be walking into a sustained heat wave. These extremes are the new normal, and they are affecting our nation's infrastructure, our environment, and our public health and safety. It is time that we get serious with three key responses to the climate threat. First, we must commit to investing in clean and efficient technologies to move away from the carbon-based energy that is contributing to the climate threat. Equally importantly, we must adapt our infrastructure and systems to these new conditions. And finally, we must put a price on carbon.

Last month, President Obama took an important step forward by announcing his Administration's plan of action on climate change, including steps to cut carbon pollution from power plants, spur clean energy innovation, and dramatically reduce the pollution that fuels climate change and extreme weather. I applaud his efforts and his leadership on this issue, but the Administration cannot do it alone. We in Congress must be an active partner in reducing carbon emissions and protecting our communities from the devastating impacts of climate change.

There are those who would have us believe that, despite the devastating impacts that we will hear about from our witnesses, addressing climate change is simply too expensive and not worth the financial costs. This is simply not true. Investing in clean energy technologies and in the infrastructure of our communities creates jobs and spurs economic growth.

The experience in Maryland shows that it works. In 2007, Maryland took a bold step for public health and the environment by implementing the toughest power plant emissions law on the East Coast.

Maryland's power plants met the challenge by installing new pollution control technologies that resulted in substantial economic benefits for the region. In March 2010, Constellation completed the upgrades at its 13-hundred Megawatt Brandon Shores coal-fired power plant. The project required a $1 billion investment that generated nearly four million man-hours of labor from the Baltimore Building and Construction Trades Council workers. This included 26 months of work for 2,000 skilled construction workers. This figure does not include the manufacturing and distributions jobs associated with the production of technologies and equipment purchased by the plant. Brandon Shores is now one of the cleanest coal-burning power plants in the country.

Maryland's experience demonstrates that technological progress in the name of public health can actually boost employment and stimulate the economy.

I believe that I have a responsibility to the people of Maryland and to the people of this country, to do all that I can to help prepare us for the consequences of climate change. We need to adapt our water infrastructure, our transportation infrastructure, and our electrical grid. We need to help our farmers to adapt so that our food supply—and that of the world—remains reliable. We need to adapt our coastal regions and prepare for the sea-level rise that is already beginning to threaten some of our coastal communities. We need to improve our public health infrastructure to deal with the heat-related illnesses that result from these extreme temperatures. In short, we need to act now to protect our communities.

I look forward to hearing from our diverse panel of speakers on the latest climate change science and the steps we can take to reduce the impacts of climate change.

Senator BOXER. Thank you, Senator Cardin.

Senator BARRASSO.

OPENING STATEMENT OF HON. JOHN BARRASSO, U.S. SENATOR FROM THE STATE OF WYOMING

Senator BARRASSO. Thank you very much, Madam Chairman. I am pleased that you are having this hearing today.

I must echo the concerns of Senator Vitter that we believe a Federal witness should be present at this hearing. It only makes sense that this Committee should able to have, and this Administration should be able to provide, a witness that can defend the Administration's Energy Policy.

Just this morning, Madam Chairman, I was speaking at a web cast event on energy by Politico, down at the museum. Heather Zichal, the Deputy Assistant to the President for Energy and Climate Change, was the speaker right before I spoke. Now, this is the President's Chief Climate Change Advisor. Administration officials are apparently available for web casts today but not for hearings to defend their policies to the public and to answer questions.

Senator BOXER. Would the Senator yield without losing his time?

Senator BARRASSO. Yes, Madam Chairman.

Senator BOXER. I just want to say, we did not invite Heather Zichal. We did not. It was the decision of the Majority that we will have hearings with the Administration down the line. I do not want people to feel that they said no. We did not ask them because we are going to have those hearings once Gina is in place and we move forward.

And so, I guarantee you, you will have more than one time to go at the Administration. I promise you. I committed to you, probably much more than once, probably two of three times. Please, do not make it sound like they did not want to come because honestly we did not invite them.

Senator BARRASSO. Thank you, Madam Chairman.

This hearing today is entitled Climate Change: It's Happening Now. Many have tried to point to the specific severe weather events in the news and on the Senate floor and to say that a tornado or a storm, that is climate change. In response I quote the Nuclear Regulatory Commission Chairman Allison Macfarland who stated before this Committee that, "I would not call these events extreme, I would consider them normal.' She stated that she made this statement as an earth scientist.

So, what we need to be talking about is jobs. The Administration has, I believe, pummeled coal country, power plants, manufacturing and small businesses for 4 years, pursuing their preferred version of a clean energy future.

Since 2009, unemployment has remained stagnant, families are hurting in States like Wyoming, Kentucky, Ohio, West Virginia, Montana and, according to the Heritage Foundation, the President's June 25th announcement to issue carbon limits for existing coal fired power plants, existing coal fired power plants, would adversely effect the more than 1,100 at nearly 500 plant locations. These plants generate 40 percent of America's affordable, reliable energy.

And this why today I am introducing legislation called the National Energy Tax Repeal Act. The bill very simply says that the authority to direct such regulations resides with Congress and cannot be issued by EPA unless Congress first authorizes it. President Obama's June 25th announcement circumvents the legislative process and the will of the American people. Congress had rejected the President's cap and trade policies in the past.

The President's proposal is extraordinarily expensive. When you combine all of what the President is proposing for new and existing coal fired power plants, the compliance costs would be $130 billion. Those costs are going to be passed on to the hardworking families and seniors on fixed incomes. In addition, more than 250,000 jobs are at risk as coal fired power plants go bankrupt and are retired. The indirect job losses from high energy costs as small businesses lay off workers to stay afloat makes the number higher.

We also know that this Administration and like-minded environmental activists are already planning the demise of natural gas. If the President is going after greenhouse gases, he will not stop at coal.

Then Presidential-Nominee Barrack Obama said himself in the San Francisco Chronicle on January 17, 2008, he said because I am capping greenhouse gases, coal powered plants, natural gas, these are the President's words as a candidate, natural gas, you name it, whatever the plants were, whatever the industry was, they would have to retrofit their operations, that will cost money, they will pass that money onto consumers.

The Sierra Club has already announced their Beyond Gas campaign. So the President has promised it, the Sierra Club has announced it, these actions are going to cost our economy even more jobs, lost opportunities for States to bring in new revenues to pay for things like college tuition, roads, hospitals.

The fact is, these costs are very real. Yet the benefits of these climate change regulations are very much unknown. Even the President's Interagency Climate Change Adaptation Task Force stated in their 2011 progress report, they said "The scope, severity and pace of future climate change are difficult to predict with precision.'

The problem is this Administration and others on this Committee are willing to bet our economic future today as if their predictions about the future are a certainty. That is not the way to manage an economy and this is certainly not the way to develop an energy future for this Country.

Thank you, Madam Chairman.

Senator BOXER. Thank you very much, Senator.

Senator Whitehouse and then Senator Inhofe.

OPENING STATEMENT OF HON. SHELDON WHITEHOUSE, U.S. SENATOR FROM THE STATE OF RHODE ISLAND

Senator WHITEHOUSE. Thank you very much, Chairman. I know how important this issue is to you and to many of our colleagues. And I think today's discussion is especially significant is light of the latest misleading line coming from the special interests that climate change has stopped and we can all pack up our bags and go home. The American people need to hear the truth.

As we all know, the past 10 years are much warmer than 10 years before them and are, in fact, warmer than any decade since recordkeeping began. And unfortunately there are plenty of other plain indicators that climate change is continuing apace.

On the second panel, we will focus on the effects of climate change and ocean acidification, both consequences of carbon pollution. Oceans are still getting warmer and more acidic. Sea level is still rising. Glaciers and Arctic sea ice are still melting. Seasons are still shifting. The most convincing thing about climate science is not how many climate scientists are part of the consensus, but how many different lines of evidence that consensus is built on.

Climate change is happening now. The consequences are real. We here in Congress should be working to slow the known cause of that change, the incessant dumping of carbon pollution into our atmosphere and oceans. And we should be working to prepare for the changes that we can no longer avoid. We need to seek bipartisan and common sense solutions. Instead, because the barricade of special interest influence has blocked action of climate change, we are taking on risk.

Some of us have put forward a solution that we think can appeal to a broad section of Senators, namely to put a price from carbon pollution coming from the largest sources. The big polluters have been getting a free ride. They are harming all of us with their emissions and they are paying no price for it.

Carbon-driven climate change hurts our economy, damages our infrastructure, compromises the security of our Nation and harms public health. These costs, however, are not factored into the price of the coal or oil that is burned to release the carbon. The big oil companies and the coal barons have offloaded those costs onto society.

The cost of the damages from carbon pollution that these corporations are unloading onto the rest of the society is called the social cost of carbon. The Administration recently released updated social cost of carbon values which they use in cost benefit analysis. While I commend them on the update, there remains room to improve the calculation to account for damages from carbon pollution that are difficult to quantify now, such as ocean acidification and species loss. I look forward to future updates factoring in these damages.

We often hear, in this chamber, colleagues extolling the virtues of the marketplace. Indeed, a fair and open marketplace is the cornerstone of our economy. Markets work, not perfectly always, but better than any other mechanism. But markets only work when they are fair and markets are not fair if the price of pollution is not taken into account. The value of open and fair markets is lost when people cheat, just as when they offload their costs onto the general public.

The mounting costs of carbon pollution on society is a market failure. A carbon fee would make the market work more efficiently by putting the costs of carbon pollution into the price of the product instead of letting the big polluters freeload on the general public. It is Economics 101. It will also be a real step toward reducing harmful carbon pollution and it will generate significant revenue, every penny of which could and should go back to the American people and propel the economy.

Climate change is, indeed, happening now. Now is the time for us to get serious about solving this problem. And I thank the Chairman for calling this hearing.

Senator BOXER. Thank you so much.

Senator INHOFE.

OPENING STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Senator INHOFE. Thank you, Madam Chairman. And I do want to thank you for, I called you this morning and, as you are well aware, I am the Ranking Member on Armed Services and we have another hearing taking place at the same time. But this is too important not to participate in. So, I thank you very much. And I will be going back and forth.

Thank you for holding the hearing. I am disappointed that we do not have Administration officials here. I anticipated that we would early on, but we do not.

Around the same time that the President gave his speech on global warming last month, his campaign team developed a talking points memo that was crafted to provide alarmists around the Country with specific instructions about how they should talk about global warming. The President wants everyone to be on the same page. He has tested and tried these talking points on focus groups and even has come up with a list of dos and don'ts which they are putting up behind us, dos and don'ts when talking about climate change which you can see in the chart behind me.

Now, these talking points are not honest or straightforward. They are purely political. In the memo's first point, it says I do not lead, it says do not lead with straight economic arguments. The President makes it clear that he does not want anyone talking about the cost of taking action to stop global warming. And we know exactly why. Whether it is legislation or regulation, any action to reduce greenhouse gases is going to cost the economy at least $300 billion to $400 billion a year.

We have used this figure now for quite some time. It is rather interesting because when it first came out, it was a Wharton figure. Later on, MIT and I think Charles Rivers and others came out. Now, that is a figure that is tied to the, a cap and trade bill. Now instead, the President instructs alarmists to "talk about how climate change is harming America now' and about "real impacts including asthma attacks and extreme weather events like hurricanes and tornadoes.'

Claiming global warming is causing extreme weather is wrong and even President Obama's nominees disagree with him. Allison Macfarlane, who was nominated by the President to be Chairman of the Nuclear Regulatory Commission, testified before this Committee just a few weeks ago. When she was asked about the weather and if she thought the tornadoes or that Hurricane Sandy were extreme weather events, she said I would not call these events extreme. I would call them normal.

Most meteorologists agree. A recent study by George Mason University reported that 63 percent of weathercasters believe that any global warming that occurs is the result of natural variation and not human activities. That is a significant two to one margin. Now, given this, we are lucky one of our distinguished panelists, which I hope I will come back, Dr. Cullen, to ask a few questions of you, is not in charge.

I am kind of glad you are not in charge of meteorological licenses. If so, then 63 percent of them would be fired. You once said, or she once said I should say in opening statement, if a meteorologist cannot speak to the fundamental science of climate change and that it is manmade, then maybe the American Meteorological Society should not give them a seal of approval.

That would mean that meteorologists like Aaron Tuttle in Oklahoma City would be out of a job. He does not believe in manmade, in global warming, but he regularly saves Oklahoma lives by predicting when and where tornadoes will strike which helps people know exactly when they need to take cover during severe storms.

And even though the President's talking points instruct alarmists not to "debate the validity or consensus of the science that is already settled' more and more reports are surfacing all the time that show the science is not settled.

In March, the Economist reported that "Over the past 15 years, air temperatures and the earth's surface have been flat while greenhouse gas emissions have continued to soar.' And just this past week Harvard and the Forest Service came out with a study that shows trees are growing faster and using less water with higher concentrations of atmospheric concentrations of CO_2 . This is the opposite of what scientists expected before. But the alarmists cannot talk about it because they have received their instructions from the President.

The President's talking points demonstrate that he is only interested in achieving his desired political outcome whatever the costs. Now, why do they want to do this? We all remember what Richard Lindzen said and I have quoted it many times. I think it is very difficult for anyone to criticize Richard Lindzen. He is the atmospheric physicist at MIT. He said that regulating carbon is a bureaucrats dream because if you control carbon, you control life.

And when you zoom out and consider this from a distance, it is a core tenant of liberalism. As the President's political philosophy, he believes that the Government can make better decisions than the people.

And I do applaud you for having this hearing, Madam Chairman.

Senator BOXER. Thanks.

Senator INHOFE. I think it is a lot of theater here but it is going to be fun and we can get back in and start talking about it again.

Senator BOXER. Your time is up. But I love the theater. Is this the second act?

[Laughter.]

Senator INHOFE. Excuse me?

Senator BOXER. I said are you giving us the second act?

Senator INHOFE. Act Two, that is right.

Senator BOXER. Anyway, I am glad you came because I do not think this is theater. I think this is deadly serious. I appreciate that you have the same song that you have had all along. I do not know what it will take to convince you but I am going to keep on trying.

Senator INHOFE. Well, then, let me respond to that.

Senator BOXER. Please do. I would not feel good if you did not.

Senator INHOFE. I would only say that there has been time, in the last 12 years, I cannot tell you how many bills have been introduced in the House and the Senate. Not one has passed the U.S. Senate, which is the more liberal branch of the two Houses. And I do not think today you could get 35 votes out of the U.S. Senate for a cap and trade bill.

Senator BOXER. Well, we are not discussing that, OK? Let us not get into cap and trade. All I am saying, and this will be the last word before I call on Senator Hirono, is this. I do not know what it will take to convince you and the deniers of what is out the window.

Senator INHOFE. It is not just me. It is two-thirds of the United States Senator.

Senator BOXER. Senator Hirono.

[The prepared statement of Senator Inhofe follows:]

STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Madam Chairman, thank you for holding this hearing today. I was looking forward to hearing from Administration officials about the President's global warming proposal, so you can understand why I'm disappointed that no officials are testifying today. Around the same time the President gave his speech on global warming last month, his campaign team developed a secret talking points memo that was crafted to provide alarmists around the country with specific instructions about how they should talk about global warming.

The President wants everyone to be on the same page. He's tested and tried these talking points on focus groups, and he even came up with a list of "Do's and Don'ts" when talking about climate change, which you can see on the Chart behind me. These talking points are not honest or straight forward. They're purely political. In the Memo's very first point, which says "don't lead with straight economic arguments," the President makes it clear that he doesn't want anyone to talk about the cost of taking action to stop global warming. And we know exactly why—whether it's legislation or regulation, any action to reduce greenhouse gases is going to cost the economy at least $300 billion or $400 billion per year. And the Administration knows that once the discussion turns to cost—they've lost the debate.

Instead, the President instructs alarmists to "talk about how climate change is harming Americans now" and about the "real impacts including asthma attacks and extreme weather events" like hurricanes and tornadoes. But claiming global warming is causing extreme weather is farfetched, and even President Obama's nominees agree with him. Allison MacFarlane, who was nominated by the President to be the Chairman of the Nuclear Regulatory Commission, testified a few weeks ago in this Committee. And when she was asked about whether she thought the tornadoes in Oklahoma or Hurricane Sandy were extreme weather events, she said, "I would not call these events extreme. I would call them normal. Most meteorologists agree. A recent study by George Mason University reported that 63 percent of weather casters believe that any global warming that occurs is the result of "natural variation" and not "human activities." That is a significant two-to-one majority.

Given this, we're lucky one of our distinguished panelists is not in charge of meteorological licenses. If she were, then 63 percent of them would be fired. She once said, "If a meteorologist can't speak to the fundamental science of climate change," and that it's man-made, "then maybe the American Meteorological Society shouldn't give them their Seal of Approval." That means that Meteorologists like Aaron Tuttle in Oklahoma City would be out of a job. He doesn't believe in manmade global warming, but he regularly saves Oklahoma lives by predicting when and where tornadoes will strike, which helps people know exactly when they need to take cover during severe storms. And even though the President's talking points instruct alarmists to not "debate the validity or consensus of the science that is already settled," more and more reports are surfacing all the time that show the science is not settled.

In March, the Economist reported that "Over the past 15 years, air temperatures at the Earth's surface have been flat while greenhouse-gas emissions have continued to soar." And just this past week, Harvard and the Forest Service came out with a study that shows trees are growing faster and using less water with higher atmospheric concentrations of CO_2 . This is the opposite of what scientists expected before, but the alarmists can't talk about it because they've received their instructions from the President.

The President's talking points demonstrate that he's only interested in achieving his desired political outcome—whatever the cost. Why do they want to do this? We all remember Richard Lindzen, the world renowned atmospheric physicist at MIT. He said that regulating carbon is a "bureaucrat's dream," because "if you control carbon, you control life." When you zoom out and consider this from a distance, it is the core tenant of liberalism and the President political philosophy. He believes that government can make better decisions than the people, and regulating carbon dioxide will give him all he needs to make nearly every decision for the American people.

OPENING STATEMENT OF HON. MAIZE K. HIRONO, U.S. SENATOR FROM THE STATE OF HAWAII

Senator HIRONO. Thank you, Chairman Boxer and Ranking Member Vitter for scheduling today's hearing. This is my first hearing as a Member of this Committee and as a Senator from Hawaii I am very glad to be here to take part in this important discussion.

Throughout human history, our natural environment has provided a stable, predictable foundation for civilization. However, there is clear evidence that foundation is changing. Today's hearing will explore the scientific evidence that changes to earth's climate are contributing to extreme weather events of increasing severity and frequency. These extreme events, as well as changes occurring in our world's oceans, are a major concern to the long-term economic and national security interests of the U.S.

In Hawaii, we have already seen the impact of climate change both on land and in the ocean that surrounds us. There are many impacts on Hawaii that I could mention, but given the short time, I will focus on three: impacts on our economy, our communities and national security.

The Pacific Ocean is the world's largest physical feature. Situated in the center of the Pacific, Hawaii is the world's most isolated archipelago. While our people and communities have always had a special relationship with the ocean, we are also acutely aware that we are at its mercy. Rising ocean temperatures, sea level rise and ocean acidification pose serious risks to our economy and communities.

For example, the sea level has risen in Hawaii at the rate of 0.6 inches per decade over the past century. Research indicates that sea levels may increase by three feet by the end of the century. This means that areas like Waikiki, I am sure many of you have been there, a critical driver of Hawaii's tourism economy, are likely to face serious flooding if sea level rise intensifies.

In addition, we are seeing more extreme weather as a result of changes to our weather patterns. This is straining our infrastructure and harming our communities. For example, while overall rainfall in Hawaii, which is critical to replenishing the groundwater we rely on, has decreased by 15 percent in the past 20 years, but yet we have seen a 12 percent increase in very heavy downpours. In fact, in the spring of 2012, severe flooding occurred that required the Governor to issue a disaster declaration for Oahu and Kauai.

President Obama also signed a Federal disaster declaration for the island of Kauai which was hard hit by flooding that caused more than $3 million in damage just to public facilities and roads. These situations demonstrate the impact climate change is already having on Hawaii's economy and communities.

As a result of scientific evidence and real life experiences with climate change, the State of Hawaii has taken an aggressive approach toward addressing climate change. We have passed State laws limiting greenhouse gas emission, promoting clean energy and energy efficiency, and a law to address climate change adaptation. These efforts are forward looking, but support on the Federal level is needed.

Hawaii is also home to the U.S. Pacific Command, PACOM, which is responsible for the entire Asia Pacific region. That is over half the planet. PACOM's leadership has continually warned of the impact of increasingly severe weather patterns on stability in the region. On average, PACOM is involved in responding to a natural disaster within the region once every 8 weeks.

These are just some of the economic and security concerns that climate change are posing in Hawaii right now. And the situation will only intensify in the future if we do nothing.

Some will argue that we should not lead on this issue as a Nation because it will not make enough of a difference unless developing nations join us. The fact is we are risking falling behind right now. China is taking this issue seriously. It has set up pilot carbon markets and is taking action to invest in renewable energy. In fact, there is a U.S.-China climate change working group to promote high level negotiations and discussion between our two countries on key climate change issues.

Climate change is a great challenge of our time. We can stand and meet the challenge, which will change the foundation of our economy and society for the better. I hope that today's hearing will serve to make the case for strong, cooperative, bipartisan action. I look forward to working with all of my colleagues on these vital issues.

Thank you, Madam Chair.

[The prepared statement of Senator Hirono follows:]

STATEMENT OF HON. MAIZE K. HIRONO, U.S. SENATOR FROM THE STATE OF HAWAII

Chairman Boxer, Ranking Member Vitter, thank you for scheduling today's hearing. This is my first hearing as a member of this Committee, and as a Senator from Hawaii I am very glad to be here to take part in this important discussion. Throughout human history our natural environment has provided a stable, predictable foundation for civilization. However, there is clear evidence that foundation is changing.

Today's hearing will explore the scientific evidence that changes to the earth's climate are contributing to extreme weather events of increasing severity and frequency. These extreme events, as well as changes occurring in our world's oceans, are of major concern to the long-term economic and national security interests of the U.S. 1In Hawaii, we are already seeing the impact of climate change—both on land and in the ocean that surrounds us. There are many impacts on Hawaii that I could mention, but given the short time I will focus on three: Impacts on our economy, our communities, and national security.

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Some will argue that we shouldn't lead on this issue as a nation because it won't make enough of a difference unless developing nations join us. The fact is we're risking falling behind right now. China is taking this issue seriously. It has set up pilot carbon markets and is taking action to invest in renewable energy. In fact, there is a U.S.-China Climate Change Working Group to promote high level negotiations and discussions between our two countries on key climate change issues. Climate change is the great challenge of our time. We can stand and meet the challenge, which will change the foundation of our economy and society for the better. I hope that today's hearing will serve to make the case for strong, cooperative, bipartisan action. I look forward to working with all of my colleagues on these vital issues.

Senator BOXER. Thank you so much, Senator.

Senator SESSIONS.

STATEMENT OF HON. JEFF SESSIONS, U.S. SENATOR FROM THE STATE OF ALABAMA

Senator SESSIONS. Thank you very much. We appreciate the desire to have a hearing focused on science and we need to talk about that. But I do agree with Senator Vitter that the Administration officials, it would be good to have them here today.

With regard to the science, we need to be honest and somewhat humble, I think, as we deal with these issues. No person knows everything about the future of climate in the world and what causes it.

We know greenhouse gases emitted by humans can have a warming affect. I think that sounds commonsensical to me. I agree that there is logic to that, as did President Bush. It is this view, Senator Boxer says that 97 percent or 98 percent that agree. Well, I think I am in the 98 percent. Dr. Spencer, who will raise some questions here today, is in the 98 percent that I believe that we have changes in the temperature and we need to analyze how they occur.

But how much can we do and what all is occurring? We have less confidence it seems to me. We know the atmosphere has warmed some over the last 100 years. We know that global temperatures have not increased in 15 years, pretty clearly.

Senator Boxer, I asked EPA for the kind of report you say you have that justifies the claim that there has been no decline, or no flattening of the temperature, and they have not produced it. So, I would like to see the document that you put into the record. I have been asking for it for months. But it is not going to say that the temperature has increased in the last 10 years because it has not.

So, the President, I believe, continues to mislead the public on this subject. He has said "Temperatures around the globe are increasing more than was predicted 10 years ago.' He said that in November. He said that again this spring. So, we need to be talking about real data and real facts. I asked Lisa Jackson about it and Gina McCarthy and we have not been able to see any data that backs that statement up.

We also know that many of the President's supporters have already benefited financially from the green energy agenda. They are out there having a real interest in maintaining this agenda and sometimes it is alarmism at expense to the taxpayers. Solyndra, a failed solar power effort, exposed taxpayers to $535 million in losses. A123 Systems, a failed battery power project, exposed taxpayers to $249 million in losses. Abound Solar, a failed solar power project, exposed taxpayers to $400 million in losses.

Wages are falling. The American people are hurting. Unemployment is high. Energy costs are high. Poor people are hurting. And we have got to be careful when we impose regulations that do not have an overt U.S. Treasury cost that cost them because they have to pay more for the electricity, pay $50 or $100 more a month to drive to work, that is not a little matter. It is a big matter. We need to know what the science is that would justify that.

But we do not really know how much of this warming will actually occur in the years ahead. That is very much in question. So, we need more science to try to figure that out. That is why I thought it was important that scientists like Dr. Spencer at UAH and Dr. Christy who assessed the data.

And I would like to submit for the record a paper prepared by Dr. Richard McKnight and Dr. John Christy entitled Why We Need a Red Team Approach to Global Science. We need some people that challenge some of this data. More and more as years go by we find some of it is not objective.

Senator BOXER. Without objection, we will place that in the record.

Senator SESSIONS. Thank you.

We keep hearing that there are record high temperatures in recent years. But Dr. Christy said by far there were far more record high temperatures in the Dust Bowl years than we are having in the last decade. Who is correct about that? Let us look at these numbers and see who is accurate in that.

The ultimate fact is as U.S. policymakers we need to know whether imposing a carbon tax and cap and trade system are cutting our greenhouse emissions by 80 percent, as the Chair proposes, would achieve the kinds of reductions in global atmospheric concentrations of CO2 that could change global temperatures.

So, I look forward to the hearing. I think it is important. And let us all maybe chill a moment and learn something.

Thank you.

Senator BOXER. Thank you. Let us all chill. That is good.

OK, we turn to Senator Sanders and then followed by Senator Fischer.

STATEMENT OF HON. BERNARD SANDERS, U.S. SENATOR FROM THE STATE OF VERMONT

Senator SANDERS. Madam Chair, thanks for very much for holding this hearing.

This truly is an Alice in Wonderland hearing. Within this little room we are clearly living in two separate planets. Two separate worlds. And whether the differences are influenced by the fact that the Koch brothers at ExxonMobil and the petroleum industry and fossil fuel industry is pouring hundreds of millions of dollars into think tanks trying to confuse the American people or are we just dealing with politics here, I really do not know.

But to deny the fact that the overwhelming, overwhelming majority, some 98 percent of scientists who have published peer reviewed articles, believe not only that global warming is real, but that it is manmade. And to continue that discussion is we are not sure, let us not talk about, let us look at something else, is almost beyond intellectual comprehension.

And I will say this. We have a lot of differences in the Congress, a lot of philosophical differences. But I predict that our grandchildren and our great grandchildren will look back on this period and they will not be appreciative of the fact that members of the U.S. Senate have refused not only not to go forward in combating global warming but even acknowledging the reality of global warming.

Madam Chair, among scientists, this is according to the American Association for the Advancement of Science, one the large scientific organizations in the world, quote, this is a month ago, 1 month ago, "There is now overwhelming agreement based on multiple lines of scientific evidence that global climate change is real, it is happening right now and it will have broad impact on society.' That is virtually what every major scientific organization, not only in the United States of America but throughout the world, is saying. And it is incredible that we are not on the floor right now discussing serious legislation to cut back on greenhouse emissions.

I think it was Senator Vitter who said, what about the costs? What about the costs? Well, let me talk about the costs. What about the costs of inaction? What will more droughts mean to agriculture in this Country? What will more floods mean in terms of property destruction? What will climate change mean for national security?

It is not only meteorologists, and by the way, not weathermen and weatherwomen, in all due respect weathermen, I am not quite sure that they are part of the scientific community, but what you have is our national security people who are telling us that if you see more drought and less food production, more drought and less drinkable water, you are going to have international conflict.

Navy Admiral Samuel J. Locklear III, who is the head of the U.S. Pacific Command, I think Senator Hirono referred to this, recently described climate change as the biggest national security threat facing the region. Climate change, he warns, and I quote, "will cripple the security environment probably more than other scenarios we all often talk about.' That is the national security issue.

Now, to my mind the time for waiting is over. We need bold action. The United States needs to do what we do best, is lead the world in a new direction. And I am very proud that along with Senator Boxer, she and I have introduced legislation that will, in fact, impose a tax on carbon.

Senator Whitehouse is absolutely right. People who are causing enormous damage to our planet are saying we need cheap energy. You are not cheap energy. Coal and oil are not "cheap' energy as they are causing catastrophic damage to this planet. It is the most expensive form of energy.

So, Madam Chair, I think the time is long overdue for us to move away from fossil fuel, to move boldly to energy efficiency and to such sustainable energies as wind, solar, geothermal, biomass and, by the way, when we do that we will also create millions of jobs as we transform this economy.

Thank you.

Senator BOXER. Thank you so much, Senator.

Senator FISCHER.

STATEMENT OF HON. DEB FISCHER, U.S. SENATOR FROM THE STATE OF NEBRASKA

Senator FISCHER. Thank you Madam Chair and thank you Ranking Member Vitter, for holding this hearing today. I would also like to thank our witnesses for being here and their willingness to share their time with us.

I would also like to welcome Senator Hirono. As a fellow member of the freshman class, it is so nice to have you on this Committee.

Today we are going to have a serious discussion, I hope. It is going to be a robust discussion. Because as we see movement to unilaterally force reductions in U.S. greenhouse gas emissions, the American people who are being forced to pay more for fuel and electricity as a result, they deserve to have an accounting of these actions.

Without reductions from China and India, the world's biggest greenhouse emitters, we must question whether the environmental benefits are even discernible and whether they are worth harming our economy at a time when three-quarters of Americans are living paycheck to paycheck.

The U.S. share of global CO2 emissions has been declining for nearly a decade, from 25 percent in 2000 to 19 percent in 2008. I believe that these declines occurred due to market forces and without expensive, burdensome and unworkable policies.

President Obama's order to EPA to cut carbon dioxide emissions from new and existing power plants would adversely affect coal fired plants the most. America has more than 1,000 coal fired generators at nearly 600 plant locations that generate 40 percent of America's affordable and reliable energy. Nebraska families and Nebraska businesses depend on coal fired generation for two-thirds of their electric needs and we would be disproportionately penalized under this plan.

It is important for our Committee to examine energy price-raising climate change policies and I am hopeful that we will have a hearing soon to do so.

With that, I will end my time and thank you, Madam Chair, and I look forward, again, to a robust discussion.

Senator BOXER. Thank you so much.

So now we turn to our panel of experts and I echo Senator Fischer's welcome and thank you all for being here. No pun intended, this is a hot topic.

Dr. Heidi Cullen, Chief Climatologist at Climate Central, Mr. Frank Nutter, President, Reinsurance Association of America, Mr. KC Golden, Policy Director, Climate Solutions, Ms. Diana Furchtgott-Roth, Senior Fellow, Manhattan Institute for Policy Research, and Dr. Robert Murphy, Senior Economist, Institute for Energy Research.

So, we welcome you.

I see that Senator Carper is here. So, we will just hold off for one moment, he will do his 5 minutes, and we will start with you, Dr. Cullen.

Go ahead, Senator.

STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE

Senator CARPER. Thank you. Please bear with me. Thank you very much, Madam Chair.

I will not need to take 5 minutes. I will just say this. I was privileged as a 17 year old to win a Navy ROTC scholarship and went off to Ohio State to study economics and fall into the Navy. And from time to time I go back to Ohio State.

There is a husband and wife research team that still works there and they run something called the Pohl Research Center that you may have heard of at Ohio State. And what they have done over the last 20, 25 years is to visit the, how many of you have ever heard of the Pohl Research Center? OK. What they have done is they have visited some of the highest mountaintops in the world, largely down around the equator, and they recover ice core samples that enable them to look back in time. And they look back in time not just 100 or 200 years, they look back 100,000, 200,000, 800,000 years.

The ice core samples disclose the levels of carbon in the atmosphere during those periods if time. And they have the ability to see where levels of carbon were high and where they were relatively low. And there is a direct correlation to the temperature in those times and the levels of carbon in those times. And we see in our atmosphere today levels of carbon that I believe are higher than any other data observed in all of those ice core samples that they have recovered over decades of work.

The other thing that I want to say, more up to the present, Madam Chair, in my State there is a major highway, Highway 1, kind of like 101 in California, that goes from the northern part of the State to the southern part of the State. When you get down into Sussex County, our southernmost county, and you turn east off of Highway 1, you head toward the Delaware Bay. You drive literally alongside a wildlife refuge, Prime Hook Wildlife Refuge, a beautiful place. And when you keep going, you drive right into the bay and off in the distance, maybe 20 miles or so, is New Jersey. But if you keep on driving, you drive right into the bay.

It was not always that way. It used to be you would drive into a parking lot. And people parked their cars or their trucks or their boats and they would fish or crab or go boating. And I have a picture from 1947, the year I was born. In 1947, there is a picture of that spot and you are standing there looking east from Delaware toward New Jersey but you are looking out across the Delaware Bay.

And in 1947 there was a bunker, a concrete bunker, I think it had something to do with the fortifications in anticipation of attack by the Germans, submarines or whatever, during World War II. It was a concrete bunker that sat about 300 feet or 400 feet west of, west of the dune line in that place, 300 feet or 400 feet west of the dune lines on dry sand, a concrete bunker. Today, that concrete bunker is in the water. It is in the Delaware Bay. You can still see the top of the bunker protruding from time to time, but it is not 400 feet west of the dune lines anymore. It is in the water.

I like to quote the guy that actually the Chair knows, a guy named Stephen Stills, and I jokingly refer to him as that famed

California climatologist who once wrote something is happening here, just what it is ain't exactly clear. Well, something is happening here and I think it is pretty clear. It is pretty clear to me. And the question is what, if anything, are we going to do about?

Thanks very much.

[The prepared statement of Senator Carper follows:]

STATEMENT OF HON. TOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF STATEMENT DELAWARE

I want to thank the Chairman for having this hearing and thank the witnesses for being here today. For years, I have worked with my colleagues—many on this Committee—and President Obama and his administration to try to tackle climate change. Yes, it's true. I'm a believer. I believe that climate change is not only real, but that it is one of the biggest challenges facing our world today. Two climatologists I met years ago from my alma mater of Ohio State University, Dr. Lonnie Thompson and his wife Dr. Ellen Mosley-Thompson, helped make me a believer.

For decades, this husband-and-wife duo has been climbing some of the tallest mountains in the world to collect ice core samples. These ice samples date back hundreds of thousands of years and contain valuable data about what was in the atmosphere and what the climate was like at the time. Their research has found that there is a direct correlation between the levels of carbon dioxide in our air and warmer temperatures.

We know humans have dramatically increased the levels of carbon dioxide in the air through burning fossil fuels. We also know, based on ice samples, carbon pollution in the atmosphere is at levels not seen in 800,000 years. And we know we have rising global temperatures. To borrow from Stephen Stills, I believe that something's happening here—and what it is actually pretty clear. We don't have to go the highest mountains in the world to see the impacts of climate change; we can find impacts in my own State of Delaware.

The harmful effects of climate change, specifically sea-level rise and extreme weather events like Superstorm Sandy, pose a unique and serious threat to my coastal home State of Delaware, as well as several of our neighbors along the coast. When I am in Sussex County, Delaware, I like to drive out to the Delaware Bay. I usually head east, and I like to go through Prime Hook National Wildlife Refuge. Years ago, I would come across a parking lot where people could walk, fish, swim or go crabbing. Today, that parking lot is entirely underwater.

If you look slightly out in the water—there lays a World War II bunker, once 300 meters from the shoreline and now almost completely submerged by the rising tides. When I talk with people who don't believe that the sea is rising, I urge them to drive out and see that parking lot, see that bunker. Despite the science and what's happening in states like Delaware, we will hear from some of my colleagues and some of today's witnesses that taking action is too expensive. They say we cannot protect our economy and our environment at the same time.

I'd like to remind my colleagues that history has proven this is a false choice: we can protect both. In fact, I would argue the costs are too great if we do not act. The Government Accountability Office agrees with me—listing this year that climate change is a high risk to our country's fiscal health. Taking action means investing in a lower carbon economy, but also investing in more resilient communities. We need to be making investments in beach replenishment, smarter infrastructure, and drought resistant crops that can help our economy weather the storms to come.

We also need to be smarter about where we put our homes, buildings and roads—especially along our coastlines. Fortunately, we aren't starting from square one. Already, this country is moving forward on a cleaner economy—due in big part to the commitments made by the Obama administration. Investments in solar, wind, nuclear, and even clean coal are moving this country away from our dirty fossil fuel dependence. Our cars, trucks and vans continue to become more efficient, saving consumers money at the pump and keeping our car companies more competitive than ever. And laws like the Coastal Barrier Resources Act, sponsored in 1982 by my good friend, former Delaware Congressman Tom Evans, have saved countless tax dollars and protected coastlines highly exposed to storms that otherwise would have been developed.

I'd like to ask for unanimous consent to submit a further statement about Congressman Evans's efforts and a recent article by Justin Gillis, which appeared in the April 8th, 2013, edition of The New York Times, for the Record. We aren't at square one, but we still have a long way to go. As I said at the beginning—I'm a believer. And I believe it's time we stop fighting over established science and work together to enact common-sense environmental protections that are good for both our earth and our economy.

Thank you again Madam Chairman.

Statement on Coastal Barrier Resources Act:

Madame Chairman, it has now been 8 months since Hurricane Sandy devastated so much of the Northeastern coast of our country. In the immediate aftermath of this tragic storm, we saw people from all walks of life pulling together, helping one another, and taking care of their neighbors. In Delaware, we witnessed State, country, and local officials, along with first responders, the Red Cross, the Delaware National Guard, and many volunteers all pitch in to help. It was both incredible and inspirational to witness, and it was a testament America's longstanding tradition of helping our neighbors, whether they live down the street or across the country.

Madame Chairman, we're now well into the summer, and as every Member who represents a coastal area knows, summertime is a vital time for our critically important tourism industry. As families and businesses continue to rebuild, I am heartened to see that coastal communities up and down the East Coast have made significant progress toward a full recovery, and are open for business in most instances. It is a testament to the decisive and comprehensive actions taken by President Obama, Secretary Donovan and the members of the President's Hurricane Sandy Rebuilding Task Force, along with the congressional delegations and Governors of all of the affected states, and countless State and local leaders, officials, residents, business owners, and volunteers.

As remarkable as the progress has been, it will take years to recover from the devastation caused by Sandy, and it's important that we get it right. Lives, communities, and businesses depend on it. We also must remember that, even as we continue to do all we can to support those who are working so hard to rebuild their lives and livelihoods, it is our responsibility to remain ever mindful of the threat of extreme weather, which is always looming along our coastal areas. Unfortunately, the Northeast and Mid-Atlantic are expected to see more frequent and larger storms like Sandy in the future. As a result, we need to do everything we can to mitigate the effects of these future storms, since we know all too well that an ounce of prevention is worth a pound of cure.

In Delaware, we've seen the benefits of mitigation up close. Over a number of years, the Army Corps of Engineers built a series of storm protection projects in Delaware, funded by State and Federal dollars. Our robust beaches and strong dune systems performed very well during the worst of Sandy, likely sparing us billions of dollars in damage. The relatively small investment of tens of millions of dollars that our State made, matching even larger Federal investments, helped to protect more than 17,000 homes in our coastal communities, whose value exceeds over $7 billion.

There is another key tool that we can use to help protect against the impact of coastal storms and reduce the significant Federal investment that is required in their aftermath. This is the legacy of a remarkable Delaware leader who served in many respects as a role model for many of us in Congress not that long ago. In 1982, Congressman Tom Evans and Senator John Chafee of Rhode Island—both Republicans—wrote a simple, yet brilliant, law to slow the growth of rising Federal disaster recovery costs. Their bill, entitled The Coastal Barrier Resources Act, declared that certain fragile, undeveloped coastlines, which were highly exposed to storm damage, could not receive any Federal subsidies, grants, or other investments. The rising cost of responding to disasters such as storms and floods was expected to require steady increases in Federal spending, making building in these areas too risky and—ultimately—irresponsible. Congressman Evans and Senator Chafee were able to pass this law with bipartisan support, and President Ronald Reagan signed it in 1982, calling it a "triumph for natural resource conservation and Federal fiscal responsibility."

Madame Chairman, that law has served America well for more than 30 years. It has preserved critical coastal habitat while protecting communities from storm and flood damage and saving countless tax dollars. It is a true win-win-win, and I am grateful it has protected many areas in my home State of Delaware. I'd ask to submit a recent article by Justin Gillis, which appeared in the April 8th, 2013 edition of The New York Times, for the Record.

Thank you.

The New York Times

April 8, 2013

Rebuilding the Shores, Increasing the Risks

By JUSTIN GILLIS

This might be a good time to take a look at the most important environmental law that nobody has ever heard of.

The real eState industry fought that law bitterly in Congress, but lost, and it landed on Ronald Reagan's desk in 1982. The president not only signed it, but did so with a rhetorical flourish, calling it a "triumph for natural resource conservation and Federal fiscal responsibility."

The law—the Coastal Barrier Resources Act—was intended to protect much of the American coastline, and it did so in a clever way that drew votes from the most conservative Republicans and the most liberal Democrats.

It is worth bringing up today because we are once again in an era when our coasts are at risk and our national coffers are strained. The $75 billion in damages from Hurricane Sandy, coming only 7 years after the $80 billion from Hurricane Katrina, told us this much: We need a plan.

The climate is changing, the ocean is rising, more storms are coming, and millions of Americans are in harm's way. The costs of making people whole after these storms are soaring. Without ideas that stand some chance of breaking the political gridlock in Washington, the situation will eventually become a national crisis.

The law that Reagan signed in 1982 might just offer a model of how to move forward.

First, the background:

Scientists are still figuring out how storms will be altered as global warming proceeds, but they are pretty certain about some things. Land ice the world over is melting in the changing climate, and the ocean is heating up, too, which makes the water expand. Those factors are causing the ocean to rise.

It rose about eight inches in the past century, requiring billions of dollars to fight erosion. Recently the rate of increase seems to have jumped, to about a foot per century—and climate scientists think it will go up quite a bit more. The cautious prediction at this point is that we could see two or three feet of sea-level rise by 2100, and possibly even six feet.

What will that mean for people living near the shore?

You might think things would be fine for them until the day the ocean finally covers their land. But it does not work that way.

Long before inundation occurs, people will be hit more and more often by coastal flooding. In places where it took a huge storm to send seawater into living rooms, a routine storm will do the trick once the ocean has risen several feet.

It should be obvious that the more people we move out of harm's way in the reasonably near future, the better off we will ultimately be.

But we are doing the opposite, offering huge subsidies for coastal development. We proffer federally backed flood insurance at rates bearing no resemblance to the risks. Even more important, we go in after storms and write big checks so towns can put the roads, sewers and beach sand right back where they were.

We are, in other words, using the Federal Treasury to shield people from the true risks that they are taking by building on the coasts. Coastal development has soared as a direct consequence, and this rush toward the sea is the biggest factor in the rising costs of storm bailouts.

So what was so clever about that 1982 law, and how can we learn from it?

Development pressure on the nation's coasts was intense back then, but hundreds of miles of barrier islands and beaches were as yet unspoiled. Environmental groups would have loved a national ban on further coastal development, but conservatives would never have gone along with that.

Two Republicans, Senator John H. Chafee of Rhode Island and Representative Thomas B. Evans Jr. of Delaware, found the magic formula. Their bill simply declared that on sensitive coastlines that were then undeveloped, any future development would have to occur without Federal subsidies.

In other words, no flood insurance and no fat checks after storms.

The law did not prohibit anybody from building anything. And in fact, some development has occurred on lands in the redlined zone. But the law has mostly held, discouraging development along some 1.3 million acres of American coastline—a monumental triumph that continues to pay dividends.

So here is a modest idea. As the first plank of our plan for coping with storm risk, what about expanding the boundaries of the program that Reagan took such pride in?

That is not to be cruel: people deserve humanitarian help after big storms. But Robert S. Young, head of the Program for the Study of Developed Shorelines at Western Carolina University, thinks we have to start weaning beach towns from the welfare roll.

One way to begin, he suggests, would be to identify the towns in the riskiest areas, the ones that the taxpayers keep bailing out again and again.

Perhaps we say to them: You get one more shot. We will make you whole after the next big storm, and if you choose to use the money to rebuild, then you are on your own.

Just maybe, in some areas that should never have been developed in the first place, the necessary retreat from the beaches would finally begin.

Senator BOXER. Well, thank you very much. And we have been rejoined by Senator Wicker, so we will hold off on the panel to hear his 5 minutes.

Go right ahead, Senator.

STATEMENT OF HON. ROGER F. WICKER, U.S. SENATOR FROM THE STATE OF MISSISSIPPI

Senator WICKER. Well, I ran up the stairs, Madam Chair, so I was hoping Senator Carper would take his additional minute so I could get my breath back.

Senator BOXER. Well, we could ask him to sing.

Senator WICKER. Well, yes.

[Laughter.]

Senator BOXER. I would do it, too.

[Laugher.]

Senator WICKER. Depending on his expertise.

But thank you very much, Madam Chair. You have billed this hearing as a forum to focus on the science of climate change. I want to reiterate the importance of treating various scientific views on climate science with deference. Comments concerning some researchers as having a flat earth mentality unnecessarily polarize what should be a robust dialog.

I also hope we can discuss today the serious implications of the Administration's unilateral move to execute its environmental agenda. In his recent speech, the President described his commitment to a coordinated assault on climate change. I think many of my colleagues would agree that we do expect that coordination to include the congressional oversight of Federal policy decisions.

One of the most disturbing actions outlined by the President's climate plan is the regulatory push against the coal industry which would have a severe and widespread impact. With these regulations, the President has confirmed what many of his critics have long alleged. Rather than advancing a truly all of the above energy strategy, this Administration is determined to wage an all out war on coal.

Both Republicans and Democrats in the Congress realize the consequences of issuing drastic regulations on coal which remains a primary source of energy production in America and fuels 37 percent of our electricity, 37 percent of our electricity still comes from coal.

Under the severe standards being proposed, many coal fired plants would go bankrupt or close, putting more than 250,000 American jobs at risk. Businesses would feel the effect of the stricter rules in the form of additional compliance costs and consumers would be saddled with higher energy bills.

Now, regarding sound science, the Administration continues to defend its aggressive policies with assertions that global temperatures are on the rise, dismissing disputed information from scientists and scholars. Recently released data, disputed data I will acknowledge, showed temperature have stayed flat over the past 15 years despite rising carbon dioxide emissions. I would note that some of these data come from the United Nations, the recorded temperatures which were much lower than predictions from climate models that the President has himself cited.

I recently joined seven of my colleagues on this Committee in requesting copies of the climate data and analysis used to support the President's statements. In our letter to Gina McCarthy, we expressed our concerns that the agency had not sufficiently responded to past requests for this information. The President's intent to pursue a costly regulatory roll out demands proof of sound science as well as transparency.

Over time, studies by scientists and researchers have actually shown there is no climate signal limited to extreme weather events. In fact, one of our witnesses today can speak directly to this issue. I also realize there are those on the other side of the issue.

At the very least, I think it is time for some tolerance in the public discourse regarding the many scientific viewpoints on climate change. Respect should be shown to those who have done the research and come to a different conclusion.

I remain committed to working with my colleagues in the Congress to reign in the Administration's intrusive power grabs to push a radical climate agenda that will not help but will cost jobs. Unwarranted rules and restrictions are unfair to all Americans who will bear the cost of higher energy prices.

Thank you, Madam Chair.

Senator BOXER. Well, this is the most fascinating time. Now we have the great Senator from New Mexico who is here. We are going to call on you. We are just about to go our panel but we will hold off to hear your opening statement.

I want to say, Senator, I am going to give this to you. This is an EPA document with maps and graphs and I put it in the record and I am going to send it over to you now. Maybe it is not enough but EPA clearly has made this case publicly that they made to the President.

Should we send it over to you?

Senator WICKER. Please pass it over.

Senator BOXER. Send it over, special delivery.

Senator WICKER. And I will deliver contrary scientific data to the Chair.

[Laughter.]

Senator BOXER. Senator, you said you did not know what they were thinking, and we think you should read this first. I guess, oh, never mind, I will not go there.

[Laughter.]

Senator BOXER. Senator Udall.

STATEMENT OF HON. TOM UDALL, U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator UDALL. Thank you, Madam Chair. Madam Chair, I know the witnesses have been waiting here for an hour to speak so I will try to be very brief. And I would just ask to put my full statement in the record.

Senator BOXER. It will be done.

Senator UDALL. Climate change, global warming, climate disruption are having a huge impact in the Southwest. I think most of the computer models we see is that the Southwest will probably be twice the temperature rise as other places in the United States. And we are seeing it right now on the ground.

I will give you an example. I was just out in a little town called Tucumcari, New Mexico. It has always had a water project that has delivered water to farmers, 700 farmers and ranchers. That water project is the last 5 years, four out of the last five, has not delivered any water. That example is being spread throughout New Mexico in terms of our ability to have the water resources we need to develop, to grow and to do the economic development.

So, we are seeing it in water. We are seeing it in the snow pack which recharges our aquifers, we are seeing it in these catastrophic forest fires which have grown in the last 10 or 15 years very dramatically. In terms of the amount of acreage, we are having larger and larger acreage and setting records every year.

But also the thing about catastrophic forest fires is they burn much hotter than they have in the past. And what you have is a soil that is parched. They talk about crown fires in these catastrophic fires with the temperatures reaching 1,000 degrees and baking the soil. So it is not, after the fire is over, the soil is not there to regenerate things.

So, there are a number of impacts. I just wanted to mention those and just say that I think each of us should look and Senators all across the Country in their communities, and you can see this impact now.

I very much appreciate what you all are doing and appreciate the panel's work and really look forward to hearing from them today.

And with that, and putting my statement in the record, I would yield back.

Thank you, Madam Chair.

[The prepared statement of Senator Udall follows:]

STATEMENT OF HON. TOM UDALL, U.S. SENATOR FROM THE STATE OF MEXICO

The climate of the southwest is in a State of transformation. Recent years have seen our communities struggling with higher temperatures, drought and forest fires on an almost constant basis. The tightrope we walk to balance water supply and the multiple demands for its uses is increasingly precarious.

The earth is warming and so is the West. New Mexico's average temperatures have been rising 50 percent faster than the global average in recent decades. Our winters are warmer and the season shorter, while summer heat has entered new territory for extremes.

In addition to the heat, the region's water woes compound the challenges. The snowpack that is so vital for our streams and rivers—and in turn for our farmers, ranchers and cities—is in steep decline. The last 10 years have seen the lowest snowpack on record in the West, and the latest research suggests that Colorado snowpack may decline even further by 13 percent by mid-century.

New Mexico's most important source of surface water is the Rio Grande and it depends on snowpack for one half to three quarters of its dependable water from the mountain snowpack in Colorado and Northern New Mexico. River-flows in the Colorado River Basin are already declining and projected to shrink further, putting huge pressure on Western states water supply for agriculture and power generation.

The Southwest is still in the grip of a multi-year drought. Is it possible that severe drought will be with us more often from now on? Signs from thousands of miles away in the Arctic suggest that this may be the case. Scientists say that unprecedented loss of Arctic snow and sea ice cover has changed the way hemispheric weather systems operate increasing the odds of droughts manifesting across our country.

Warmer winters, water stress and drought are wreaking havoc with forests across the Southwest. Iconic pinon pine forests have been dying across thousands of square miles across Arizona, Colorado, New Mexico, and Utah due to heat stress and drought, as well as the depredations of pine beetles. In Arizona and New Mexico alone, warm temperatures have led to bark beetles and wildfires killing 20 percent of trees over the last 30 years.

Massive wildfires have been prevalent throughout the region. Last year, New Mexico suffered the largest wildfire ever recorded in the State—the Whitewater-Baldy fire that burned a staggering 259,000 acres. A suffocating pall of smoke seemed to hang over the entire west last summer.

The threat of climate change is no longer a threat. It is a reality and it is predicted to intensify. We need to respond. We can no longer just point to global trends—this is local. The impacts are affecting us and damaging our communities. We need to accept that this crisis is now at our front door and we need to take action to defend our families, homes and communities.

Senator BOXER. Well, thank you.

And now it is your term, experts, to make your case to us.

So, Dr. Heidi Cullen, Chief Climatologist at Climate Central, welcome.

STATEMENT OF HEIDI CULLEN, PH.D, CHIEF CLIMATOLOGIST, CLIMATE CENTRAL

Ms. CULLEN. Chairman Boxer, Ranking Member Vitter, Committee members, thank you for the opportunity to speak today.

I am Heidi Cullen. I serve as Chief Climatologist at Climate Central which is an independent climate science research and journalism organization. We take no policy positions.

My testimony aims to give the Committee an overview of how extreme weather events are affected by human-induced climate change which is caused primarily by heat-trapping emissions from the burning of fossil fuels. The bottom line is certain types of extreme weather are on the rise in the United States. Their links to climate change are clear. Heat waves and heavy downpours are becoming more frequent and more intense.

In the Midwest and in the Northeast, we are already seeing increased flooding. In the West, higher temperatures and decreased precipitation are already helping drive an increase in wildfires and droughts. Let me put two recent examples into their broader climate context because in each case there is a clear link to human-induced climate change.

First, the deadly Yarnell Hill fire which, as Chairman Boxer mentioned, killed 19 elite firefighters last month. It played out in the midst of one of the most extreme heat waves on record in combination with prolonged drought and low snow pack. Extreme heat, drought, low snow pack. These are three Western wildlife ingredients that are made more likely by human-induced climate change. Overall, hotter, drier weather and earlier snow melt are helping wildfires in the West start earlier in the year, last later into the fall and burn more acreage.

Couple this with long-standing fire suppression policies, population growth and development, these fires now threaten more homes and cause more evacuations. Climate models predict an alarming increase in large fires in the West in coming years.

Second, Hurricane Sandy, the largest Atlantic hurricane on record, took an unusual left hook into my home State of New Jersey. Human-induced climate change can affect storms like Sandy in different ways.

First, ocean temperature. Waters off the East Coast were running about 5 degrees Fahrenheit above average during the summer of 2102. Global warming is already contributing to warmer ocean temperature and warmer oceans fuel stronger storms. As a result, the intensity of the strongest hurricanes is expected to increase.

Second, blocking. An area of high pressure near Greenland blocked upper air flow over the Atlantic, forcing Sandy to take this left hook. More frequent blocking events may be related to the loss of Arctic sea ice which is melting largely as a result of warmer temperatures caused by human-induced climate change.

Third, sea level rise gave Sandy's nine foot storm surge a higher launching pad. Global warming is causing sea level to rise because water expands as it warms and melting land-based ice adds water to the oceans. One recent study estimates that global sea level rise caused Sandy to flood roughly 25 square miles more than it would have, putting the homes of an additional 38,000 people in New Jersey and 45,000 in New York City below the storm tide and in harms way.

Switching gears a little bit. Despite continued record warmth and a steady rise in atmospheric greenhouse gas concentrations, some have questioned whether global warming has stopped because the rise in global mean surface temperature has been slower over the past 15 years. This is an area of active research that is incredibly important to our understanding of the interplay between natural climate variability and human-induced warming. What is very clear is that global warming has not stopped.

I would like to stress that there is just very much more to our climate system that just the atmosphere. The land surface, ice sheets and the oceans all carry the burden of human-induced warming. Our oceans currently absorb more than 90 percent of the excess heat trapped by rising carbon dioxide levels.

So, the temperature rise in the atmosphere may have temporarily slowed but the warming continues to penetrate into other components of our climate system. During the past decade, it appears roughly 30 percent of the excess heat has gone into the deep ocean below 2,300 feet. Heat stored in the deep ocean matters. It does not go away. It just prolongs the effects of global warming.

In conclusion, certain types of extreme weather events in the United States have become more frequent and intense, particularly heat waves and heavy downpours. These extremes have real consequences for people and the economy. Heat waves are the No. 1 weather-related killer. Heat waves make droughts and wildfires worse. Heavy downpours set the table for flooding and sewage overflows.

This new normal that we are moving into of increased extremes is really still a glimpse of what lies ahead is we do not change course.

Thank you and I look forward to your questions.

[The prepared statement of Ms. Cullen follows:]

CLIMATE CENTRAL

Extreme Weather Within the Context of Our Changing Climate

Heidi Cullen, PhD
Chief Climatologist, Climate Central
Senior Research Fellow, Wharton Risk Management and Decision Processes Center, University of Pennsylvania
Visiting Lecturer, Princeton University

Briefing to the United States Senate Committee on Environment and Public Works
July 18, 2013

Introduction

Chairman Boxer, Ranking Member Vitter and distinguished members of the Senate Environment and Public Works Committee – thank you for the opportunity to present today. It is a privilege and an honor to testify on this important topic.

I am Heidi Cullen and I currently serve as Chief Climatologist at Climate Central. Climate Central is an independent organization of scientists and journalists who research and report on climate and energy. Climate Central surveys and conducts scientific research on climate change and informs the public of key findings. Our scientists publish in peer-reviewed literature and our journalists report on climate science, energy, sea level rise, wildfires, drought, and related topics. Climate Central does not lobby, or support any specific legislation, policy or bill. I am also a Senior Research Fellow at the Wharton Risk Management and Decision Processes Center at the University of Pennsylvania. Assessing and communicating the risks of climate change is something I care deeply about.

Climate change was for a long time thought to be an issue for the distant future. But I am here today to testify that it has, in many respects, moved into the present. The impacts of human-caused climate change are being observed right here and right now in our own backyards and neighborhoods.

My testimony today draws from peer-reviewed literature and is an attempt to concisely review the following:

1. The science of extreme weather and climate change.
2. The so-called global warming hiatus of the early 2000s.
3. The important role of oceans in our climate system.

1. The Big Picture

When it comes to climate change, scientists focus on carbon dioxide (CO_2) because it is the most important long-lived global warming gas. CO_2 is emitted via human activities including fossil fuel burning, cement production and deforestation. Once emitted, a molecule of CO_2 can remain in the atmosphere for hundreds of years. Global CO_2 emissions reached a record high of 35.6 billion tons in 2012 (Peters et al., 2012). Carbon dioxide and other greenhouse gases warm the planet by absorbing the sun's energy and preventing heat from escaping back into space. The latest carbon dioxide emissions continue to track the high end of emission scenarios (Figure 1). Without significant emissions reductions, the world's average temperature could climb as much as 7 to 11°F by 2100 (Peters et al., 2013).

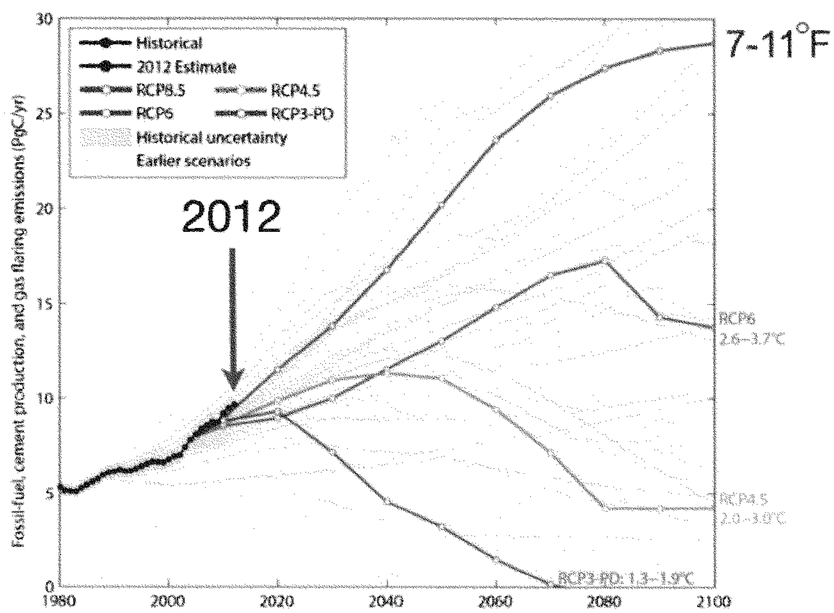

Figure 1: Observed emissions (black dots) and emissions scenarios (colored lines). Source: Peters et al., 2013, Global Carbon Project[1].

This past May, the amount of carbon dioxide in the air exceeded 400 parts per million (ppm) for the first time in at least 800,000 years (Figure 2). The news marks a troubling milestone, showcasing the steady increase of human-caused CO_2 emissions over the past century. Additional lines of evidence including ice cores and ocean sediments, suggest this may be the highest atmospheric CO_2 concentration as far back as 15 million years (Tripati et al., 2009).

[1] http://www.globalcarbonproject.org/carbonbudget/index.htm

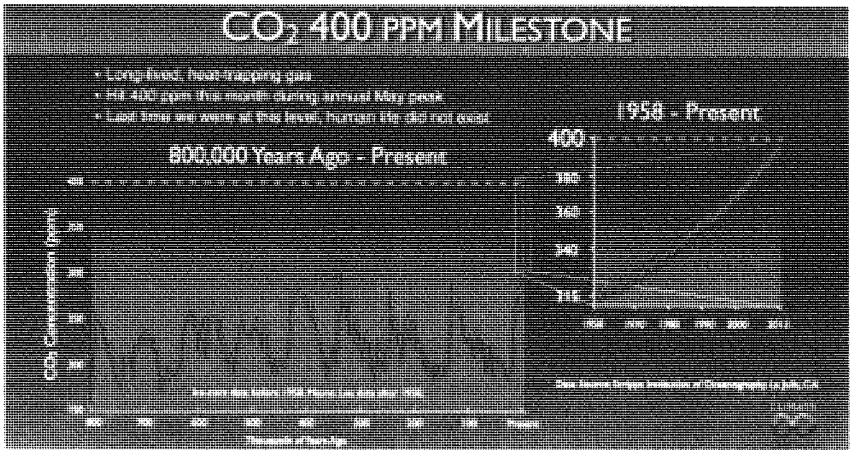

Figure 2: Carbon dioxide in the air exceeded 400 parts per million (ppm).

Across the globe, we are observing things we would not expect to observe in a climate controlled purely by natural variability. According to the National Oceanic and Atmospheric Administration (NOAA), 2012 was the 10th warmest year since records began in 1880. The annual global combined land and ocean surface temperature was 1.03°F above the 20th century average of 57.0°F. This marks the 36th consecutive year (since 1976 – during the presidency of Gerald R. Ford) that the yearly global temperature was above average. Currently, the warmest year on record is 2010, which was 1.19°F above average. Including 2012, all 12 years to date in the 21st century (2001–2012) rank among the 14 warmest in the 133-year period of record. Only one year during the 20th century—1998—was warmer than 2012.[2]

Despite this remarkable string of warmer-than-average temperatures, it is important to note that human-induced warming is superimposed on a backdrop of natural climate variations, meaning that the rise in temperature has not been, and will not be, smooth over space or time. There will still be cold spells, cool days, etc. for places just as we saw this past winter along the U.S. East Coast.

Here in the United States average temperatures have increased by roughly 1.5°F since record keeping began in 1895. More than 80 percent of this temperature increase has occurred since 1980. The most recent decade was the nation's warmest on record. Looking back, 2012 was an impressive year in terms of extreme weather and climate events. It was the warmest year on record in the lower 48 states. According to NOAA, the average temperature in the United States for 2012 was 3.2°F above the 20th-century average, and 1°F above 1998, the previous warmest year (Figure 3). The year also featured a massive drought, deadly heat waves that broke thousands of temperature records, and a powerful Hurricane Sandy that devastated parts of the Mid-Atlantic and Northeast. The

[2] http://www.ncdc.noaa.gov/sotc/global/2012/13

National Snow and Ice Data Center announced that Arctic sea ice had reached a new minimum extent that was drastically lower than the previous record, set in 2007, by an area about the size of Texas. Sea ice in the Arctic has also decreased dramatically since the late 1970s, particularly in summer and autumn. Since the satellite record began in 1978, minimum Arctic sea ice extent (which occurs in early to mid September) has decreased by more than 40 percent (NSIDC, 2012). This decline is unprecedented in the historical record and is consistent with human-induced climate change (Min et al., 2008; Kay et al., 2011).

There were 11 extreme weather and climate disasters in 2012 *each* costing upwards of $1 billion. According to NOAA's National Climatic Data Center in Asheville, N.C., these billion-dollar events cost the United States a total of $110 billion, which puts 2012 behind only 2005 on the list of costliest years since 1980 (Smith and Katz, 2013).

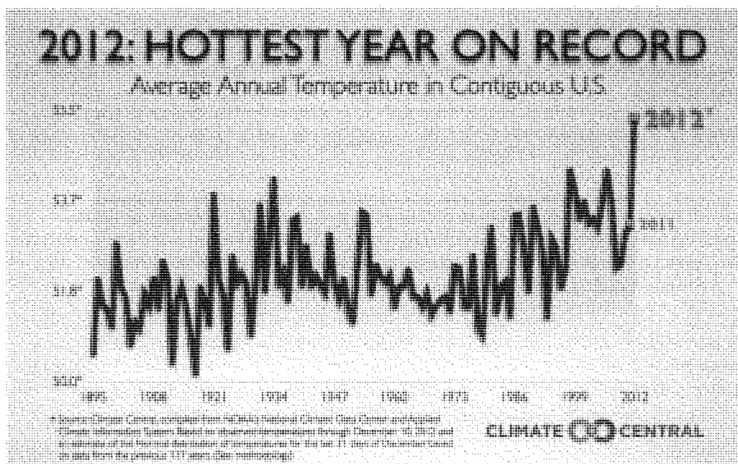

Figure 3: Average annual temperature in the contiguous United States.

Records continue to fall in 2013, with the continuation of drought conditions throughout the West. One of the greatest heat waves in North American history came in late June and peaked in early July, smothering states from Arizona to Washington state under a persistent "heat dome" of high pressure. It was during this heat wave that 19 firefighters lost their lives battling the Yarnell Hill fire in Arizona. The extraordinary heat wave, caused by an unusually extreme standing wave pattern in the jet stream, brought Earth's highest June temperature ever recorded on Sunday, June 30, when the mercury hit 129.2°F in Death Valley, Calif.

The seemingly endless string of extreme events has left many wondering if the weather here in the United States has fundamentally changed. Are we moving in the direction of ever more dangerous and costly extremes? The losses associated with these extreme events have raised questions about the overall vulnerability of our communities and the need to focus on pre-disaster resilience planning. The short answer to this first scientific question is yes. We can already see the impacts of warming in certain types of extremes. The second question is a matter of policy. According to the Federal Emergency Management Agency (FEMA), every dollar spent on enhancing communities' ability to withstand extreme events reduces the cost of damage from such events by about $4.[3]

1a. Extreme weather

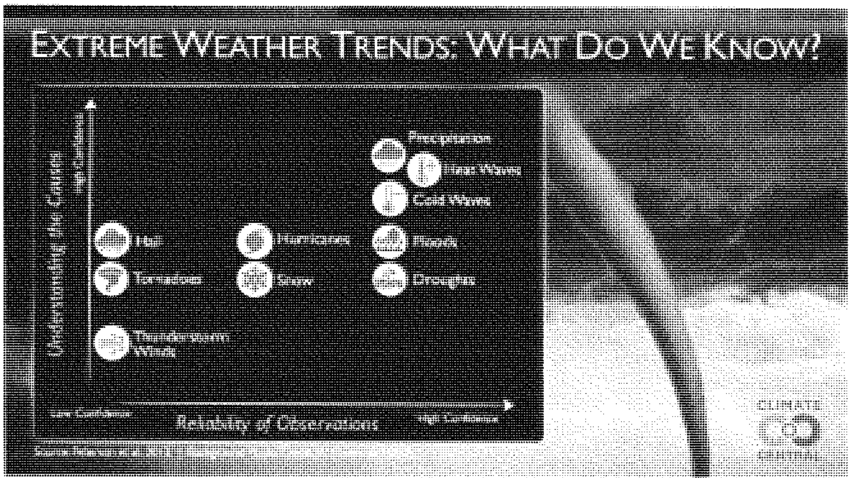

Figure 4: Our understanding of extreme weather events within the context of climate change is a function of the reliability of our observations coupled with our understanding of the causes of the extreme weather phenomenon. Source: Peterson et al., 2013.

The current state of the science on extreme weather trends is summarized in Figure 4. Our understanding of extreme weather events and trends within the context of climate change is a function of the reliability of our observations (e.g., how much data do we have about droughts?) coupled with our physical understanding of the causes of the specific extreme weather phenomenon (e.g., what causes a tornado or a heat wave?). There are certain types of extremes that we understand better than others and there are certain types of extremes for which we have better (wider coverage in space, longer records in time, and more accurate measurements) observational data than others. What follows is a summary of our understanding broken down by the type of extreme event.

- *Heat Waves/Cold Waves*

Periods of extreme heat and extreme cold can have profound societal, agricultural, economic impacts. Extreme heat ranks as the No. 1 weather-related killer in the United States (National Weather Service 2012; Borden and Cutter, 2008.) The scientific community has a solid physical understanding of heat waves and cold waves. Because our climate is warming, heat waves are expected to occur more often, while cold waves are expected to decrease. In fact, recent decades tend to show an increase in the number of heat waves and

[3] http://www.climatecentral.org/news/campaign-for-climate-resilience-spreads-at-local-level-16135

a decrease in the number of cold waves, but over the long term, the drought years of the 1930s stand out as having the most heat waves (Figure 5). The chances of record-breaking high temperature extremes will continue to increase as the climate continues to warm. These results parallel the results of Meehl et al. (2009), who found that the current observed ratio of record high maximum temperatures to record low minimum temperatures averaged across the United States is about 2 to 1.

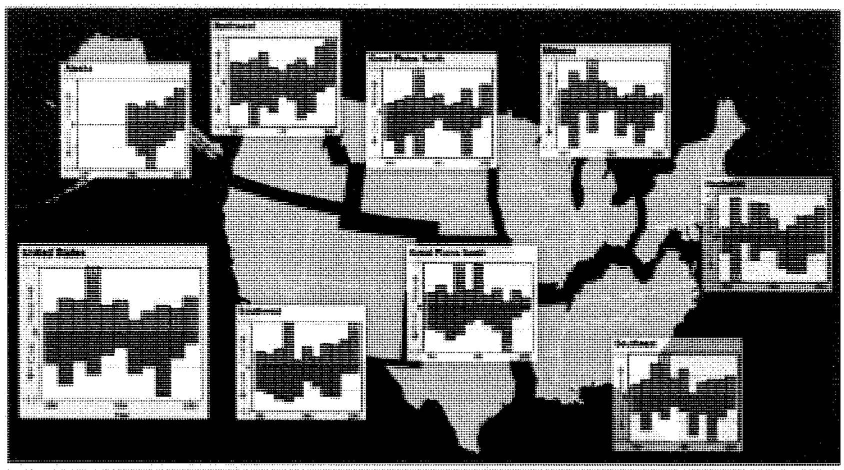

Figure 5: Time series of decadal-average values of heat wave (red bars) and cold wave (blue bars) indices from Peterson et al., 2013. Recent decades tend to show an increase in the number of heat waves and a decrease in the number of cold waves but, over the long term, the drought years of the 1930s stand out as having the most heat waves.

There has also been an increasing trend in persistently high nighttime temperatures. High overnight temperatures have broad negative impacts because they deprive people and animals from getting a reprieve from the heat, increasing the chances of heat-related illness. For a more specific example, the *State of the Climate in 2011* report, published by NOAA and the American Meteorological Society (AMS), looks at how human-induced global warming is influencing recent extreme weather and climate events. The report notes that global warming has already been playing a role in shifting the odds for several extreme events, including the 2011 Texas drought - the worst one-year drought in Texas history, costing nearly $8 billion in agricultural losses[4] - including the closing of a beef-processing plant in Plainview, Texas that employed 2,300 people[5]. The study concluded that human-induced climate change made the 2011 Texas heat wave and drought 20 times more likely than it would have been 50 years ago.[6]

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[4] http://www.statesman.com/news/news/state-regional/drought-cost-texas-close-to-8-billion-in-agricultu/nRmNt/

[5] http://www.nytimes.com/2013/02/28/us/drought-fells-a-texas-towns-biggest-employer.html?pagewanted=all&_r=0

[6] http://www.ncdc.noaa.gov/bams-state-of-the-climate/2011.php

- ***Wildfires***

The deadly Yarnell Hill fire that killed 19 elite firefighters in June played out, like other wildfires in the West this summer, in the midst of one of the most extreme heat waves on record, in combination with a prolonged drought. While the factors contributing to specific fires are varied and include natural weather and climate variability as well as human factors, such as arson, the National Climate Assessment found that human-induced climate change has already increased the overall risk of wildfires in the Southwest.

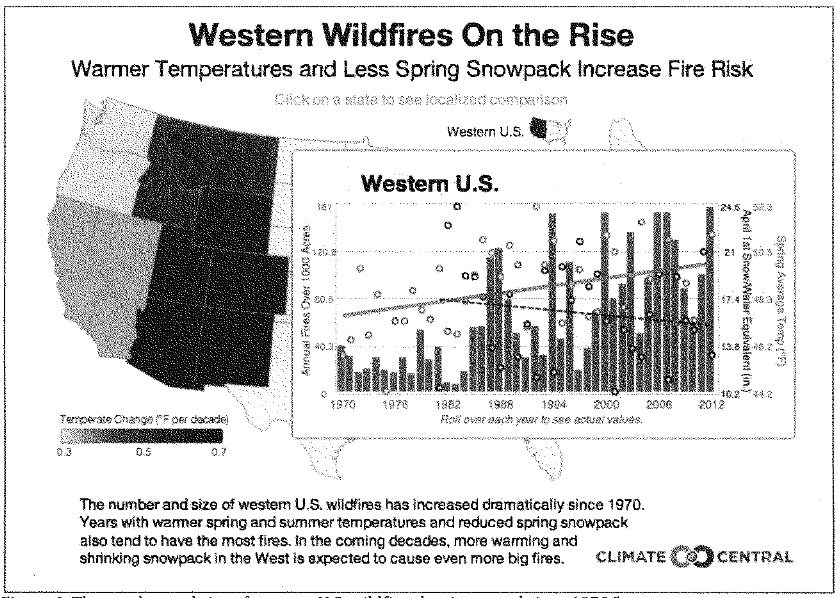

Figure 6: The number and size of western U.S. wildfires has increased since 1970.[7]

According to Climate Central research[8], average spring and summer temperatures across 11 Western states have increased by more than 1.5°F since the 1970s (Figure 6). Spring temperatures in Arizona have warmed faster than any other state, rising nearly 1°F per decade since 1970, which has likely played a key role in Arizona's rapid increase in fires over the past two decades. The number of large fires burning each year in states like Arizona and Idaho have tripled or even quadrupled over that time. And in other states, including California, Colorado, New Mexico, Nevada, and Wyoming, the number of large fires has doubled. During the past decade there were seven times more fires greater than 10,000 acres each year in 11 Western states and nearly five times more fires larger than 25,000 acres each year, when compared to an average year during the 1970s. Years with abnormally warm spring and summer temperatures tend to be years with more and bigger fires. Years with low spring snowpack (measured as the amount of water in snowpack on

[7] http://www.climatecentral.org/news/rising-temps-shrinking-snowpack-fuel-western-wildfires-16222

[8] http://www.climatecentral.org/news/report-the-age-of-western-wildfires-14873

the ground as of April 1) also tend to be years with more fires. When there is a relatively thin snowpack come spring, it can melt quickly as the weather warms, leaving the forest drier earlier and much more likely to burn. Across the Southwest in particular, several recent years of below-average spring snowpack has extended the region's drought and fueled more big fires.

Overall, hotter and drier weather and earlier snow melt, coupled with land use changes and other trends, mean that wildfires in the West start earlier in the year, last later into the fall, threaten more homes, cause more evacuations, and hurn more acreage. The growing season also starts earlier, so there is more to burn. According to Craig D. Allen, a research ecologist at the United States Geological Survey station at Bandelier National Monument in New Mexico, the fire season has lengthened substantially, by two months, over the past 30 years.[9] Other factors contributing to the increase in wildfire trends include long-standing fire-suppression policies that have left many forests with substantial amounts of vegetation to serve as fuel, population growth, and more specifically, development in areas that have a history of wildfires, known as the "wildland-urban interface."

In 2009, The Quadrennial Fire Review projected that the effects of global warming would lead to "greater probability of longer and bigger fire seasons, in more regions in the nation." Specifically, climate change would result in shorter, wetter winters coupled with warmer, drier summers.[10] Climate models used to predict future fire risks show an alarming increase in large wildfires in the West in coming years, as spring snowpack melts earlier, summer temperatures rise, and droughts occur more frequently and with greater intensity.

- Heavy Downpours/Floods/Drought

Heavy downpours are increasing nationally (Figure 7), especially over the past three to five decades. According to the National Climate Assessment (currently available in draft form[11]) those events in the top 1 percentile of intensity have increased in every region of the contiguous United States since 1958 - with the largest increases occurring in the Midwest and Northeast and smallest increase occurring in the Northwest. The reason for these heavier rain events is relatively simple: in a world warmed by heat-trapping greenhouse gases, there's more evaporation, the atmosphere can hold more water vapor, and when that water vapor condenses as rain or snow, there's more of it available to fall. As a result, many flood management/storm water systems are not designed for 21st century rainstorms.

It is important to note that while the trend in intensity has been upward, it has not been steady. The record contains ups and downs from one decade to the next. This provides another example of the fact that human-caused climate change hasn't replaced natural climate variability: it appears on top of it. The frequency and intensity of extreme precipitation events are projected to increase throughout much of the country in the future.

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[9] http://www.nytimes.com/2013/07/02/us/experts-see-a-hotter-drier-west-with-more-huge-fires.html
[10] http://www.iafc.org/files/wild_QFR2009Report.pdf
[11] http://ncadac.globalchange.gov/

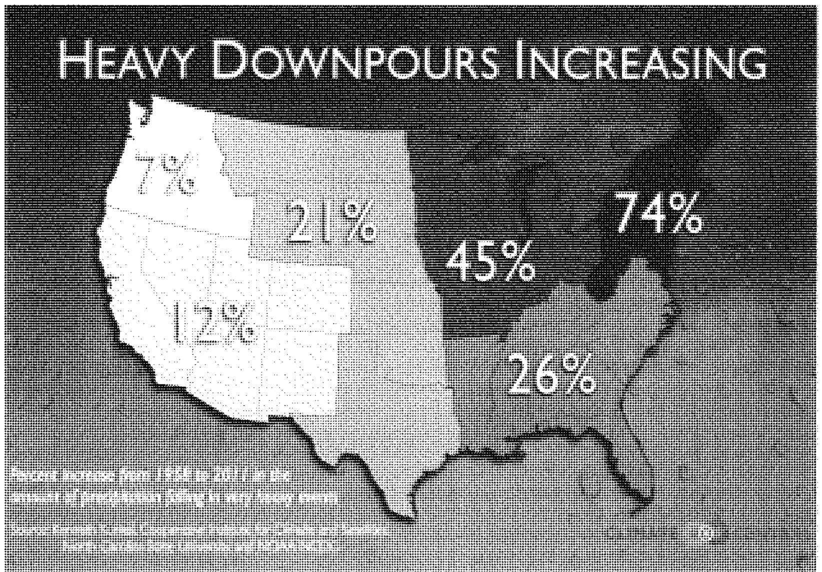

Figure 7: Percent increase from 1958 to 2011 in the amount of precipitation falling in very heavy events.

When it comes to understanding the causes of changes in floods and droughts, we don't know quite as much - even though we have good data. Overall, because of the way large-scale warming will affect the atmosphere, we expect to see dry regions become drier and wet regions become wetter. In general, the northern parts of the United States (especially the Northeast and Alaska) are projected to see more precipitation, while the southern parts (especially the Southwest) are projected to see less.

There is, however, evidence of a detectable human influence in the timing and magnitude of snowmelt and resulting streamflow in some western states (Barnett et al. 2008; Andersen and Shepherd, 2013). Changes in the magnitude of peak annual river floods are shown in Figure 8. Flooding in the northern half of the eastern Great Plains and much of the Midwest has been increasing, especially over the past several decades. Flooding has decreased in the Southwest, although there have been small increases in other western states. In the areas of increased flooding, increases in both total precipitation and extreme precipitation events are contributing to the flooding increases. In general, heavier rains lead to a larger fraction of rainfall running off and, depending on the situation, more potential for flooding. Floods are projected to intensify in most regions of the United States, even in areas where average annual precipitation is projected to decline, but especially in areas that are expected to become wetter, such as the Midwest and the Northeast.

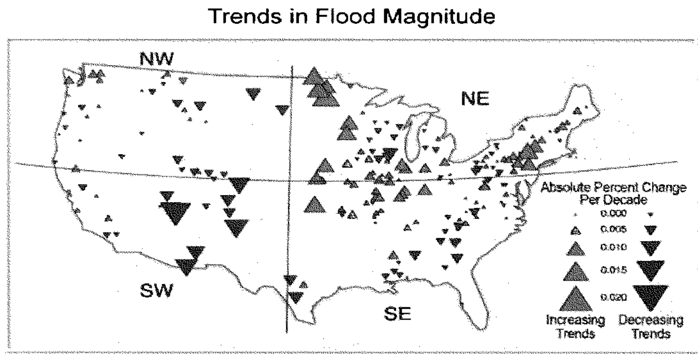

Figure 8: Trends in flood magnitude. Source: Hirsch and Ryberg, 2012.

Overall, precipitation has increased on average since 1900, with the largest increases the Midwest, southern Great Plains, and Northeast. Portions of the Southeast, the Southwest, and the Rocky Mountain states have experienced decreases. More winter and spring precipitation is projected for the northern United States, and less for the Southwest, during this century.

Examination of trends and variability of hydroclimatic conditions in the lower 48 states during the past century indicates that there has been a general drying across the western United States during recent decades (Figure 9). Precipitation has already declined in some areas within the Southwest and the Rocky Mountain states, and decreases in precipitation are projected to intensify in those areas and spread northward and eastward in summer. However, even in areas where precipitation does not decrease, projected higher air temperatures will cause increases in surface evaporation and loss of water from plants, leading to drier soils. As soil dries out, a larger proportion of the incoming heat from the sun goes into heating the soil and adjacent air rather than evaporating its moisture, resulting in hotter summers under drier climatic conditions.

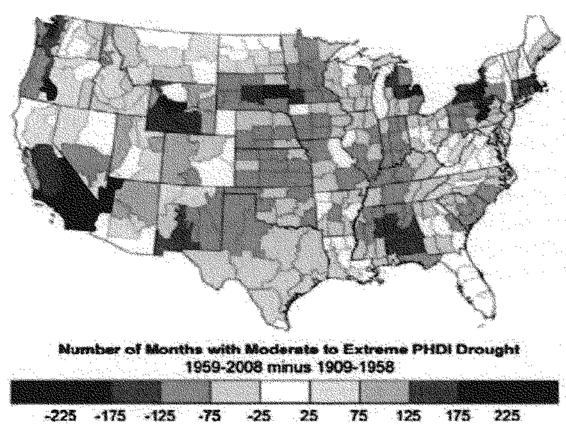

Figure 9: Geographic distribution of century-scale changes in droughts from Peterson et al., 2013.

- *Sea Level Rise*

Sea level rise is among the most serious potential consequences of global warming. Since 1880, sea level has risen approximately 8 inches around the world, on average, as a result of global warming. According to projections included as part of the draft National Climate Assessment, sea level could he as little as another 8 inches or as much as 6 feet 7 inches above 1992 levels by the end of the century. This high-end projection would put the homes of 7.8 million Americans today at risk of being flooded (Figure 10).

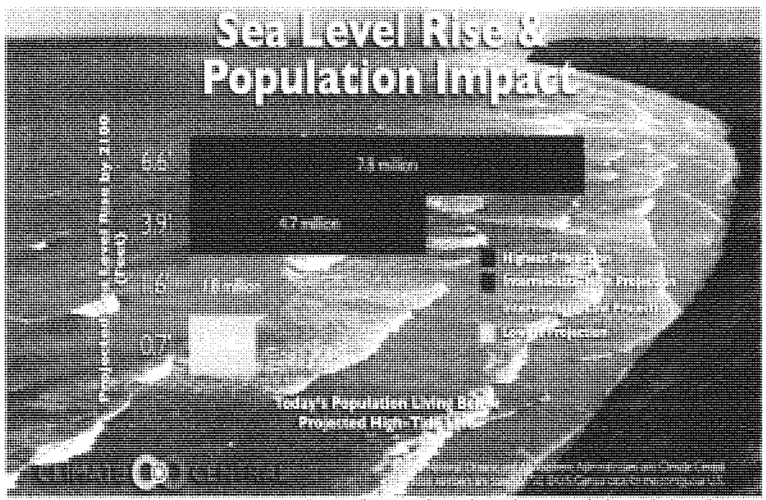

Figure 10: Potential population impacted (based on number of people currently living below the projected high-tide line) based on four sea level rise projections.

In the near term, sea level rise will be experienced as more coastal floods reach higher. Sea level rise due to global warming has already doubled the annual risk of extreme coastal flooding across widespread areas of the nation (Strauss et al., 2012). In some areas, especially for Louisiana, Texas, and mid-Atlantic states, sinking land will add to the rise and further exacerbate problems. All along the Pacific, from Seattle to the Oregon coast to San Francisco to Los Angeles, the component of past and mid-range projections of sea level rise from global warming more than triple the odds of "century" floods by 2030. The same is true inside the Chesapeake and Delaware Bays, and many sites to the north.

Sea level rise occurs for two reasons. First, water expands as it warms. As a result the ocean swells and rises. Second, more water is emptying into the ocean with each passing year as ice on mountaintops and ice sheets in Greenland and Antarctica continue to melt. It is still not known exactly how fast sea level will rise because 1) it is difficult to predict the dynamics of ice sheets collapsing and sliding into the sea and 2) it is not known exactly how much warmer the Earth's temperatures will be in the future.

Sea level rise is already contributing to increased storm surge. A recent example of this was during Hurricane Sandy. At 13.88 feet, the storm tide (relative to Mean Lower Low Water) associated with Sandy set a record for Battery Park and inundation was widespread. A recent estimate looked at the sea level rise component of Hurricane Sandy's storm surge and concluded that sea level rise caused Sandy to flood an area roughly 25 square miles greater than it would have in 1880 - increasing the number of people living on land lower than the storm tide by about 38,000 in New Jersey and about 45,000 in New York City (Strauss et al, 2012; Miller et al., in press).

- ***Hurricanes***

By some measures, there has been a small increase in the overall strength of hurricanes and in the number of strong (Category 4 and 5) hurricanes in the North Atlantic since the early 1980s and a decrease in the eastern North Pacific (Figure 11). A recent paper (Emanuel, 2013) suggests that, contrary to previous findings, tropical cyclones are likely to become both stronger and more frequent in the years to come. The study found this is especially likely in the western North Pacific but also in the North Atlantic, where about 12 percent of the world's tropical cyclones occur each year.

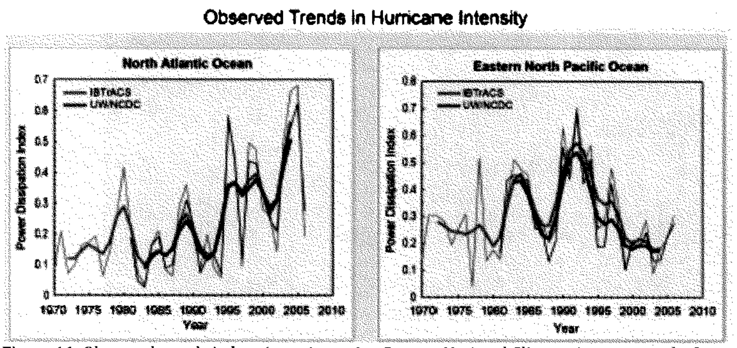

Figure 11: Observed trends in hurricane intensity. Source: National Climate Assessment draft report. Updated from Kossin et al., 2007).

However, a number of previous studies suggest that warming will cause tropical storms to be fewer in number globally, but stronger in force, with more category 4 and 5 storms (Knutson 22 et al. 2010), which is worrisome since major hurricanes (Category 3 or greater) are responsible for the most damage. This consensus view was expressed most recently in a 2012 report from the U.N. Intergovernmental Panel on Climate Change (IPCC, 2012).

With regard to other types of storms that affect this country, winter storms have increased slightly in frequency and intensity, and their tracks have shifted northward over the United States.

It is not surprising that Superstorm Sandy raised questions about links to global warming. Sandy was the largest (diameter of tropical storm force winds extending out 1000 miles[12]) and second most destructive Atlantic hurricane on record. According to Dr. Jeff Masters at Weather Underground, New York City experienced its worst hurricane since the city's

[12] http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf

founding in 1624[13]. Sandy's 9-foot storm surge rode in on top of a high tide to bring water levels to 13.88 feet at The Battery (Figure 12), smashing the record 11.2 feet water level recorded during the great hurricane of 1821.

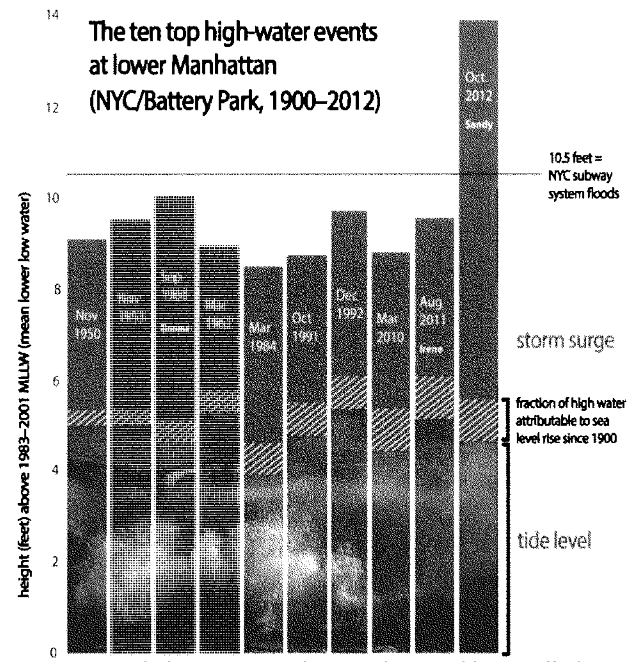

Figure 12: Top 10 high water events in lower Manhattan and fraction of high water attributable to sea level rise since 1900. Source: C. Calvin and B. Henson, UCAR.

There were three climate factors that helped shape Hurricane Sandy's unusual track and strength:

1. Ocean surface temperatures off the East Coast were running about 5°F above average during the summer of 2012. Global warming is contributing to warmer ocean temperatures.

2. Sea level rise gave the surge a higher launching pad than it would have had a century ago, making it more damaging than it otherwise would have been.

3. Upper-air flow over the Atlantic Ocean was temporarily jammed by a powerful area of high pressure near Greenland. It's possible that more frequent blocking events may be related to the loss of Arctic sea ice (Francis and Vavrus, 2012). This blocking affected Sandy's track.

[13] http://www.wunderground.com/blog/JeffMasters/article.html?entrynum=2282

Sandy was indeed a very unusual storm. A recent study (Hall and Sobel, 2013) calculated that the occurrence rate of a Sandy-style storm is 0.0014 per year, meaning that if future hurricane activity matches the recent past we should expect a storm like Sandy on average about once every 700 years. The fact that this calculation shows Hurricane Sandy's track to be so rare under long-term average climate conditions implies either the New York-New Jersey area was simply unlucky or that a climate-change influence increased the probability of its occurrence.

- *Tornadoes*

Tornadoes are currently the least understood extreme weather event when examined within the context of global warming. Tornado data do not reveal any obvious trends in tornado occurrence or deaths that would suggest a clear link to global warming (Figure 13). A recent paper (Kunkel et al., 2013), found that the occurrence of EF-1 and stronger tornadoes on the Enhanced Fujita Scale has shown no trend since 1954. Similarly, there is no evidence to indicate that EF-4 and EF-5 tornadoes — like the one that devastated a large swath of Moore, Oklahoma in May — are becoming more frequent or severe. In general, it's hard to identify meaningful trends in historical tornado data due to changing reporting practices (e.g., the advent of advanced radar technology).

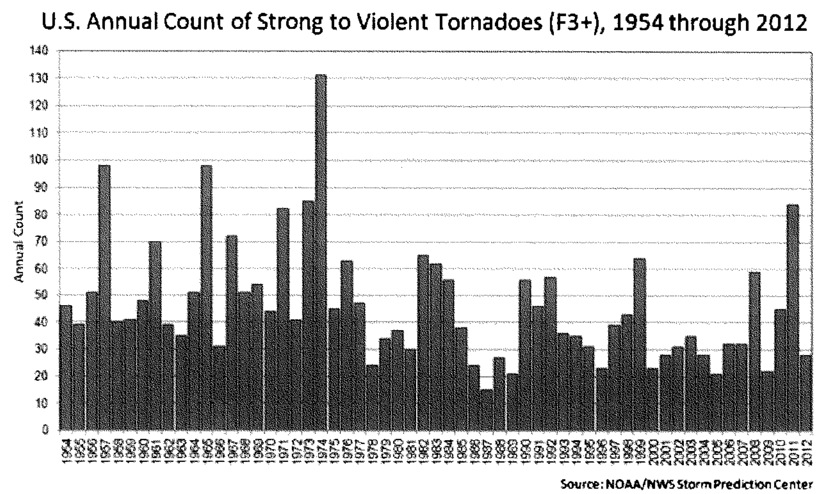

Figure 13: Number of annual EF-3 or greater tornadoes from 1954 to 2012. Credit: Storm Prediction Center.

Because historical tornado data is not considered very reliable or consistent, scientists have focused on how a warming climate might alter two of the basic ingredients that go into producing a tornado. First, you need warm, humid air beneath a layer of cool, dry air. Second, you need those layers to be traveling at different speeds or in different directions, a phenomenon called wind shear. These two conditions are common in the Plains states during the spring and early summer.

The jet stream pushes cool, dry air from the Rockies over slower-moving humid air from the Gulf of Mexico. When a disturbance like a cold front or a low-pressure system causes the two layers to interact, the hot layer tries to rise, and you get a rotating column of air that can turn into the sort of violent thunderstorm that sometimes spawns tornadoes.

Climate change will likely affect these two ingredients in opposite ways. On one hand, warmer air can hold more moisture than cool air can, so moisture content will increase with global temperatures. More moisture, plus higher temperatures may lead to more atmospheric instability and hence more thunderstorm activity.

On the other hand, wind shear is expected to decline as the Arctic warms. Most recent models point to higher moisture content resulting in more strong thunderstorms, but the lower wind shear means a smaller fraction of them will spawn tornadoes. Whether tbere will be so many more thunderstorms that they end up creating more net tornadoes, despite the lower wind shear, is unclear.

1b. What is causing the trend toward more extreme weather?

Ongoing research (Francis and Vavrus, 2012; Petoukhov et al., 2013) suggests a possible mechanism for the increasing extremes we are beginning to see. Specifically, by changing the temperature balance between the Arctic and mid-latitudes, rapid Arctic warming is altering the course of the jet stream, which is responsible for steering weather systems from west to east around the globe. The Arctic has been warming about twice as fast as tbe rest of the Northern Hemisphere, due to a combination of buman emissions of greenhouse gases and unique feedbacks built into the Arctic climate system. According to this new research, the jet stream is becoming "wavier," with steeper troughs and ridges. Weather systems are moving more slowly, increasing tbe chances for long-duration extreme events, like droughts, floods, and heat waves. The tendency for weather to get stuck in one pattern is going to favor extreme weather conditions.

2. Global Warming Has Not Stopped

Global warming has not stopped. It is important that we distinguish between global mean *temperature* and global *warming*. While the temperature rise in the atmosphere may have temporarily slowed, the warming continues to penetrate into every component of our climate system.

The human impact on our climate system is significant. Current greenhouse gas concentrations are trapping enormous amounts of heat into our climate system every day. Despite, a record warm year in 2012, a steady rise in atmospheric greenhouse gas concentrations and a continued uptick in extreme weather events, some have begun to question whether global warming has stopped. Despite the fact that all 12 years of the 21st century (2001-2012) rank among the 14 warmest in the 133-year period of record, it is true that the rise in global surface temperature has been slower over the past 15 years when compared with the rate of increase during the 1970s, 80s and 90s (Figure 14).

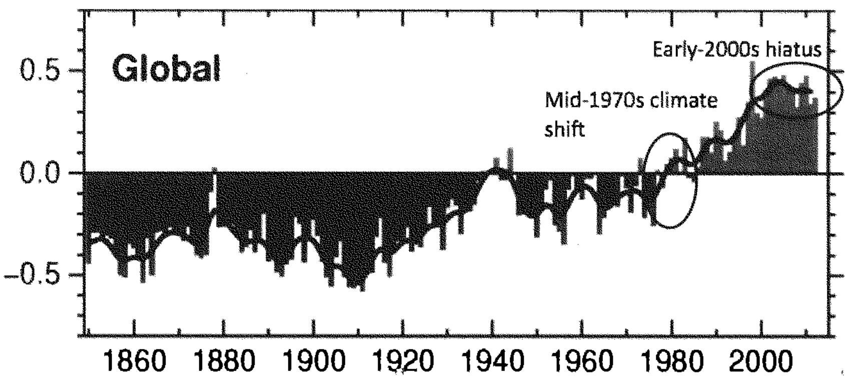

Figure 14: Global temperature anomaly from HADCRUT3. Courtesy: J. Meehl, NCAR.

First, this claim depends on the strategic selection of start and end points. The starting point for this so-called warming hiatus is almost always 1997-1998, a particularly warm period because of a strong El Niño. It is also important to note that the period contains several moderate-to-strong La Niña events, which tend to cool the planet slightly – including in 1999-2000, 2007-2008 and 2010-2011. The "early-2000s hiatus" is an area of active research that scientists are treating with extreme interest, as it is important to our understanding of the interplay between natural variability and human-induced warming, and also serves as a case study for improving the performance of our climate models. The active research question is focused on finding where the warming went and what possible sources of natural variations, resulting in a cooling effect, may have masked the warming.

A recent analysis of global ocean heat content measurements seem to have located the missing warming - in the deep ocean. Whereas upper ocean waters, from the surface to 2,300 feet depth, show no warming from 2004 to 2008, the waters from 2,300 to 6,500 feet show warming at an unprecedented rate. During the past decade, about 30% of the excess heat has been dumped into the deep ocean below 2,300 feet (Meehl et al., 2011; Balmaseda et al., 2013; Meehl et al., 2013). Ongoing research suggests that aerosols from a series of volcanic eruptions in the 2000s may also be playing a contributing role (Santer et al., in review).

3. The Important Role of the Oceans

It is important to keep in mind that there is much more to our climate system than our atmosphere. The oceans take up about a quarter of the CO_2 that we are putting into the atmosphere by fossil fuel burning and deforestation. The land surface takes up another quarter (Canadell et al., 2007).

Even more dramatic is the fact that the ocean absorbs more than 90 percent of the excess heat trapped by rising carbon dioxide levels (Church et al., 2011; Figure 15). This will continue until the surface ocean warms enough to balance the radiative forcing. This moderating effect of the ocean explains why there is 1°F of warming still in the pipeline even if we stop adding CO_2 today. This is because water is both slower to warm and slower to release its heat than air. The process is no different than a cup of coffee. The coffee cools because it's releasing heat into the air above it, but the extra heat takes time to escape. Understandably, the process takes even longer if the coffee (ocean) continues being warmed as it is releasing heat. This is exactly what we see playing out in our climate system today. Therefore, it will take several decades for the climate to catch up to the warming expected for a given level of atmospheric carbon dioxide.

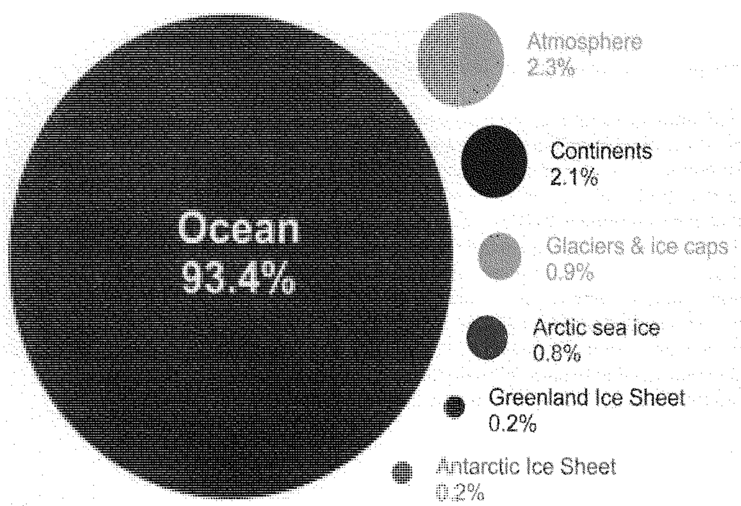

Figure 15: A breakdown of where the warming is going - components of global warming for the period 1993 to 2003 calculated from IPCC AR4 5.2.2.3.

3a. It's Largely Irreversible

Up until recently, most scientists were working under the assumption that if we went cold turkey and brought CO_2 emissions to zero, CO_2 concentrations (measured in parts per million or ppm) in the atmosphere would peak and then be most of the way back down toward pre-industrial levels in about 100 to 200 years, with the warming decreasing along with them. A recent study, using a climate model known as an Earth-system model of intermediate complexity, or an *EMIC*, looked at how long it would take for the concentration and climate to head back down (Solomon et al., 2009). Because EMIC's are not as sophisticated as general circulation models, they have the advantage of being fast allowing researchers to run very long simulations of the Earth's climate. The goal of the experiment being to see what the atmosphere remembered of current human activities 1,000 years from now, in the year 3000. The experiment tested what would happen if CO_2 emissions suddenly stopped after peaking at different concentrations, ranging from 450 to 1,200 parts per million. In the model, CO_2 levels dropped so slowly that by the year 3000 the atmospheric concentration was still substantially above pre-industrial levels. Global temperatures also stayed high, which means that downstream impacts such as irreversible dry-season rainfall reductions in several regions comparable to those of the "Dust Bowl" era and inexorable sea level rise are also irreversible. This irreversibility is just one of the reasons why the United States National Academy of Sciences recently highlighted the need for an effective national response, including "enacting policies and programs that reduce risk by limiting the cause of climate change and reducing vulnerability to its impacts" (NRC, 2011).

In conclusion, climate change is, in many respects, the ultimate procrastination problem. The longer we wait, the greater the risks we will face and the greater the costs will be to respond.

Summary

The four primary points of my testimony today are as follows:

1. Global warming is occurring and it continues to influence all facets of our climate system – the atmosphere, oceans, land surface and ice sheets. This is a well-established fact despite recent claims of a so-called global warming hiatus.
2. There is very high confidence that the climate change of the past 50 years is primarily due to human activities (Stott et al., 2010).
3. There is strong evidence that certain types of extreme weather events in the United States have become more frequent and/or intense - including heat waves and heavy downpours, and in some regions floods, wildfires and droughts. For other types of extremes, such as tornadoes, evidence is much more limited.
4. Weather extremes that can be physically linked to human-induced climate change will likely worsen if emissions globally are not reduced. Because of the long timescales of the ocean – the warming is largely irreversible.

Thank you.

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Senator BOXER. Thank you so very much.

We call on Mr. Frank Nutter, Reinsurance Association of America. It is nice to see you again.

STATEMENT OF FRANKLIN W. NUTTER, PRESIDENT, REINSURANCE ASSOCIATION OF AMERICA

Mr. NUTTER. Madam Chair, Senator Vitter, thank you for the opportunity to testify.

Reinsurance is essentially the insurance of insurance companies and one of its widely recognized purposes is to allow insurers to transfer natural and manmade catastrophe risk from their books.

Insurers are dependent, more dependent, on the vagaries of climate and weather than any other financial services sector. The industry is at great financial peril if it does not understand global and regional climate impacts, variability, developing scientific assessment of a changing climate. And through its pricing structure, it is also a mechanism for conveying the consequences of decisions about where and how we build and where people live. The industry really needs to be very proactive in dealing with that.

Our industry is science-based. Blending the actuarial sciences with the natural sciences helps us with an understanding about climate and its impact on a variety of weather conditions.

Insurers see climate primarily through the prism of extreme natural events. I have included a variety of charts and slides in the presentation, but the first one is from Munich Reinsurance showing the rising number of natural catastrophes globally and in the United States.

In the 1980's, the average number of natural catastrophes globally was 400 events per year. In recent years, the average is 1,000. Munich Re's analysis suggests that the increase is driven almost entirely by weather-related events.

It is indisputable that the recent rise in damages, insured economic and uninsured, is heavily influenced by the concentration of people and property in geographically vulnerable areas. Urbanization, increased development and population shifts have placed more people with destructible assets and the most impact, mostly impacted by extreme weather.

NOAA's recent State of the Coast Report observes that of a population of 313 million, 39 percent live in coastal shoreline counties and 52 percent live in watershed counties. NOAA reports there are 49 million housing units in these counties and we are going to see a population increase of nearly 10 million people before the next census in 2020.

The insured coastal property values along the East and Gulf coasts now totals nearly $10 trillion. The research and consulting firm Corelogic reports that there are 4.2 million homes along the Gulf Coast and Atlantic Coast exposed to storm surge, the most significant factor in damages associated with Superstorm Sandy. One million of these properties are in the category of extreme risk to storm surge.

Catastrophe-modeling firm AIR estimates the insured value of coastal properties, and this is replacement costs, not market value, is expected to increase at a rate of 7 percent a year, which means that they would double every decade.

I provided a variety of charts suggesting that thunderstorm convective storms are also creating significant losses. But severe wind is not the only peril reflecting this pattern. The 2012 U.S. drought alone cut crop yields, reducing the Third-Quarter 2012 GDP by .4 percent, the equivalent of another Superstorm Sandy.

The question, of course, is what if the past is not prologue and in a changing climate whether economic and social trends exacerbate this impact and that future projected losses from past events reflect rising exposures in areas proven to be at high risk. I have included a chart reflecting past events and what would happen if they occurred in the same place today given property values and people.

In a study on climate change impacts conducted for FEMA by consulting firm AECOM, the firm concluded that the typical 100-year flood plain nationally will grow by 45 percent and by 55 percent in coastal counties. Notably in this report, they attribute 70 percent of the projected growth in the 100-year flood plains to climate change and 30 percent to expected population growth.

I have also included a chart about disaster assistance, declarations that have been made and funded by this Congress, and also a study by Dr. David Cummins suggesting that the average annual future disaster assistance related to storms, weather and climate events is likely to be $20 billion a year. Currently, Congress funds FEMA at $1 billion a year for this purpose.

I have also included statements from Swiss Reinsurance which states that climate change has the potential to develop into our planet's greatest environmental challenge for the 21st Century. The industry, Swiss Re says, can only be effective in its role if the regulatory and legislative framework establishes the right incentives for emissions reductions and adaptation on a global scale.

Munich Re says anthropogenic climate change is believed to contribute to this trend, a jump in catastrophe losses, though its influences vary by peril and in different ways. It is crucially important, Munich Re says, for us as risk managers to find improved solutions for adaptation and mitigation.

And last, I have cited the Geneva Association, which is a research think tank on insurance economics, which says there is therefore a need for urgent and concerted mitigation action to reduce greenhouse gas emissions. We therefore need concerted adaptation as well to avoid the predicted impacts of climate change.

Thank you very much, Madam Chair. I appreciate the opportunity.

[The prepared statement of Mr. Nutter follows:]

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STATEMENT

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TESTIMONY

OF

FRANKLIN W. NUTTER
PRESIDENT
REINSURANCE ASSOCIATION OF AMERICA

CLIMATE CHANGE: IT'S HAPPENING NOW

BEFORE

UNITED STATES SENATE
COMMITTEE ON ENVIRONMENT AND
PUBLIC WORKS

JULY 18, 2013

My name is Frank Nutter and I am President of the Reinsurance Association of America (RAA). The RAA is a national trade association representing reinsurance companies doing business in the United States. RAA membership includes reinsurance underwriters and intermediaries licensed in the U.S. and those that conduct business on a cross border basis.

Thank you for the opportunity to testify before the committee to address the RAA's perspective on weather and climate-related weather impacts in the United States.

Reinsurance is essentially insurance for insurance companies. It is a risk management tool for insurance companies to reduce the volatility in their portfolios and improve their financial performance and security. It is widely recognized that reinsurance performs at least four primary functions—(1) helps insurance companies manage their risks; (2) stabilizes loss experience; (3) provides transfer for insurers of major natural and man-made catastrophe risk; and (4) increases insurance capacity.

Reinsurers have assisted in the recovery from every major natural and man-made catastrophe over the past century. 60% of the insured losses related to the events of September 11, 2001 were absorbed by the global reinsurance industry. In 2005, 45% of the insured losses from Hurricanes Katrina, Rita and Wilma were paid by reinsurers; in 2011, insured losses for the New Zealand earthquakes totalled $17 billion, with reinsurers paying 73% of that total. In 2012, "Superstorm" Sandy caused an estimated $18 billion in insured losses. Reinsurers are expected to pay up to 40% of the insured losses.

Property casualty insurers are more dependent on the vagaries of climate and weather than any other financial services sector. Within the insurance sector, reinsurers have the greatest financial stake in appropriate risk assessment. The industry is at great financial peril if it does not understand global and regional climate impacts, variability and developing scientific assessment of a changing climate. Integrating this information into the insurance system is an essential function.

Insurance is a critical component for economic and social recovery from the effects of extreme weather and climate driven events. Through its pricing structure it is also a mechanism for conveying the consequences of decisions about where and how we build and where people chose to live. In this regard, it must be proactive and forward-looking in a changing climate/weather environment.

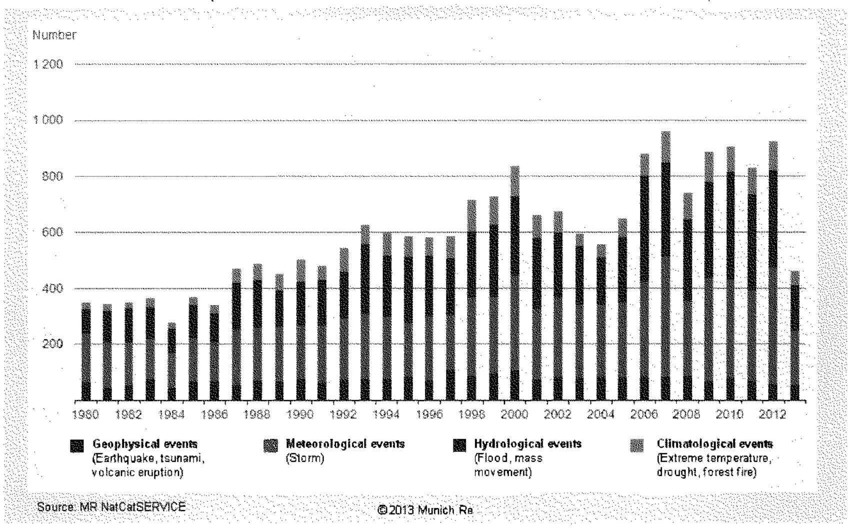
Our industry is science based. Blending the actuarial sciences with the natural sciences is critical in order to provide the public with resources to recover from natural events. As the scientific community's knowledge of changes in our climate and the resulting weather continue to develop, it is important for our communities to incorporate that information into the exposure and risk assessment process, and that it be conveyed to stakeholders, policyholders, the public and public officials that can, or should, address adaptation and mitigation alternatives. Developing an understanding about climate and its impact on droughts, heat waves, the frequency and intensity of tropical hurricanes, thunderstorms and convective events, rising sea levels and storm surge, more extreme precipitation events and flooding is critical to our role in translating the interdependencies of weather, climate risk assessment and pricing.

Exposure Assessment

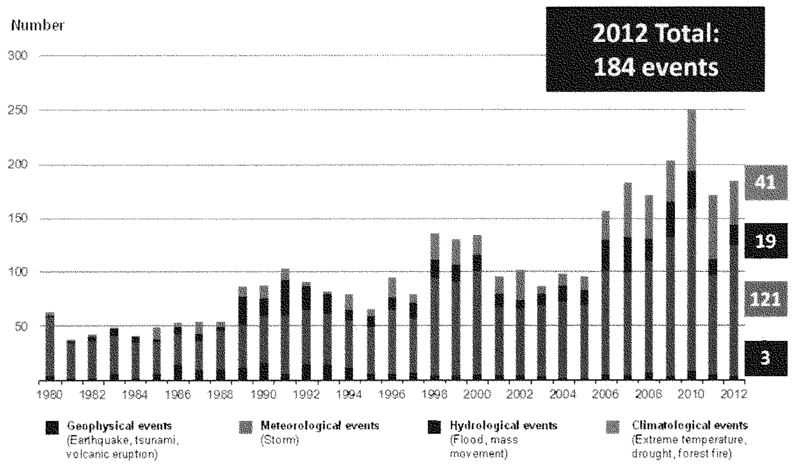
Insurers see climate primarily through the prism of extreme natural events. Research by Munich Re reflects a rising number of natural catastrophes globally and in the U.S.

Natural Catastrophes Worldwide 1980 – 2013

Number of Events (Annual Totals 1980 – 2012 vs. First Six Months 2013)



Natural Catastrophes in the USA
1980 – 2012
Number of events

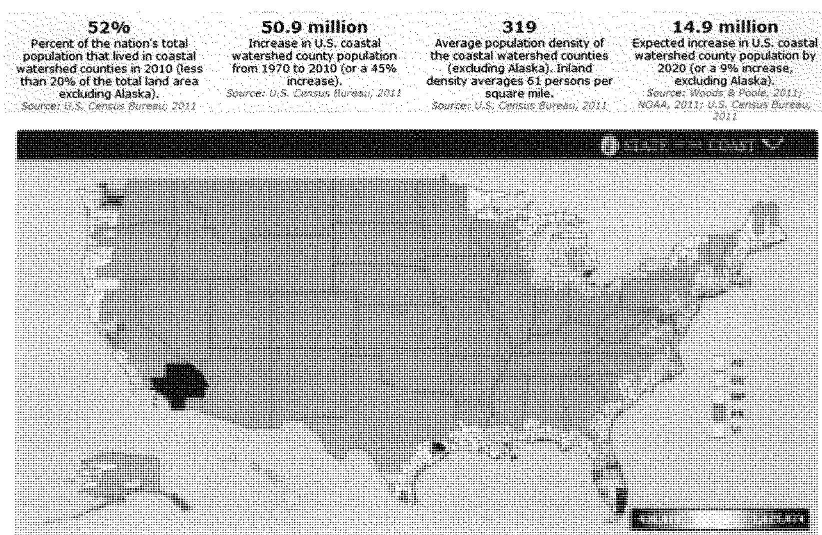


Source: Munich Re

In the 1980's, the average number of natural catastrophes globally was 400 events per year. In recent years, the average is 1000. Munich Re's analysis suggests the increase is driven almost entirely by weather-related events. North America has seen a fivefold increase in the number of such events since 1980. In comparison, Europe has seen a twofold increase.

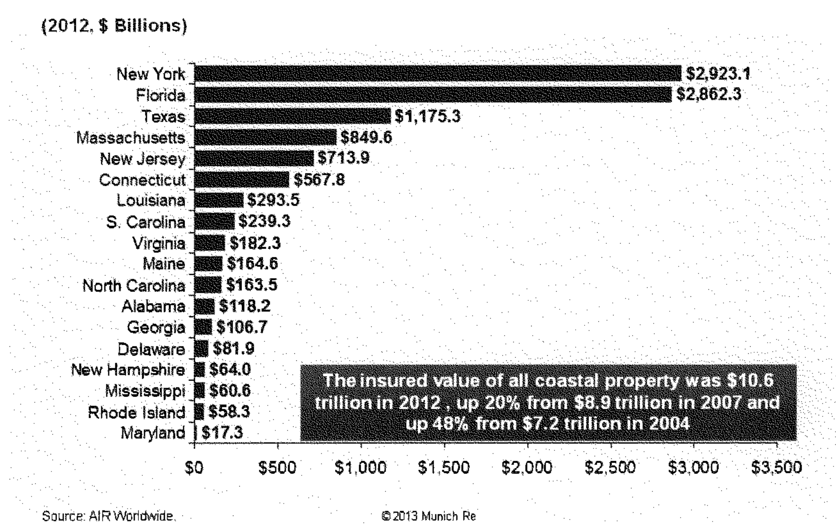
In this regard, it is indisputable that the recent rise in damages, insured, economic and uninsured, is heavily influenced by the concentration of people and property in geographically vulnerable areas. Urbanization, increased development and population shifts have placed more people with destructible assets in areas most impacted by extreme weather. NOAA's recent State of the Coast report observes that in a U.S. population of 313 million (based on the 2010 census), coastal shoreline counties comprise 39% or 123 million people; watershed counties comprise 52% of the U.S. population. In coastal shoreline counties, NOAA reports there are 49 million housing units with an expected increase in population of 10 million people before the next census in 2020. The NOAA report notes that an average of 1355 building permits are issued per day in these shoreline counties.

U.S. Population Living in Coastal Watershed Counties



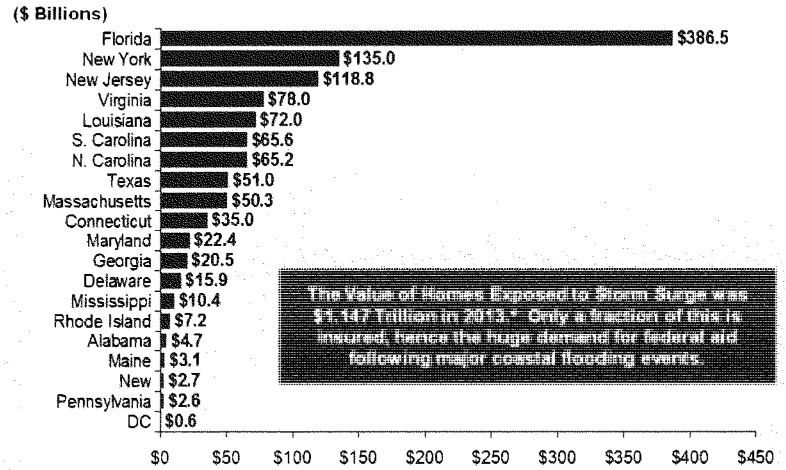
The Insurance Information Institute and Munich Re report that insured coastal property values on the East and Gulf coasts total nearly $10 trillion. Florida and New York each have nearly $3 trillion of insured coastal values.

Total Value of Insured Coastal Exposure in 2012



Research and consulting firm Core Logic reports there are 4.2 million homes along the Gulf and Atlantic coast exposed to storm surge–the most significant factor in damages associated with Superstorm Sandy. Most of these storm surge affected properties are in 10 metropolitan areas. One million of these are in the category of extreme risk to storm surge and another 839,000 in the high risk category. Core Logic notes that 23 of the 25 most populous U.S. counties are ocean-facing.

Total Potential Home Value Exposure to Storm Surge Risk in 2013*



*Insured and uninsured property. Based on estimated property values as of April 2013.
Source: *Storm Surge Report 2013*, CoreLogic. ©2013 Munich Re

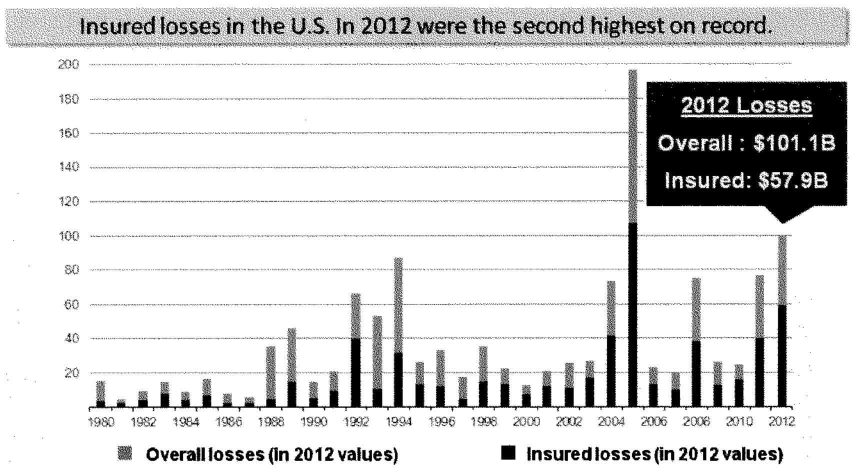
Catastrophe modeling firm AIR estimates the insured value of coastal properties (defined as replacement cost not market value) is expected to increase at a rate of 7% per year which means that values would double every decade.

Together with changes in weather patterns, intensity, and number of events, the result, of course, is an inevitable rise in insured and uninsured damages globally and in the U.S.

Natural Catastrophes in the USA

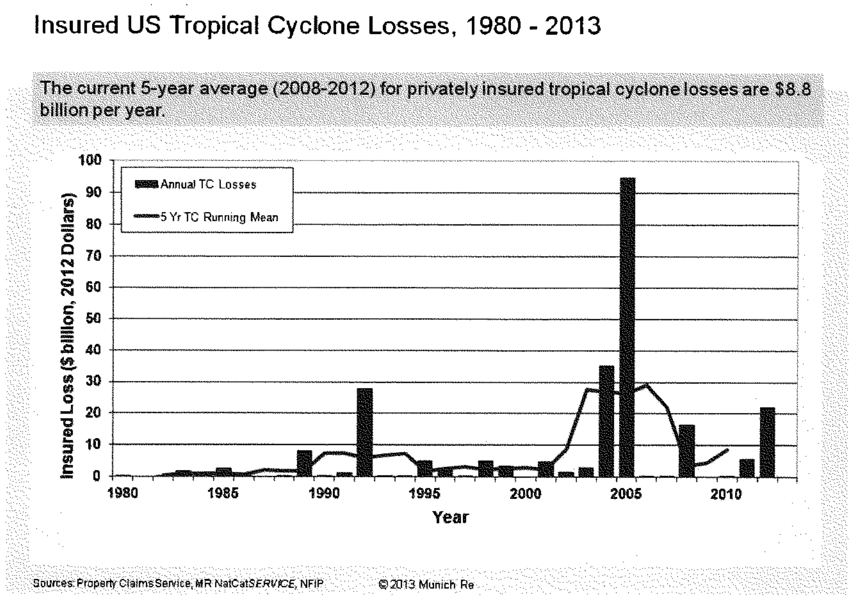
1980 – 2012

Overall and insured losses

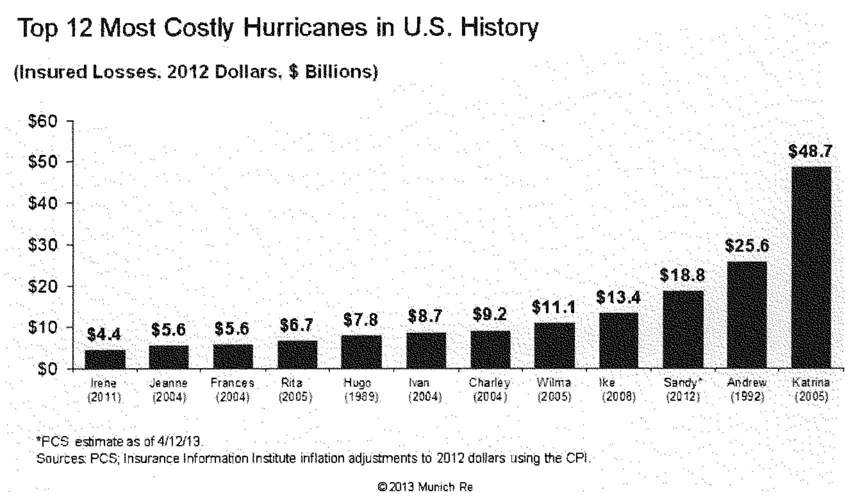


Source: Munich Re

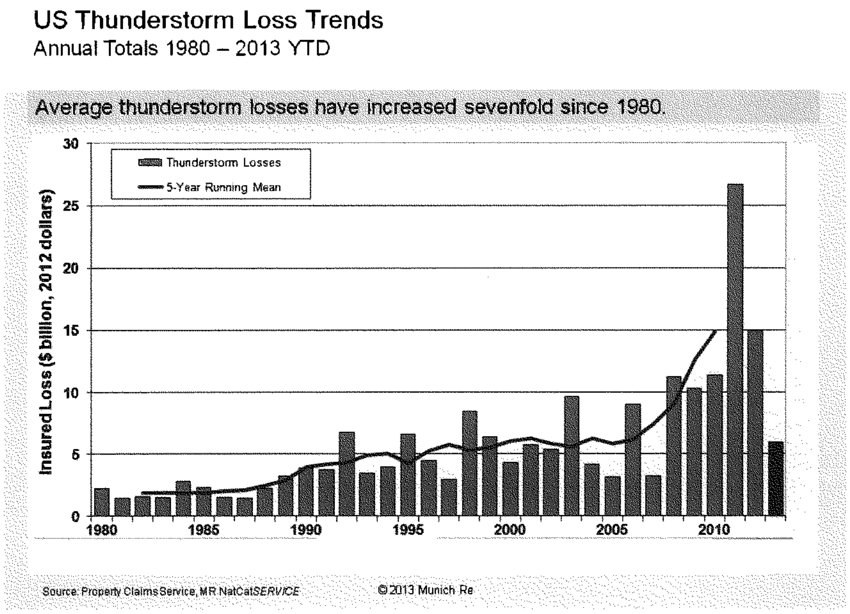
Hurricane related losses tend to dominate the pattern of large losses.



The pattern is recent. Ten of the 12 most costly hurricanes have occurred in the last nine years.

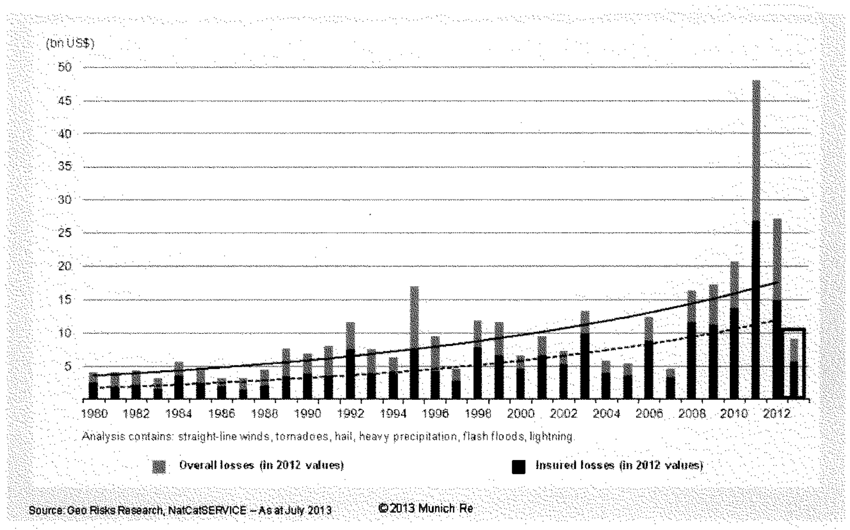


However, other climate/weather related perils also cause major damage.



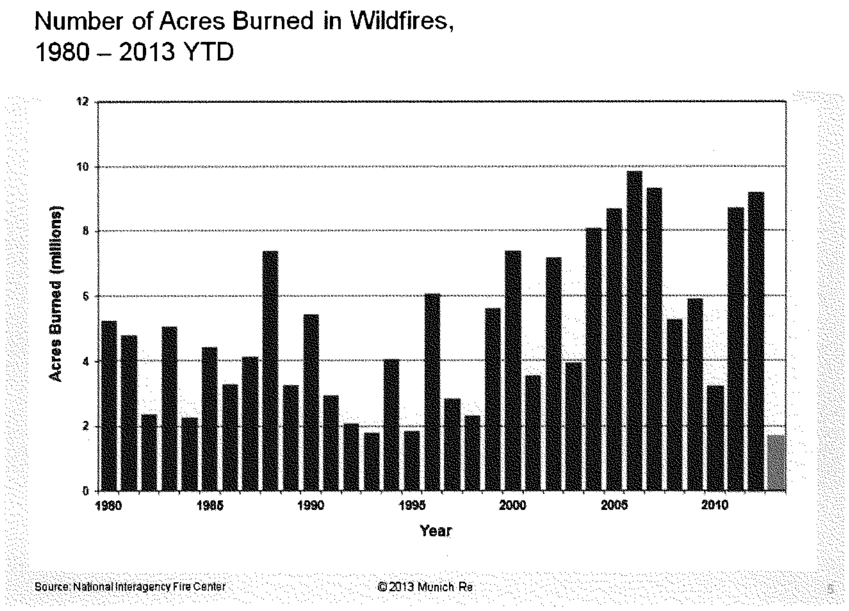
Tornado losses in the U.S. exceeded $1 billion only once prior to 1998. Since then, there have been 29 such events.

Convective loss events in the U.S.
Overall and insured losses 1980 – 2012 and the half year 2013



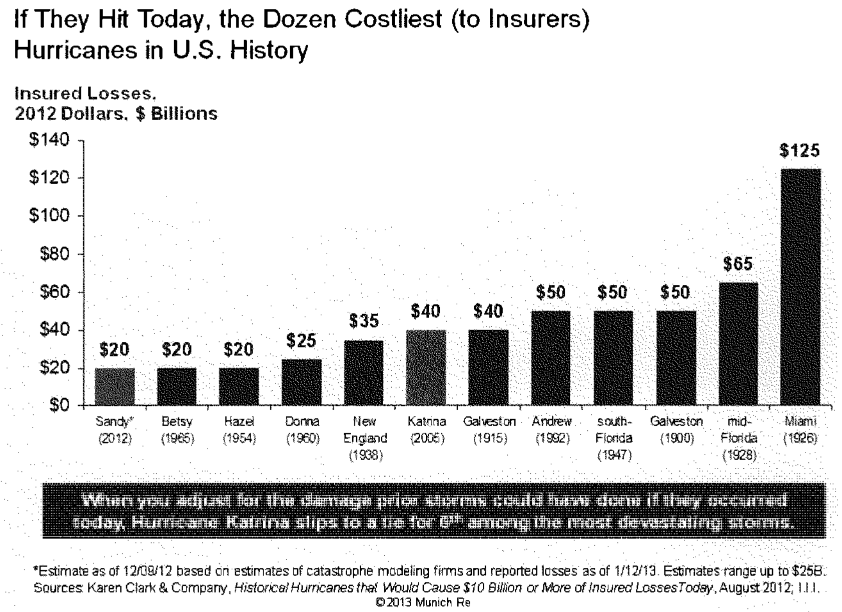
Severe wind is not the only peril reflecting this pattern. Goldman Sachs Global Economics reports the 2012 U.S. drought alone cut crop yields, reducing 3rd quarter 2012 GDP by .4%—the equivalent of another Supertsorm Sandy. Droughts are now the third most costly category of natural catastrophe loss with crop losses dominant.

Recent wildfire major events have destroyed homes and threatened communities.



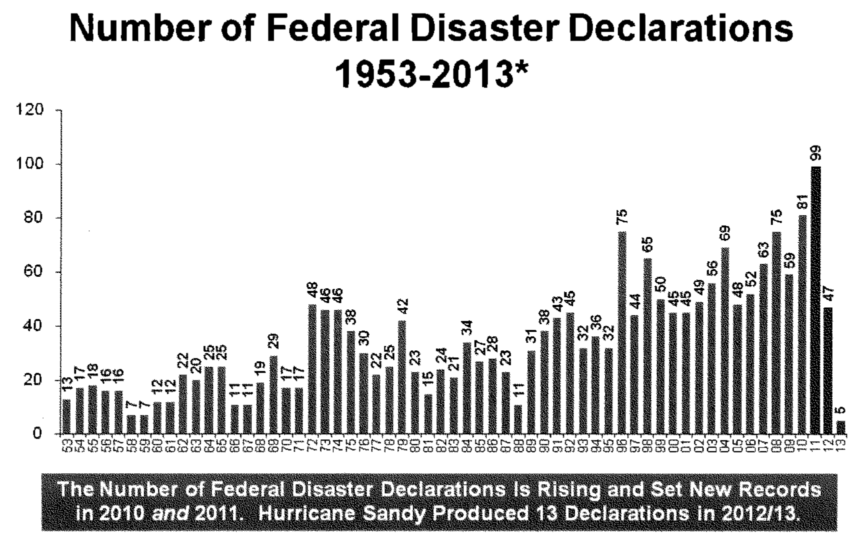
Future Assessment

But what if the past is not prologue and, in a changing climate, weather, economic and social trends exacerbate the impact. The Insurance Information Institute projected future losses from past events that reflect rising exposures in areas proven to be at high risk to major climate/weather events.



In a study on Climate Change Impacts conducted for FEMA by AECOM, the firm concluded that the typical 100 year floodplain nationally would grow by 45% and by 55% in coastal areas (with significant regional variations and assuming a fixed shoreline). Notably the report attributed 70 percent of the projected growth in 100 year floodplains to climate change and 30 percent to expected population growth (the analysis assumes 4 feet of sea level rise by the year 2100). The study recommends immediate attention to the implications for the Federal government's National Flood Insurance Program, which is already $26 billion in debt.

Disaster assistance is already a major expense to the Federal government and has set records in recent years.



*Through Feb. 24, 2013.
Source: Federal Emergency Management Administration; http://www.fema.gov/disasters; Insurance Information Institute.

Dr. David Cummins of Temple University's School of Risk Management estimates the subsidization of disaster-prone areas embedded in Federal disaster assistance practices has encouraged development and increased Federal exposure. He estimates the expected average annual bill for Federal disaster assistance related to natural catastrophes at $20 billion. Current funding for FEMA's Disaster Relief Fund is $1 billion. Dr. Cummins estimates this unfunded liability over the next 75 years at $1.2 to $5.7 trillion, at the high end, essentially the unfunded obligations for Social Security.

Adaptation and Mitigation Strategies

Swiss Re has been a leader in addressing climate change for many years.

"Today, global warming is a fact. Since the beginning of industrialization and the rapid growth of world population, man's activities – along with natural variability – have contributed to a change of climate manifesting itself as a considerable increase in global temperature. Climate change has the potential to develop into our planet's greatest environmental challenge of the 21st century.

As an enabler of change, the financial services industry can help guide society towards an effective response. However, the industry can only be effective in this role if the regulatory and legislative framework establishes the right incentives for emissions reduction and adaptation on a global scale."

Munich Re shares this view:

"Anthropogenic climate change is believed to contribute to this trend (a jump in catastrophe losses) though it influences various perils in different ways.

In order to realize a sustainable model of insurance, it is crucially important for us as risk managers to learn about this risk of change and find improved solutions for adaptation and mitigation." (Peter Roeder)

"Globally, climate change alone will increase worldwide losses by 100% by the end of the 21st century. The overall increase in losses in the United States due to climate change alone will be more than 70% by the end of the century according to a wind-based model."

The Geneva Association (International Association for the Study of Insurance Economics) states the need for action as follows:

"The economic and social impacts of climate change could be immense; there is therefore a need for urgent and concerted *mitigation* action to reduce GHG emissions, supported by strong incentives from policy-makers. But regardless of the action taken to mitigate climate change, we can expect many decades of changing climate risks due to inertia within the climate system. We therefore also need concerted *adaptation* to avoid the predicted impacts of climate change and especially to protect the most vulnerable populations."

Congressional Action

As Congress considers the impact of climate change, the RAA suggests the following legislative principles or actions to consider:

- Provide tax credits to individuals for specified mitigation and resiliency actions associated with extreme weather and climate change.
- Incent communities to develop and implement mitigation and resiliency initiatives.
- Reform the National Flood Insurance Program to reflect extreme weather and climate risk in its rates.
- Apply Federal standards to state/local building codes and incorporate climate and extreme weather risk into these standards.
- Purchase or relocate properties near coastal or river areas at repeat risk.
- Use nature to mitigate risk before and after extreme events.
- Transfer development rights from coastal and river properties to areas inland (Strengthen the Coastal Barrier Resources Act)
- Fund adequate remote sensing for NOAA and NASA.
- Require the Army Corps of Engineers to assess climate risk for all projects.
- The Federal government should lead by example: GSA should assess its buildings and critical facilities in light of climate and extreme weather information.

- Fund climate and weather research through the National Science Foundation, NOAA and other Federal agencies at priority levels.
- Use disaster assistance as an incentive for local communities for climate and extreme weather sensitive, forward looking recovery.

Conclusion

The Reinsurance Association and its member companies welcome the attention of Congress to the critical issues of extreme weather and climate. We are committed to work with you to address the exposure of citizens and their property to extreme weather risk and to seek ways to improve the resilience of our communities.

Resources

- Core Logic: Storm Surge Report: Residential Storm Surge Exposure Estimate for the US Coastal Areas (2012)
- Federal Financial Exposure to Natural Catastrophe Risk, David Cummins, Michael Suher and George Zanjani (2010)
- Goldman Sachs, Global Economics, Commodities and Strategy Research
- ClimateWise, Summary of the IPCC Special Report on Managing the Risks of Extreme Events and Disasters
- Applied Insurance Research Coastline at Risk: Update to the Estimated Insured Value of US Coastal Property (2013)
- NOAA State of the Coast National Coastal Population Report (March 2013)
- Geneva Association (International Association for the Study of Insurance Economics): The Insurance Industry and Climate Change (July 2009)
- Munich Reinsurance, Climate Variability and Climate Change
- AECOM: The Impact of Climate Change and Population Growth on the national Flood Insurance Program through 2100 (June 2013)

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August 29, 2013

Environment and Public Works Committee Hearing
July 18, 2013
Follow-Up Questions for Written Submission

Questions for Frank Nutter

Question from:

Senator Barbara Boxer

1. Mr. Nutter, the federal government often provides emergency relief to help businesses, homeownerns, and communities rebuild following disasters. Based upon the data and trends the reinsurance industry is witnessing now, can you please describe the expected risk exposure to the federal government from future extreme events and how such exposure could impact the federal deficit?

Answer:

The best analysis of the Federal government's exposure is contained in a study by Dr. David Cummins of Temple University. The study concludes that over the next 75 years the costs to the Federal government for disaster assistance range from $1.5 trillion to $5.7 trillion (essentially the same as the unfunded costs of Social Security). The full study is attached and an update can be found at:
http://rmi.gsu.edu/faculty/PAPERS_W/Zanjani/Update_Cummins-Suher-Zanjani_2010.pdf

Senator Tom Udall

Cost of Climate-Related Disasters

Institutions worldwide today are by necessity planning beyond straightforward technology solutions to clean energy and greenhouse gases emissions that we have known about for decades. Policy guidance and new economic instruments for all parts of society now focus on new or retrofitted infrastructure, insurance, migration and conflict. They focus on adaptation because we bypassed opportunities for solving our climate crisis decades ago when it was much cheaper and much easier to solve. Nonetheless, the evidence indicates it remains far cheaper to mitigate our climate change problem today than to face the enormous, ever-increasing cost of adapting in both our immediate and long-term future.

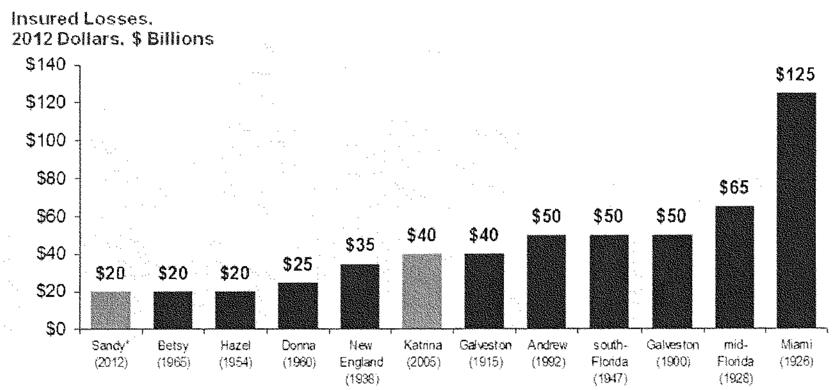
Economists have determinded in many studies over many years that the costs of adaption to climate change will be many times greater than the costs of mitigating climate change before it becomes hugely uncontrollable.

3. What are the findings of economists and the insurance industry with regard to the costs of climate-enhanced disasters?
4. What are the projections for the near-term future (out of 2050) for the increased costs of climate-related disasters?
5. Will today's disasters become tomorrow's normal occurrences, and will we be able as a society to pay for this eventuality?

Answer:

I have attached four charts showing natural catastrophe related losses (insured and economic), the number of such events and the losses for past storms if they were to occur today with adjustments for population and economic growth. With respect to the "new normal", the increase in population and building stock in high risk areas together with scientific analysis documenting sea level rise, floodplain expansion and likely storm surge increase today's events are a precursor to increased loss and damage. Today's losses are not the new normal but likely a baseline for increased climate/weather related losses.

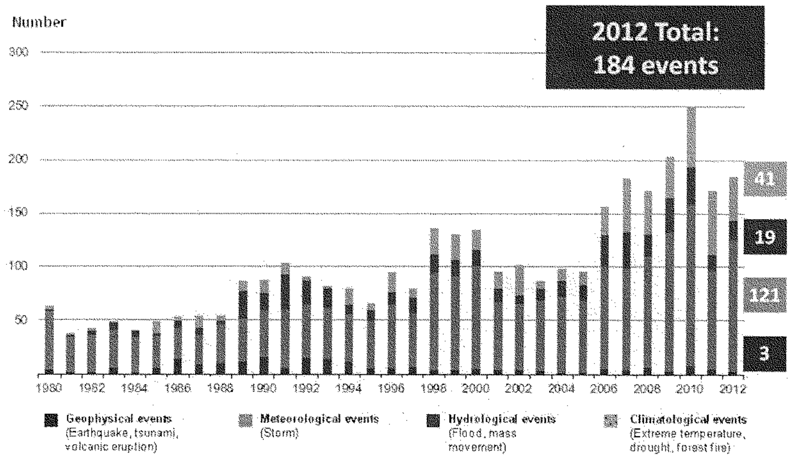
If They Hit Today, the Dozen Costliest (to Insurers) Hurricanes in U.S. History



When you adjust for the damage prior storms could have done if they occurred today, Hurricane Katrina slips to a tie for 6th among the most devastating storms.

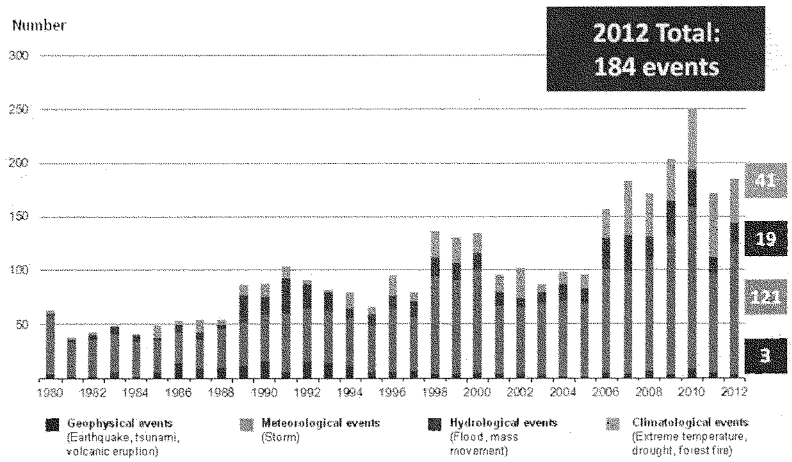
*Estimate as of 12/09/12 based on estimates of catastrophe modeling firms and reported losses as of 1/12/13. Estimates range up to $25B.
Sources: Karen Clark & Company, *Historical Hurricanes that Would Cause $10 Billion or More of Insured LossesToday*, August 2012; I.I.I.

Natural Catastrophes in the USA
1980 – 2012
Number of events



Source: Munich Re

Natural Catastrophes in the USA
1980 – 2012
Number of events



Source: Munich Re

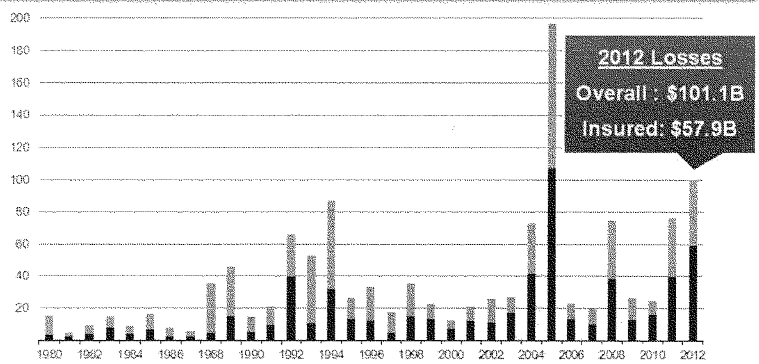
US Natural Catastrophe Update

Natural Catastrophes in the USA

1980 – 2012

Overall and insured losses

Insured losses in the U.S. In 2012 were the second highest on record.



Source: Munich Re

Senator David Vitter

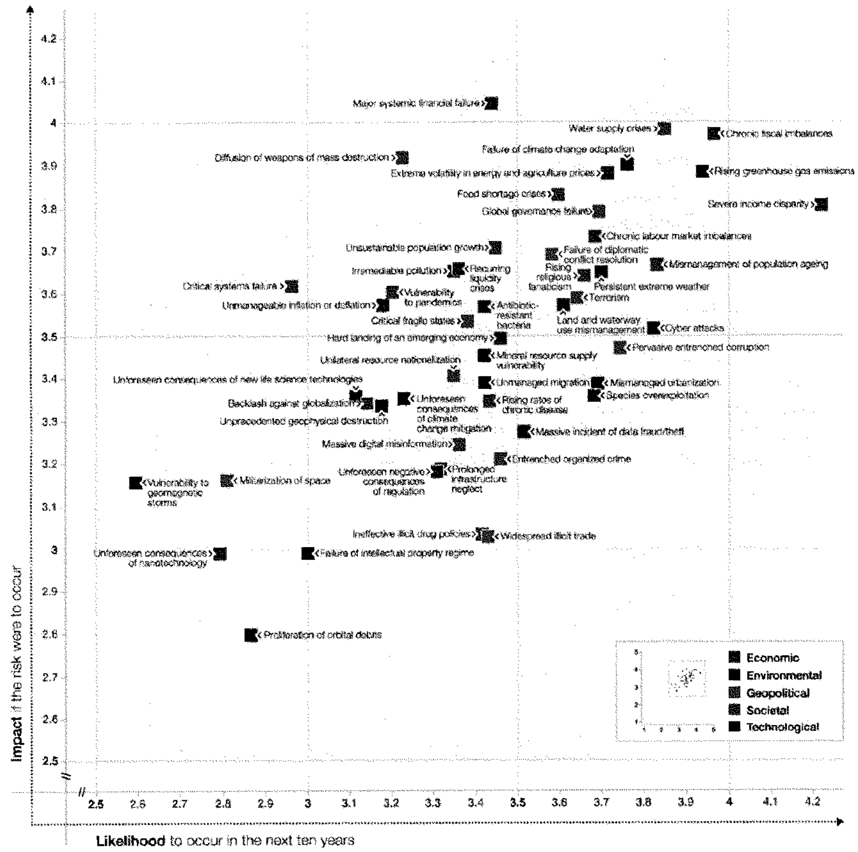
1. Mr. Nutter, as you may be aware, Lloyd's of London recently completed a survey of almost 600 corporate executive about the risks faced by their businesses. Climate change was ranked #32, behind "piracy" but ahead of "space weather". High taxation was ranked #1. Regulation was ranked #5.

   a. Do you think businessmen understand the risks they face better than their insurers?

   b. Why do you think they placed taxation, the sort of taxation that Chairman Boxer and Senator Feinstein propose as the #1 risk they face?

Answer:

Business leaders tend to focus on immediate risks/problems and rank longer term risk lower because they require longer term solutions applied over longer periods. Given that no one business can address the full scope of climate change, it is understandable that business leaders would move to address immediate risk that they face and which they can address within their own resources. I have attached a survey of business leaders conducted each year at the World Economic Forum that reflects the threat of climate change and the failure to adapt to climate change as particularly high in likelihood and impact.



Source: World Economic Forum

4 Federal Financial Exposure to Natural Catastrophe Risk

J. David Cummins, Michael Suher, and George Zanjani

4.1 Introduction

In the aftermath of the terrorist attacks of September 11, 2001, Congress passed supplemental appropriations of over $26 billion for redevelopment, clean up, and aid to attack victims and their families. By the standards of the time, the nature and extent of the expenditures were unprecedented. However, the new standard would be broken only a few years later, when Congress appropriated emergency funds for over $80 billion in disaster assistance in the aftermath of Hurricane Katrina and three other hurricanes, which all occurred in one four-month period.

Viewed in the context of federal disaster policy over the last century, the responses to September 11 and Hurricane Katrina fit well with a long-term trend of a continuously increasing federal role in disaster assistance (e.g., Moss 1999, 2002). Over twenty years ago, Kunreuther and Miller (1985) observed:

> The role of the federal government with respect to hazards has been changing . . . there has also been a realization that government has been

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The views expressed in this chapter are those of the authors and do not necessarily represent the positions of Temple University, the Federal Reserve Bank of New York, the Federal Reserve System, Brown University, or Georgia State University. We would like to thank Karen Clark, Gary Kerney, Robert Klein, Deborah Lucas, Greg Niehaus, two anonymous reviewers, and participants at the NBER/Kellogg conference on Measuring and Managing Federal Financial Risk and the American Risk and Insurance Association (ARIA) 2007 annual meeting for their insightful comments.

viewed as the protector of risks in ways that would have been unthinkable 50 years ago. Even 30 years ago there was a reluctance by local communities to rely on federal relief for recovery purposes.

Reactions to more recent disasters have revealed a telling shift in political sentiments at the state and local level. The response of Missouri Governor Mel Carnahan to calls for fiscal restraint in the aftermath of the Mississippi River flooding in 1993[1] ("This is not the time for debating the fine points of long-term policy!") seems more representative of local opinion today. Moreover, development has been steadily increasing in catastrophe-prone areas, so the property at risk is far greater now than at any time in the past.[2] Indeed, the subsidization of high-risk areas embedded in federal disaster policy has almost certainly encouraged development in those areas, thereby increasing federal exposure.[3]

The combination of rising standards for federal assistance and the growing private exposure suggests that the "stealth entitlement" of federal disaster assistance has grown large enough to merit a deeper assessment. Following Governor Carnahan's exhortation, we make no attempt in this chapter to dissect the "finer points" of public disaster policy. Instead, we set ourselves the more concrete objective of assessing the federal exposure. In other words, if we take as given the current generosity of federal disaster policy and the current state of development in catastrophe-prone areas, what is the taxpayer's expected annual bill for disaster-related expenditures? And what could the bill be in a bad year?

The numbers we estimate in answering the foregoing questions are significant. Based on the historical relationship between catastrophe damages and federal expenditures, together with prospective assessments of future catastrophe damages from (a) a leading catastrophe modeling firm, Applied Insurance Research (AIR), and (b) the projection of historical catastrophe loss data from Property Claims Services (PCS), we estimate the average expected bill for disaster assistance related to hurricanes, earthquakes, thunderstorms, and winter storms to be about $20 billion a year. In a bad year, corresponding to a catastrophic event of severity expected only once every century, the bill could exceed $100 billion. Conservative methods guide both estimates, so more liberal assumptions (e.g., extrapolating recent growth in federal generosity to the future instead of assuming no change) would yield considerably higher estimates.

To get a sense of the significance of these figures in relation to other, more familiar obligations of the Federal Government, we take the expected

1. Cited by Moss (1999, 259).

2. For example, the amount of property exposed to hurricane losses in Florida grew by 27 percent to $2.5 trillion between 2004 and 2007. See Hartwig (2008).

3. This is an important moral hazard issue that is beyond the scope of the present chapter. It would be useful to explore the link between federal disaster policy and development in future research.

annual expense over the next seventy-five years and compute a net present value (NPV) of this "unfunded liability." Doing so yields a figure between \$1.2 and \$7.1 trillion, depending on assumptions of growth and discount rates. For comparison, the trustees of Social Security project a shortfall with an NPV of \$4.9 trillion over this same horizon.

Even the conservative estimate of \$20 billion a year is far higher than the Federal Emergency Management Agency (FEMA) regular budget for disaster relief. Regular appropriations for the Disaster Relief Fund (DRF; the main vehicle for federal relief) averaged about \$1 billion over the fiscal years from 2001 to 2005, while supplemental appropriations to the Disaster Relief Fund averaged \$16.5 billion over the same period (GAO 2007). Our estimate of future relief spending is accurate enough to allow budgeting for disasters in the regular appropriation process.

The rest of this chapter is organized as follows. Section 4.2 offers background, including details on federal disaster policy. Section 4.3 discusses the methodology used for (a) assessing the relationship between federal disaster relief and catastrophe damages and (b) estimating the prospective distribution of aggregate catastrophe losses for the United States. Section 4.4 discusses the results, including the effects of modifying assumptions. Finally, section 4.5 concludes with a discussion of the policy implications of our findings.

4.2 Background

The Federal Government's financial exposure to catastrophic risk stems mainly from ad hoc disaster relief distributed to individuals, business, and communities; direct exposure of government facilities and service provision operations to disasters; and government insurance programs such as the National Flood Insurance Program (NFIP) and the Terrorism Risk Insurance Program (TRIP). We discuss each of these sources next.

4.2.1 Disaster Relief

Historically, disaster relief expenditures have been the most significant component of federal catastrophe exposure. One consequence of the seemingly ad hoc nature of the relief is that only a small portion of anticipated relief expenditures is contained in the budget. However, although the full extent of the federal obligation to assist may not be explicitly enumerated by legislation, history suggests that federal action is inevitable after major disasters; indeed, assistance seems discretionary in name only. In the words of Moss (1999, 334):

> Disaster spending has become a political sacred cow. . . . Again and again in the aftermath of disasters, representatives from the affected states have insisted that their constituents deserve no less than what other victims

received and that the particular nature of their disaster might justify even more. Federal catastrophe coverage has thus been subject to a ratcheting-up process.

The Stafford Emergency Assistance and Disaster Relief Act of 1988 and its antecedents, beginning with the Disaster Relief Act of 1950, guide the process for federal relief in the aftermath of catastrophes. The act formally requires the Federal Government to offer aid when state and local resources are overwhelmed by a major catastrophe. The Stafford Act designates FEMA to give declaration recommendations to the president after a disaster, and the Homeland Security Presidential Directive (HSPD)-5 makes the secretary of homeland security "responsible for coordinating Federal resources within the United States to prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies" (DHS 2006b).

If the president makes a declaration, then FEMA is charged with overseeing the response, both directly and by administering funds to other federal agencies. The money comes from the DRF, a "no-year" account (i.e., any dollars appropriated remain available until expended) that receives annual appropriations though is largely reliant on supplemental appropriations from Congress in the event of major catastrophes.

The other sources of significant federal spending on disasters are the Small Business Administration (SBA), which makes subsidized disaster loans to households and businesses, and the US Department of Agriculture (USDA), which dispenses disaster loss funds to farmers. Most funding for the SBA is provided through its annual appropriations from Congress. The president may make a major disaster declaration or an emergency declaration. The latter is less significant and aims for federal costs not to exceed $5 million. If the president makes a more substantial major disaster declaration, some types of available federal aid actually have Stafford Act mandated *floors* on the federal share of expenditures. These mandated floors include 75 percent of eligible costs for "essential assistance" and "debris removal" and 100 percent of "housing assistance" (Bea 2006).

4.2.2 Exposures to Federal Facilities and Operations

Federal Government property, such as military bases or Veterans Affairs (VA) hospitals, can be susceptible to direct physical damage from catastrophes. The Federal Government is also bound to provide certain everyday public services, including providing Social Security and Medicare benefits and running federal law and order institutions. The prompt resumption of these services postdisaster can entail significantly higher-than-normal operational costs (DHS 2006a).

4.2.3 Insurance Programs

The US Federal Government plays significant roles in disaster insurance markets. In particular, it essentially acts as the major underwriter of residential flood insurance (through the NFIP, administered by FEMA); it also effectively acts as the country's largest reinsurer of terrorism risk through the TRIP.

The maximum government exposure under the TRIP is laid out by statute. For 2009 to 2014, the Federal Government is technically liable for up to $61.625 billion of terrorism losses, of which some fraction may be recouped from the industry.[4] To date, no losses have been paid under the TRIP. Of course, it is likely that the government's exposure to terrorism losses is significantly larger than the limits laid out in the TRIP. The government paid out approximately $16 billion through the September 11 Victims' Compensation Fund of 2001,[5] and pressures for ad hoc payments are likely to develop if a terrorist event larger than the $100 billion maximum under the TRIP were to occur.

The NFIP boasts about $1.1 trillion in exposures nationally.[6] Although it is described as a "self-financing" program, the NFIP has borrowing rights at the Treasury when losses exceed its resources. This borrowing authority was increased dramatically to $20.8 billion to cover claims following Hurricane Katrina. In reality, the NFIP is not self-supporting and has been criticized for leaving a high proportion of flood-exposed properties uninsured and not operating on sound actuarial principles (Cummins 2006; Jenkins 2006). Hence, in its present form, the NFIP creates more financial exposure for the Federal Treasury than was envisioned when the program was established.

Other federal insurance programs are also exposed to catastrophe losses. Notably, the US Department of Agriculture insured $50 billion of crop value in 2006 through the Federal Crop Insurance Corporation (Federal Crop Insurance Corporation 2007).

4.2.4 Additional Sources of Exposure

The aftermath of a major catastrophe will entail significant economic disruption for the affected region and potentially for entire national industries. Lost jobs, reduced wages, and lower output will all result in a lower tax base. This means less federal revenue at a time of increased federal spending. Government postdisaster aid will contribute to rebuilding the tax base and thus over the long run will lessen the size of indirect exposure created by lost tax revenues.

Next, we describe our collection and analysis of data on federal disaster expenditures and catastrophe losses.

4. The figure of $61.625 billion is obtained by multiplying the federal coinsurance share for 2007 to 2014 (85 percent) by $72.5 billion (calculated as the maximum insured loss amount of $100 billion less the aggregate industry retention of $27.5 billion). See Dunham and Dembeck (2008).

5. Victims' compensation is not explicitly part of the TRIP, which primarily provides reinsurance for property-casualty insurance coverages. Data on September 11 victims' compensation are from the following website: http://www.usdoj.gov/archive/victimcompensation/payments_deceased.html.

6. See: http://www.fema.gov/business/nfip/statistics/cy2007cov.shtm.

4.3 Data and Methodology

As noted previously, ad hoc disaster assistance has historically been the most important source of direct federal financial exposure to catastrophes. Hence, the remainder of the chapter focuses on that component of exposure. We use data on disaster damages and disaster assistance to project the distribution of expected federal disaster relief expenditures.

There are three basic steps to this analysis. The first step is to document the relationship between catastrophe damages and federal relief expenditures over the period from 1989 to 2008 to estimate the amount of federal relief expenditures likely to be "produced" by catastrophe losses. The second step is to develop a prospective annual catastrophe loss distribution for the United States. The third and final step, performed in the results section, is to apply the estimated ratio of federal relief expenditures to catastrophe damages (obtained in the first step) to the estimated catastrophe damage distribution (obtained in the second step) to produce an estimated annual federal disaster expenditure distribution for the United States. In this step, we also calculate the net present value of the implicit government liability arising from catastrophe losses.

4.3.1 Data on the Relationship between Catastrophe Loss and Federal Disaster Relief

We combine loss estimates for recent catastrophes with figures for emergency supplemental appropriations to assess the generosity of postdisaster federal aid.

We restrict our attention to catastrophes with at least $1 billion in total damages (in nominal terms) between 1989 and 2008. The main source for total damage estimates is data from the National Oceanic and Atmospheric Administration's (NOAA) National Climactic Data Center (NCDC) and Munich Re (2008, 2009). For each catastrophe, we also identify insured losses using the Insurance Services Office's (ISO) Property Claims Services estimates of privately insured losses and the National Flood Insurance Program payouts for flood losses under the NFIP. Our selection criterion yields sixty-five events, with the majority being hurricanes and tropical storms. Also included are the Loma Prieta, Northridge, and Nisqually earthquakes;[7] the Oklahoma City and September 11 terrorist attacks;[8] and various significant floods, storms, and wildfires.[9] As the NOAA relates, unlike with private

7. Total losses for the Loma Prieta and Northridge earthquakes, described as overall losses in the entire affected region, come from Munich Re (2005). Total losses for the Nisqually earthquake come from Meszaros and Fiegener (2002).

8. Oklahoma City bombing total damage figure comes from "Governor, Finance Director Release Bomb Damage Estimates," press release from the Office of Governor Frank Keating. Available at: http://www.state.ok.us/osfdocs/nr5-18.html. September 11 total damage figure comes from Bram, Orr, and Rapaport (2002).

9. The NOAA damage estimates are used for all events except the three earthquakes, the Oklahoma City bombing, and the September 11 terrorist attacks.

and NFIP insured losses, where every dollar paid out in claims is recorded, there is no federal agency tasked with keeping track of total losses resulting from catastrophes in the United States.

The NOAA bases its estimates on compilations of statistics from Storm Data (NCDC publication), the National Weather Service, the Federal Emergency Management Agency, other U.S. government agencies, individual state emergency management agencies, state and regional climate centers, and insurance industry estimates.[10] The figures from the NOAA and the others we use for total damages always encompass insured and uninsured property damages. For longer duration events, like the 1993 Mississippi Flood, droughts, and the earthquakes in our sample, our total loss figures include additional economic costs, such as reduced agricultural output. In the case of September 11, our total loss figure explicitly includes economic costs associated with labor losses. The catastrophes, with the associated estimates of total and insured losses, are summarized in figures 4.1 and 4.2, where figure 4.1 presents nominal losses and figure 4.2 presents exposure and price-adjusted losses.

The gap between insured and total losses is, of course, significant. In the case of earthquakes, this can be attributed partly to low rates of earthquake insurance purchase; similarly, in the case of hurricanes and tropical storms, significant amounts of damage can result from flood—and many households are either uninsured or only partially insured against flood. Deductibles, coinsurance, and uninsured damages (e.g., certain "economic costs" just described) further contribute to insured losses being substantially below our estimate of total losses. For the entire sample of sixty-five events, the ratio of insured to total loss averages less than 50 percent.

For federal expenditures, we only use figures for emergency supplemental appropriations for disaster assistance. This is legislation outside of the regular annual budgeting process. By our estimates, it accounts for about 80 percent of all federal disaster spending over the period, as we discuss next. The money can go to any agency involved in relief, but the majority is provided through FEMA's Disaster Relief Fund. The appropriations include funds for disaster relief, repair of federal facilities, and hazard mitigation activities directed towards reducing the effects of future disasters. Not included are funds for "counterterrorism, law enforcement, and national security" (Murray 2006, p. 2).

It should be noted that the narrow focus on supplemental appropriations ignores some elements of federal financial exposure to disasters. We do not include the budgeted portion of federal disaster spending, which covers annual appropriations to FEMA's Disaster Relief Fund, much of the

10. The National Oceanic and Atmospheric Administration describes their estimates of total costs as "the costs in terms of dollars and lives that would not have been incurred had the event not taken place. Insured and uninsured losses are included in damage estimates. . . . Economic costs are included for wide-scale, long-lasting events such as drought" (Lott and Ross 2006, p. 1).

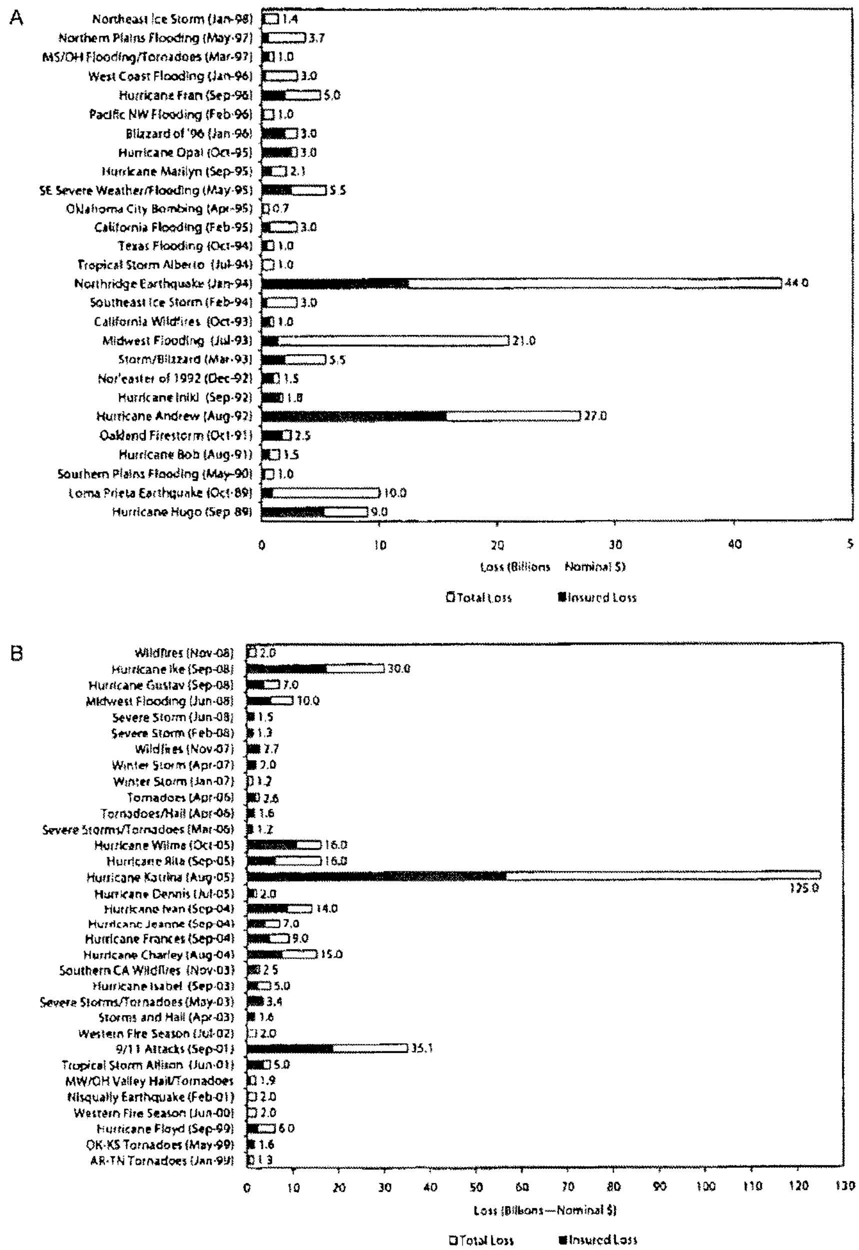

Fig. 4.1 Sample of major disasters, nominal losses: *A*, 1989–1998; *B*, 1999–2008

A

B

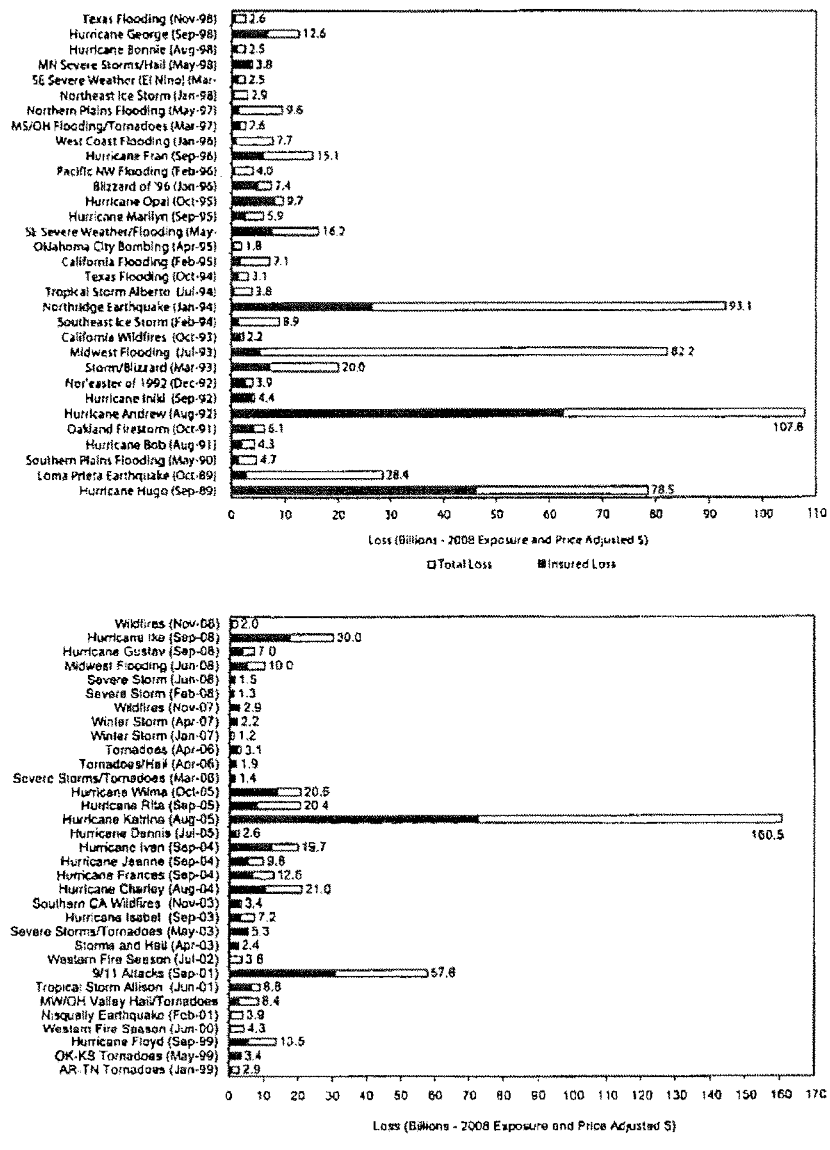

Fig. 4.2 Sample of major disasters, exposure and price adjusted losses: *A*, 1989–1998; *B*, 1999–2008

Note: Insured and total loss figures are adjusted at the state level by our 2008 exposure index. This index captures both price-level changes and changes in the size of the housing stock. The intent is to estimate the losses a past disaster would cause if it occurred today.

Small Business Administration's subsidized disaster loans program, and reconstruction projects that take place long after the fact. Also not included are farm and economic supplemental appropriations through the USDA for specifically agricultural disasters, like droughts. Total USDA spending on farm disaster aid totaled $54.4 billion over this time horizon.[11] We also treat NFIP losses as insurance payments and thus exclude them from the expenditure data. Of course, a case could be made for including them: while the program was close to being self-financing through 2004 (at which point the NFIP had aggregated only a $200 million deficit), the picture looked far different after record flood losses of the 2005 hurricane season, when the cumulative deficit of losses over premiums was $4.9 billion. Although the deficit was reduced to $556 million by 2007, the program is unlikely to be self-supporting in the long run and is badly in need of reform.[12]

Other special items are also excluded: for example, in the case of the 2001 terrorist attacks, we have not included the billions in indemnification distributed through the Victims' Compensation Fund. In summary, our figures for total federal disaster expenditures capture a significant portion, but not all, of the nonbudgeted federal exposure to disaster risk; furthermore, we do not attempt to capture exposures that are already reflected in the budget.

We draw on the Congressional Research Service analysis of appropriations, the text of the aid legislation, and the date of catastrophe occurrence to assign aid to catastrophes.[13] The appropriation legislation for disasters is usually part of larger bills, and often money is earmarked for multiple recent disasters. This fact, combined with the large number of hurricanes in the sample, make drawing inferences by catastrophe type difficult. Instead, we focus on all the events together.

Figure 4.3 shows the ratio of federal expenditures to total losses. The ratio of aid to total losses has a mean of 33 percent and a median of 30 percent, and the ratio of aid to uninsured losses has a mean of 101 percent and a median of 64 percent. In aggregate, the sixty-five events, in values adjusted to 2008 exposure and price levels, comprise about $1.1 trillion in total losses, $450 billion in insured losses, and $375 billion in emergency spending. These aggregated figures are summarized in table 4.1 (panel B).

While there is significant volatility in the aid ratios across the sample,

11. Chite (2006). See also Murray and Lindsay (2008).

12. Data are from the FEMA website (http://www.fema.gov/business/nfip/statistics/statscal.shtm) and represent cumulative premiums minus cumulative losses from 1978 to 2007. Statements about FEMA being self-supporting are usually based on a comparison of premiums and loss payments. However, this comparison is misleading, because it ignores program expenses. Hence, even during periods when premiums exceed loss payments, it is not necessarily the case that the program is truly self-supporting.

13. Appropriation legislation is sometimes explicit in assigning particular dollars to a particular catastrophe or set of catastrophes, in which case the allocation is straightforward. In other cases, legislation appropriates funds for unspecified catastrophes in the future, in which case the date of occurrence is relevant for assignment.

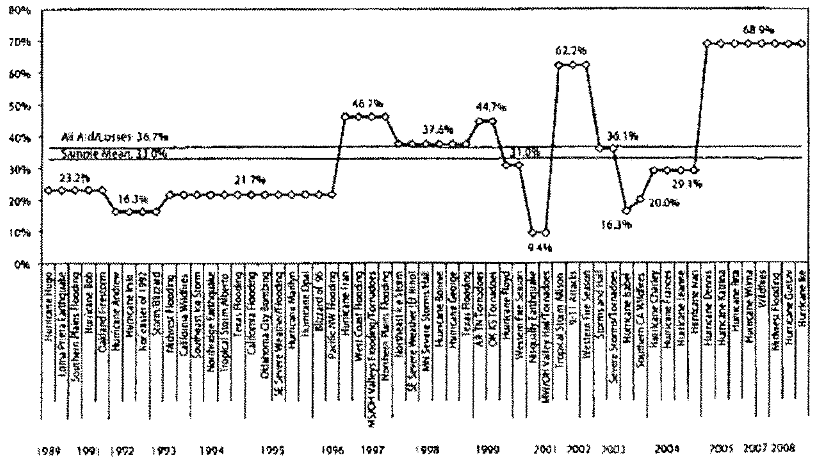

Fig. 4.3 Federal aid ratios: 1989 to 2008

Note: Each data point represents a specific disaster in our sample, with labels for the most significant disasters. The "all aid/losses" ratio is computed after adjusting loss and aid figures by our 2008 exposure index. This index captures both price-level changes and changes in the size of the housing stock. This yields a ratio that is not overweighted by recent disasters.

there is some evidence of an increase in generosity over time: emergency federal aid/total losses for 9/11 and surrounding natural disasters was 62 percent, even though federal aid did not breach 50 percent of total loss for any of the previous events in the sample. Beginning in the 2005 hurricane season and continuing through 2008, federal aid averaged 69 percent of total losses.[14]

To obtain a more comprehensive picture of Federal Government spending on disaster aid, we tabulate annual total federal disaster spending and compare it to annual catastrophe losses for fiscal years from 1989 to 2008. The data are presented in table 4.1 and figure 4.4. In addition to the emergency supplemental appropriations previously discussed, we include regular annual appropriations to FEMA's Disaster Relief Fund, USDA emergency funding for agriculture disasters,[15] and the subsidization cost of SBA disaster loans.[16] Annual catastrophe losses are comprised of NOAA's billion-dollar weather events; the Loma Prieta, Northridge, and Nisqually earthquakes; and the Oklahoma City and September 11 terrorist attacks. Over this span, in values adjusted to 2008 exposure and price levels, we observe $512 billion

14. It is difficult to distinguish the level of funding for the specific events during this period, because the Congressional acts authorizing the payments tended to lump together funding for several events rather than distinguishing specific funding per event.

15. Funding for "market loss payments to compensate for low farm commodity prices" is excluded.

16. Emergency supplemental figures are adjusted to avoid double counting for some SBA disaster loan subsidies and DRF original appropriations.

Table 4.1 Summary of catastrophe loss and federal aid: 1989 to 2008

Panel A–Values in billions: Nominal $

Aggregate			Mean	Median
Emergency supplemental appropriations by event				
Number of events	65	Aid to total loss	33.0%	30.1%
Total loss	510.0	Insured loss to total	45.7%	44.6%
Insured loss (including NFIP)	235.9	Aid to uninsured loss	101.4%	63.8%
NFIP	27.2			
Federal aid	240.6			
Aid to total loss	47.2%			
Insured loss to total	46.3%			
Aid to uninsured loss	87.8%			
Total federal disaster spending by year				
Number of years	20	Aid to total loss	62.0%	55.7%
Total loss	542.1			
NFIP	32.9			
Federal aid	285.7			
Aid to total loss	52.7%			

Panel B–Values in billions: 2008 exposure and price adjusted $

Aggregate			Mean	Median
Emergency supplemental appropriations by event				
Number of events	65	Aid to total loss	33.0%	30.1%
Total loss	1,021.9	Insured loss to total	45.7%	44.6%
Insured loss (including NFIP)	449.9	Aid to uninsured loss	101.4%	63.8%
NFIP	44.2			
Federal aid	374.7			
Aid to total loss	36.7%			
Insured loss to total	44.0%			
Aid to uninsured loss	65.5%			
Total federal disaster spending by year				
Number of years	20	Aid to total loss	62.0%	55.7%
Total loss	1,136.6			
NFIP	59.8			
Federal aid	511.8			
Aid to total loss	45.0%			

Note: In panel B, loss figures are adjusted at the state level by our 2008 exposure index. This index captures both price-level changes and changes in the size of the housing stock. The intent is to estimate the losses a past disaster would cause if it occurred today. Federal disaster spending is also adjusted using the same index, which yields an aggregate aid ratio that is not overweighted by recent disasters.

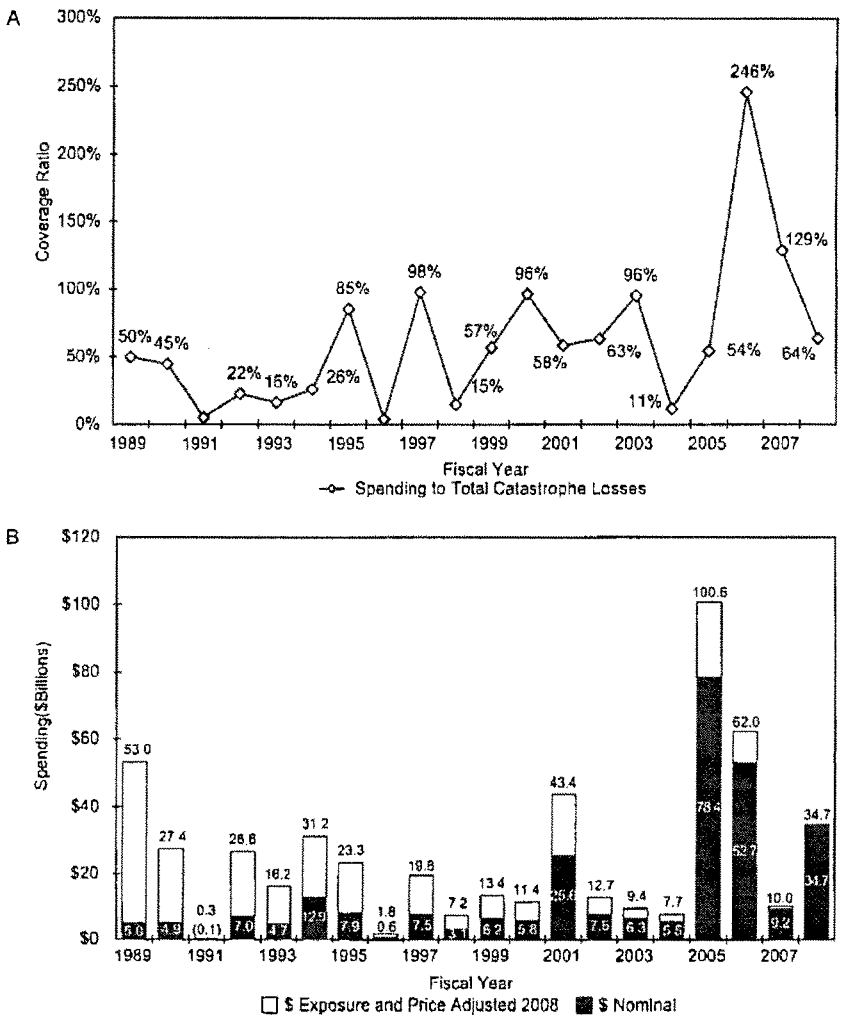

Fig. 4.4 Total federal disaster spending: FY1989 to FY2008

Note: In panel B, values are adjusted at the state level by our 2008 exposure index. This index captures both price-level changes and changes in the size of the housing stock. The intent is to estimate the spending that would have resulted if a past disaster occurred today.

in total disaster spending and $1.1 trillion in catastrophe losses,[17] for a coverage ratio of 45 percent. It should be noted that the annual coverage ratios in

17. The main distinction between the catastrophe losses used in this calculation relative to those used previously relates to the inclusion of drought losses. This augmentation is necessary due to the inclusion of the USDA expenditures.

Senator BOXER. Thank you so much, Mr. Nutter.

Mr. KC Golden, Policy Director, Climate Solutions.

STATEMENT OF KC GOLDEN, SENIOR POLICY ADVISOR, CLIMATE SOLUTIONS

Mr. GOLDEN. Thank you, Madam Chair, Senator Vitter, Members of the Committee.

My name is KC Golden. I am the Policy Director for Climate Solutions, a Northwest regional organization promoting practical solutions to climate disruption.

Last month, I had the opportunity to testify at a House subcommittee hearing on the issue of coal export and the witness seated next to me, representing the manufacturers at that hearing, objected to the idea that we would consider the climate impacts of coal export in evaluating these export proposals, fearing that might be a slippery slope that would lead to climate impact tests for other kinds of commodities like corn and toys.

Now, I think common sense can be our guide here. Corn and toys are not among the leading preventable causes of global climate disruption. The increasing use of coal around the world is, so that is something we ought to consider.

But I think the witness had a fair point in at least one respect. The issue of how and where exactly in the economy we account for the costs of climate pollution is, indeed, a very important consideration in climate policy design.

But in June 2013, last month, 25 years after our foremost climate scientists went before Congress and testified that climate change was indeed a serious problem that required decisive action, a full quarter of a century ago, we were not having a hearing about climate policy design in the U.S. House. We were having a hearing about how to increase fossil fuel exports.

At that same hearing, the Army Corps of Engineers testified that they would not look at the climate impacts of coal exports in their review and ironically enough, on that same day, the Commander of the Corps announced his support for more aggressive flood protection standards, stronger, more expensive levees, to deal with climate impacts.

So, we can count on the Corps to request larger budgets to deal with the aftermath, to deal with climate impacts, but we can apparently not count on the Corps to analyze those impacts in the context of decisions which might help us actually prevent some of them.

We are setting ourselves up for pounds of cure, tons of cure, at public expense because we lack the responsible climate policies that might provide Americans with a prudent ounce of prevention.

Now, my written testimony affirms in some detail that we have no shortage of practical, economically attractive solutions available to us right now. Indeed, in the Northwest and throughout America Americans are implementing those solutions. We are reducing our climate pollution and we are building healthier communities and stronger economies as we go. But we cannot implement these solutions at the necessary pace and scale without the active partnership, the leadership, of our Federal Government.

Now, there are, of course, many important Federal climate initiatives underway now and without diminishing their importance in any way, I will simply submit that they are not remotely sufficient to the task in the absence of a credible national climate policy commitment with at least the following three features.

First, we need responsible science-based limits on climate pollution. This would be the clearest possible signal to energy markets, to our international partners, to ourselves, to our kids, that we are stepping all the way up to the climate challenge.

Second, we need a fair price for carbon pollution. Free and unlimited carbon dumping is the prevailing climate policy of the United States right now. When prices tell the truth about costs, markets will function more effectively, they will allocate capital more effectively, and climate solutions will accelerate.

Third and finally, we need an end to any Federal support for major new capital infrastructure investments that make the problem impossible to solve. This does not mean that we need to cease fossil fuel consumption overnight. But it does mean that we must avoid major, new long-term capital intensive infrastructure investments that lock in dangerous climate disruption. We simple need to stop digging the hole deeper if we hope to get out of it.

Madam Chair, this final, simple, common sense principle, it is vital, I believe, to ensuring the integrity and the credibility of America's commitment to climate solutions. Our policy must be a way to answer to the growing number of victims of climate-related disasters and more importantly to our kids, the prospective victims of still-preventable climate disasters.

As we enter now an era of climate consequences that are so vivid and that you have heard described here today, we need a national policy that enables us to look our kids in the eye and say in no uncertain terms that we can and will do what it takes to protect them, to make this better. But they will not believe us until we stop making it worse.

Thank you. I look forward to your questions.

[The prepared statement of Mr. Golden follows:]

Testimony of KC Golden
Senior Policy Advisor, Climate Solutions
before the

Committee on Environment and Public Works
United States Senate
"Climate Change: It's Happening Now"

July 18, 2013

Madame Chair, Ranking Minority Vitter, members of the committee, thank you for the opportunity to tesify today. My name is K.C. Golden, and I serve as Senior Policy Advisor to Climate Solutions, a Northwest regional organization promoting practical and profitable solutions to climate disruption.

My testimony will affirm that climate solutions are feasible, practical, and economically sound. Americans are stepping forward to develop and deploy these solutions now. Our commitment to deliver clean energy, energy efficiency, and better transportation choices is helping us build stronger local economies and healthier communities. But we cannot implement these solutions at scale without the active engagement and partnership of our federal government, including the United States Congress. And so it is with tremendous hope and determination that I welcome this opportunity to speak with you and invite that partnership.

My knowledge of these issues and the examples I will use are based primarily on my experience implementing solutions in the Pacific Northwest, but there are similar examples of Americans delivering promising solutions throughout the nation. My testimony will focus on three points:

- **We have the tools – the technologies, the resources, the economic models – to deliver cost-effective climate solutions at scale.**

- **Key Federal actions needed to accelerate deployment of climate solutions are straightforward: responsible limits on climate pollution; a fair price for dumping carbon into the atmosphere; and an end to federal support for major new capital investments that make the problem intractably worse.**

- **The absence of these federal actions is taking a high toll on Americans now, including the rising cost of climate damages, costly misallocation of our energy dollars, and undermining Americans' efforts to develop and deploy solutions.**

After reviewing some of the testimony you will hear today about the dimensions of the climate crisis and the human costs it imposes, one can't help but wonder why the United States of America has been so slow and timid in rising to this challenge. If there were viable solutions that spared us these astronomical costs, wouldn't the world's most powerful nation, with the world's greatest technical and economic resources, already be implementing those solutions?

To make sense of this apparent contradiction between the dimensions of the crisis and the weakness of our national response, we might be tempted to conclude that we *have* no viable solutions. We might infer that the technology doesn't exist; that the economics of switching from fossil fuels to clean energy are prohibitive; that we lack the knowledge, the policy tools, the technical capacity, the economic models or some other critical resource for implementing solutions at scale.

The purpose of my testimony here today is to affirm that none of these insurmountable obstacles exist. We can do this. In the Northwest, we *are* doing it. But no city, no state, no region can do it at the scale and pace that the climate crisis demands without the power and will of the United States Congress. We are prepared to play our part and then some, but nothing short of a firm national commitment and international leadership for solutions will do the job.

1. **We have the tools – the technologies, the resources, the economic models – to deliver cost-effective climate solutions at scale.**

Climate disruption is a *big* challenge, but at its core, it is not overwhelmingly complicated. The primary solution is the transition from inefficient use of fossil fuels to efficient use of clean energy forms that do not add to the concentration of heat-trapping gases in the atmosphere. (Terrestrial carbon storage – in healthy forests, soils, and wetlands – will also play an important role in stabilizing greenhouse gas concentrations[1].)

Non-fossil energy forms are abundant and reliable. The sun delivers thousands of times more energy to the Earth than humans use, and has been doing so, without an outage, for over 4 billion years. The amount of solar energy that hits in the Earth in an hour is more than humans use in a year[2]. The fossil fuels we use today are, of course, one form of this energy – solar energy harvested by plants and stored in the Earth's crust. But this is hardly the only way to harvest, store, and use solar energy. Wind, waves, biomass, and hydropower are all solar-derived energy sources. Technology for converting these resources to usable heat and electricity is widely available now, at costs that are already competitive with fossil fuels in many applications. The climate challenge in a nutshell is the challenge of meeting our energy needs with fresh energy instead of "canned" fossil fuels, while squeezing far more work out of

[1] See Northwest Biocarbon Initiative: http://climatesolutions.org/programs/NBI/nbi_onepager
[2] "Spotlight on Solar Energy," *Nature Education* http://www.nature.com/scitable/spotlight/solar-energy-8731061

the energy we use by using it more efficiently. (I include brief observations about the prospective roles of two non-fossil, non-solar-derived resources – geothermal and nuclear – in footnotes 3 and 4 below[34].)

The availability and feasibility of climate solutions at scale is thoroughly documented. Some of the more comprehensive treatments include:

- McKinsey and Company's "Pathways to a Low-Carbon Economy"[5], which develops a global greenhouse gas abatement cost curve, combining a range of technologies, many of which carry a negative price tag. They find that known climate solutions can be deployed at a pace and scale sufficient to avert catastrophic climate changes, at a cost of less than 1% of global GDP.
- In its "Renewable Electricity Futures Study,"[6] The National Renewable Energy Laboratory finds, "Renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the country."
- The Princeton Carbon Mitigation Initiative has developed a widely used tool for comparing and analyzing climate solutions called "Stabilization Wedges"[7] Their analysis confirms: "We already have the technology we need to take the world off the path toward dramatic climate change."

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[3] Geothermal energy – in both direct application and for power production – holds tremendous potential. See, e.g., http://thinkprogress.org/climate/2011/11/06/359699/google-geothermal-supply-chu/ and http://www.nrel.gov/gis/geothermal.html.

[4] Nuclear power remains plagued by cost, safety, waste, and weapons proliferation problems. (http://pbadupws.nrc.gov/docs/ML1129/ML112940552.pdf) For those who see promise in new nuclear designs, the climate policy recommendations below should be attractive as a fair way to level the playing field with fossil fuels and offer new nuclear "A Fair Shot, not a Free Ride": http://grist.org/article/2009-11-09-new-nukes-a-fair-shot-not-a-free-ride/

[5] "Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve," McKinsey and Company, http://www.epa.gov/statelocalclimate/documents/pdf/mckinsey_summary_11-19-09.pdf

[6] National Renewable Energy Laboratory http://www.nrel.gov/analysis/re_futures/

[7] Princeton Carbon Mitigation Initiative: http://cmi.princeton.edu/wedges/intro.php An accelerated application of the basic wedges approach is necessary to develop solutions at the required pace and scale, as former Acting

In the Pacific Northwest, we are ground-truthing these estimates of clean energy potential. Renewable energy isn't "alternative" energy in Washington and Oregon. It's the backbone of our existing power system. We have honed our "renewable edge" with decades of investment in energy efficiency, maximizing the value and productivity of our hydroelectric supplies while improving the comfort of our buildings and the competitiveness of our industries. Our air is cleaner, our economy is stronger, and we enjoy some of the lowest cost power in the nation because of our long-term commitment to clean energy.

In recent years, we have begun to add substantial amounts of new renewable resources to our energy portfolios. And we have adopted climate plans[8] that commit our jurisdictions to responsible limits on climate pollution and accelerated deployment of clean energy systems. Climate disruption and ocean acidification represent clear and present dangers[9] to Northwest communities and economies – threatening our water, power, and food production systems, undermining the health and productivity of our forests, eroding our shorelines, and increasing the loss of lives and property from extreme weather and fires. We cannot solve this problem alone, but we are committed to do our part, and we believe that doing so helps us build a healthier future and a stronger, more durable economy.

These historic and new clean energy commitments are vital to the region's economy. They support our existing manufacturing and industrial base, including global leaders in aviation, wood products, and materials. They are accelerating the development of dynamic new, job-creating industries including renewable energy, energy efficiency, advanced transportation, software, and smart grid technology.

Assistant Secretary of Energy Joe Romm describes at: http://thinkprogress.org/climate/2011/01/10/207320/the-full-global-warming-solution-how-the-world-can-stabilize-at-350-to-450-ppm/

[8] Washington State Executive Order 09-05, "Washington's Leadership on Climate Change," at http://www.ecy.wa.gov/climatechange/2009EO.htm ; Oregon Global Warming Commission Interim Roadmap to 2020 at http://www.keeporegoncool.org/sites/default/files/Integrated_OGWC_Interim_Roadmap_to_2020_Oct29_11-19Additions.pdf

[9] See, e.g., Washington State impact assessment at: http://www.ecy.wa.gov/climatechange/

And our clean energy edge is an important part of the overall quality of life that attracts investment, innovation, and an excellent workforce to our region. Clean energy leadership is part and parcel of our regional identity and our economic profile.

As a result of this leadership, we are phasing coal out of our regional energy supplies. Seattle City Light sold off its share in a coal plant in 2000, and completely eliminated net carbon emissions from the City's power supply in 2005, while providing some of the cheapest power in urban America. In 2011, we reached a consensus agreement[10] to phase out that same coal plant – the only coal-burning commercial power plant in Washington, and the source of roughly 10% of the state's total emissions of climate pollution. That agreement enjoyed unanimous support from the plant's owner, the local community, conservation groups, and the workers at the plant. Our successful experience with clean energy created a widely-shared sense of confidence in our ability to power our future with cleaner energy sources.

The Northwest Power and Conservation Council, created by an act of Congress in 1980, develops long-range electric power plans for the 4-state region served by the Bonneville Power Administration. In its sixth and most recent plan, the Council concludes that the most cost-effective plan for the region would meet 85% of the region's projected growth with energy efficiency, and most or all of the remaining 15% with new renewable resources. At the Council's meeting earlier this month, Washington Governor Jay Inslee charged the Council with developing a plan to meet all of the region's electricity needs (including load growth and existing demand) with clean, carbon-free resources.

We take pride in our clean energy achievements and our commitment to climate solutions. Our communities are healthier, our economy is stronger, and our future is more secure as a result of these investments. But we know full well that no city or state can successfully address the climate challenge unilaterally. And so our climate strategies are designed to pioneer and prove out the technologies,

[10] "Transalta Agreement Shows the Power of Compromise," *Olympian*, March 11, 2011 at http://www.theolympian.com/2011/03/11/1574719/transalta-agreement-shows-the.html

energy systems, and transportation strategies that can power a healthy future, in our region or anywhere else. Rising to the climate challenge means not just reducing our own carbon footprint, but opening up energy pathways to economic security – pathways that work for the long haul, not just for us, but for the billions of people worldwide who yearn for economic opportunity. We call this "sustainable prosperity," and we believe it's our best future.

"Global warming" accurately describes the trajectory of the global average temperature, but no one lives in the global average temperature. No one works or plays or gets anything done in the global average temperature. When we think concretely about the impacts, the causes, and the solutions, the action is primarily local. Communities can do most of the practical work of implementing solutions. But we know we can't build this future on an island. We need federal action to create the larger policy context in which local actions can succeed and drive national and global solutions at scale. Next, I'll address some of the most important features of that policy context.

2. **Key Federal actions needed to accelerate deployment of climate solutions are straightforward: responsible limits on climate pollution; a fair price for dumping carbon into the atmosphere; and an end to major new capital investments that make the problem intractably worse.**

The federal government has many vital roles to play in rising to the climate challenge, some of which it is already playing. My testimony will not comprehensively address these roles and actions, but rather focus on three that are foundational for driving solutions at scale.

In focusing on these three, I do not mean to understate the importance of other critical federal actions, including but not limited to expanding America's commitment to energy innovation[11], clean

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[11] See, e.g., the recommendations of the American Energy Innovation Council http://americanenergyinnovation.org/the-business-plan-summary/

energy deployment in federal operations (particularly the military and the federal Power Marketing Administrations), low-income weatherization, energy codes and standards, clean transportation infrastructure, tax credits for clean energy production and manufacturing, and international leadership in climate solutions. But all of the federal government's existing and prospective clean energy and climate initiatives would be made more effective, efficient, and productive if the United States had the basic infrastructure of a responsible climate policy, as described below.

Responsible limits on climate pollution:

There is of course no single policy that will effectuate all the necessary solutions. But there is a policy choice that calls the essential question — a single decision that will signify a genuine commitment to reduce fossil fuel dependence and deliver climate solutions at scale, with real accountability for results: *firm, science-based limits on climate pollution.*

The United Nations Framework Convention on Climate Change[12] (which the first President Bush signed in 1992) commits the world to implement actions that avoid dangerous climate disruption. The Copenhagen Accord[13] further refined that commitment, calling for emission reductions designed to prevent global average temperatures from increasing by more than 2 degrees Celsius, the scientific standard for dangerous climate change.

Limits on climate pollution that meet these scientific requirements are the simplest, strongest climate policy. Some states and cities, and the rest of the world's advanced economies, have adopted such limits in various forms. The absence of such a policy in the United States remains the most conspicuous missing piece of a viable global strategy for solutions.

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[12] http://unfccc.int/2860.php
[13] http://unfccc.int/meetings/copenhagen_dec_2009/items/5262.php

A limit on climate pollution is not a complete policy blueprint, by any means. But it is a foundation — a serious public policy commitment to do the whole job. It is the clearest possible signal — to energy markets, to the international community, to ourselves — that we are stepping up to the climate crisis and the unprecedented opportunity for economic renewal in solving it. It will unleash investment and innovation to implement existing solutions and develop new ones. It leaves many questions unanswered, but it answers the first and most important threshold climate policy question: "Do we have the will to do what is right and necessary?"

A fair price far dumping carbon pollution in the atmosphere:

"The problem of climate change involves a fundamental failure of markets: those who damage others by emitting greenhouse gases generally do not pay,"[14] according to Sir Nicholas Stern, Chair of the British Academy and author of Stern Review[15], a comprehensive assessment of the economic costs of climate disruption and climate solutions. Economists refer to this market failure as an "externality" – a circumstance in which real costs are not properly accounted for in economic transactions because they remain external to the prices paid by buyers in the marketplace.

As other testimony today will show, these costs are real and present. Americans are paying them now, in the form of more extreme weather events, more destructive fires, drought, and a variety of other climate impacts. Were these costs more accurately reflected in the economic choices we make in energy markets, we could *avoid* many of them. We could choose non-fossil energy sources that would be *cheaper* if these climate-related costs were properly accounted for and included in prices.

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[14] "Stern: Climate change a market failure," *Guardian,* http://www.guardian.co.uk/environment/2007/nov/29/climatechange.carbonemissions
[15] *Stern Review on the Economics of Climate Change* http://webarchive.nationalarchives.gov.uk/+/http:/www.hm-treasury.gov.uk/sternreview_index.htm

This market failure amounts to a massive subsidy. Americans are forced to pay the costs of climate disruption -- a huge, involuntary transfer of private costs onto the public. Internalizing this cost by pricing carbon would spare of us many of these impacts and damages, as energy markets began to more efficiently allocate capital toward solutions. When prices tell the truth about costs, markets function will more effectively, and climate solutions will accelerate. Experience in British Columbia, which relies on a revenue-neutral carbon tax, confirms that the policy has been effective in reducing emissions while BC's economic growth outpaces the rest of Canada's[16].

Prices for carbon pollution are the natural corollary to limits. In a market economy, scarcity generally drives value, so when the right to pollute becomes more limited, it also becomes more valuable (insofar as it can, like other goods and services in a market economy, be bought and sold). Carbon prices can either be set directly by governments, through a carbon tax, or set by markets, by issuing a limited quantity of pollution allowances and allowing them to be traded. The difference between a system of tradable allowances and a carbon tax is largely a matter of whether government sets the allowable *quantity* of carbon pollution (and allows private markets to arrive at the corresponding price) or government sets the *price* (and allows markets to arrive at the corresponding quantity.) Both limits and prices are necessary in order to drive innovation, investment, and deployment of climate solutions at scale. The Climate Protection and Sustainable Energy Acts introduced by Senators Boxer and Sanders would set a predictable, price, escalating over time, while returning most of the revenues directly to citizens as dividends. Clean energy investments funded by this policy would help to ensure that consumers have a growing array of cost-effective alternatives to fossil fuel dependence.

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[16] "British Columbia's Carbon Tax Shift: The First Four Years" *Sustainable Prosperity*, http://www.sustainableprosperity.ca/dl872&display

Fair carbon pricing is simply sound economic policy. It would allow energy markets to function more efficiently, reduce total energy costs, and more equitably assign accountability for the true costs of climate pollution. The absence of these prices imposes real and growing economic burdens on Americans and makes all other emission reductions efforts less efficient and productive than they should be, as I will describe in the final section.

Opponents of carbon pricing sometimes characterize it as a penalty for fossil fuel consumption. As the growing number of victims of climate-related disasters can attest, the cost "penalty" associated with fossil fuels *already exists*; pricing carbon simply asks those who cause the costs to incur them, rather than foisting them on to everyone else. And it is important to note that the purpose of such a policy in this context is not to pay the cost at all. By correctly and fairly aligning prices with costs, carbon pricing empowers consumers, producers, investors, and other economic actors to make more rational decisions to *avoid* the cost of carbon by reducing emissions. When we square up to the true costs of climate disruption, we will find that we have better, less costly ways to meet our energy needs.

An end to major new capital investments that make the problem intractably worse:

In its 2011 World Energy Outlook[17], the International Energy Agency warned that the global pattern of energy infrastructure investment must shift, decisively and immediately, away from fossil fuels or we will "lose forever" the chance to avert catastrophic climate disruption. This does not mean that we need to cease fossil fuel consumption immediately. It does, however, mean that we must *stop making the situation worse* with large and irreversible *new* investments that "lock-in" emission trajectories which guarantee dangerous climate disruption. Once these long-term investments are

[17] "The world is locking itself into an unsustainable energy future which would have far-reaching consequences, IEA warns in its latest World Energy Outlook", *International Energy Agency*, http://www.iea.org/newsroomandevents/pressreleases/2011/november/name,20318,en.html

made, their emissions are locked in not for months or years, but for decades. And the impacts of those emissions will persist for centuries.

In his recent speech announcing his climate plan[18], President Obama indicated that the State Department would not approve the Keystone Pipeline if it significantly increased emissions of climate pollution. Leaving aside the subtleties of the factual determination, the principle is vital for federal climate policy: *Specifically and categorically, we must cease making large, long-term capital investments in new fossil fuel infrastructure that "locks in" dangerous emission levels for many decades and makes avoiding catastrophic climate disruption impossible.*

This core principle emerges from multiple lines of scientific and economic research, most notably the International Energy Agency's 2011 World Energy Outlook. As a guide to policy development, it makes simple common sense. A comprehensive strategy for global climate solutions called "Design to Win"[19] put the point succinctly: "First, don't lose."

It will take decades to decarbonize our transportation and energy systems. We can do it over time, patiently and incrementally, building stronger economies and healthier communities as we go, and without precipitous economic disruption. But we cannot make big new capital investments now that irrevocably commit us to catastrophic climate failure. Federal actions that facilitate such investment are inconsistent with a genuine commitment to climate solutions.

Now that the era of climate consequences is upon us, the application of this principle is vital in order to ensure the integrity of the federal government's commitment to climate solutions. Federal climate policy must be a way to answer to the victims of climate-related disasters – and to our kids, the

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[18] "Remarks by President on Climate Change" http://www.whitehouse.gov/the-press-office/2013/06/25/remarks-president-climate-change

[19] "Design to Win," California Environmental Associates http://www.climateactionproject.com/docs/Design_to_Win_8_01_07.pdf

prospective victims of still-preventable climate disasters. Our policy must affirm that we will do what it takes to protect them, to make it better. But they won't believe us until we stop making it worse.

3. **The absence of these federal actions is taking a high toll on Americans now, including the rising cost of climate damages and economically costly misallocation of our energy dollars.**

It would be impossible to comprehensively catalogue all of the economic, physical, and human damage that is occurring now as a result of our national failure to adopt a responsible climate policy. The most troubling impacts are, of course, the unprecedented loss of life and property due to increasingly extreme weather-related disasters and other climate impacts. But the lack of a national policy is also having other near-term, practical impacts on consumers, policy makers, businesses, and energy investments – impacts that weaken our economy, raise our energy bills, and make the climate crisis more intractable. Below, I offer a few examples from recent experience.

Critical policy, permitting, and programming decisions are more difficult and less effective without rational climate policy.

Last month, I testified to the Committee on Energy and Commerce Subcommittee on Energy and Power on the issue of exporting Powder River Basin coal from proposed terminals in the Pacific Northwest. A witness representing the National Association of Manufacturers objected to the notion that federal environmental analysis of proposed coal export facilities might include consideration of the climate impacts of burning the coal. He worried that such an evaluation would create a slippery slope, necessitating evaluation of the climate consequences of other products, including corn and toys.

Common sense should prevail here. The export of corn and toys is not one of the leading preventable causes of catastrophic global climate disruption. The introduction of large amounts of cheap, subsidized, American coal into the world's fastest growing economies is, because it would trigger economic "lock-in" to dangerous climate disruption, described above.

However, the concern raised by the witness is, in at least one respect, legitimate. Because we have no meaningful national climate policy, we are left to ask and answer these kinds of questions on ad hoc basis, leading to outcomes that are surely less efficient and effective than we could achieve with a thoughtful, comprehensive policy. The issue of where and how to ensure accountability for the costs of climate pollution is indeed a very important climate policy design consideration[20]. But in June of 2013, 25 years after our foremost climate scientist first confirmed to Congress[21] that climate change was a real threat requiring decisive and immediate action, we were not having a hearing on climate policy design in the House of Representatives. We were grappling with one of the many adverse consequences of failing to design and adopt a climate policy.

In the absence of federal policy on climate, we are left to consider the climate implications of coal export outside the context of any structured, systematic approach to solving the problem. State and county officials reviewing permits for coal docks are faced with questions about the dynamics of Asian energy markets and how they influence the climate impact of exporting Powder River Basin coal. The alternative to considering these impacts – simply ignoring them as the climate crisis escalates, and permitting facilities that will significantly exacerbate the problem – is not a responsible course of action. But almost anyone could devise a better way to fairly and fully evaluate this issue than the way we will have to do it now, in the absence of a responsible federal climate policy.

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[20] The Climate Protection Act introduced by Senators Boxer and Sanders would assign accountability "upstream" (at the coal mine, oil refinery, natural gas processing point, or at the point of importation), thereby minimizing complexity and administrative costs.
[21] "Global Warming Has Begun, Expert Tells Senate," *New York Times,* June 24, 1988
http://www.nytimes.com/1988/06/24/us/global-warming-has-begun-expert-tells-senate.html

Ironically, on the same day last month when the Army Corp of Engineers announced that it would not consider the climate impacts of coal export in its environmental review of proposed coal export terminals, the commander of the Corps called for new, stronger standards for levee design and flood protection to cope with climate disruption[22]. Taxpayers can count on the Corps to request larger budgets for responding to climate impacts but not, apparently, to analyze those impacts in the context of decisions which might *prevent* them. We are gearing up for pounds of cure at public expense, because we lack the responsible federal climate policies that would provide an ounce of prevention.

The failure to adopt a responsible national energy policy results in misallocation of energy investment and waste of consumers' energy dollars.

Consumers' energy dollars generally flow to their utilities, which make energy investments on their behalf, in order to serve current and foreseeable energy needs. For investor-owned utilities, state public utility commissions set rates, allowing utilities to recover the costs of these investments, plus a reasonable return. In evaluating which costs utilities will be allowed to recover, utility commissions aim to minimize the costs of reliable energy service to consumers, encouraging utilities to choose the least-cost mix of resources to serve their customers.

With no national climate policy, the large and growing costs of carbon pollution are generally not included in the price that utilities pay for energy to serve their customers. And yet those costs are being paid by customers, and all Americans, every day. We pay for the cost of controlling the fires and floods that are becoming more frequent and intense as climate disruption accelerates. We pay to raise seawalls and levees. We pay higher food prices when crops and ranches fail due to drought. Growing numbers of Americans are paying with their lives. But none of these costs are paid by utilities when they buy the energy that creates this climate pollution on our behalf.

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[22] "Army Corps Chief Suggests US Needs Stronger Levees as Climate Changes" from *Climate Wire* http://www.nwra.org/content/articles/army-corps-chief-suggests-us-needs-stronger-levees/

Public utility commissions are thus faced with a difficult challenge: either ignore these costs, which essentially guarantees that total energy costs to consumers (including climate damages) will be unnecessarily high; or try to assess these costs in utility ratemaking and regulatory decisions, in the absence of a meaningful national plan or policy to reduce climate pollution to safe levels. Understandably, public utility commissions often consider such evaluations to be outside of their realm of expertise or responsibility.

This is, of course, an almost universal problem for climate action; relevant decision-makers often consider it to be outside the scope of their jurisdiction or effectiveness. And so as a practical matter, they too often ignore the costs of climate pollution. That doesn't make the costs go away; on the contrary, failure to consider these costs generally increases them. But one can understand the plight and frustration of decision-makers with smaller jurisdictions than yours, when they are asked to consider climate consequences that could have been evaluated and managed so much better and more comprehensively by the United States Congress.

Public and private clean energy initiatives would work better, accomplish more, and cost less if we had a rational climate policy.

Many clean energy policies and programs exist now at the federal, state, and local levels. But all of these policies and programs are swimming against the tide of a vast economic distortion – the disincentive created by failure to internalize the real costs of climate pollution. Notwithstanding this economically perverse incentive structure, many of these programs are quite successful. Energy codes have saved an enormous amount of energy and emissions, and put billions of energy dollars back in consumers' pockets[23]. Renewable energy standards have accelerated investment, reduced emissions,

[23] Building Codes Fact Sheet, USEPA
http://www.epa.gov/cleanenergy/documents/suca/buildingcodesfactsheet.pdf

and delivered a new driver for good jobs and prosperity in many states[24]. Production tax incentives have helped to reduce the competitive handicap that American clean energy businesses face in the absence of a national climate policy. Energy efficiency codes and programs have been a boon to the economy. In the Northwest, energy efficiency gains have been the biggest, cheapest, and most successful part of our energy strategy for the last 30 years[25].

However, virtually all of these programs and policies could work better, accomplish more, and cost less if we had a sound national climate policy. For example, suppose a tax incentive were designed to bridge the gap between a fossil energy resource costing $60 per megawatt-hour and a renewable resource costing $70 per megawatt-hour. Much of the gap is due to the fact that the fossil resource externalizes the cost of carbon pollution; the public in effect subsidizes that resource by picking up the tab for the climate impacts. If the cost of that pollution were internalized with a fair carbon price, the gap would be smaller. Under those circumstances, a given amount of public expenditure (or foregone revenue) would go further, delivering more clean energy for the same cost.

In a market economy, public policy should be aligned with private incentives wherever possible. Our prevailing national climate policy is free and unlimited carbon dumping, a policy that is directly at odds with other policies like energy codes and clean energy incentives. A climate policy with responsible limits and fair prices for climate pollution would align private incentives with public policy goals, and get America working much more efficiently and effectively for solutions.

The lack of a federal climate policy undermines individuals, communities, states, and businesses in their efforts to be part of the solution.

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[24] "Renewable Energy Standards, State Success Stories" Governors' Wind Energy Coalition http://www.governorswindenergycoalition.org/wp-content/uploads/2013/03/RES-White-Paper-March-2013.pdf
[25] Northwest Power and Conservation Council http://www.nwcouncil.org/media/30092/2012_06.pdf

A less quantifiable but critically important impact of the failure to adopt a national climate policy is the confusing and counterproductive effect of that failure on the many Americans who want to be part of effective solutions.

A participant in a focus group on climate once said, "I don't think it's a big issue, because nobody's doing anything about it." This is a remarkable insight. Surely, she deduced, if it were as bad as all that, the responsible authorities would be addressing the problem with urgency and resolve. That would be a much more reliable barometer of the risk than all the claims and counterclaims on cable news.

We *should* be able to expect that public institutions and elected officials respond to grave threats, guided by objective facts, in order to prevent mass-scale human tragedies. Americans *should* have confidence that when America faces a big problem, when we need to mobilize our national resources and will for big solutions, the United States Congress will act.

Millions of Americans are implementing climate solutions – driving cleaner cars, installing more efficient lights, improving the efficiency of their offices and factories, etc.. But they understandably wonder whether their efforts make much difference in the absence of a serious national policy commitment. Mayors and governors who have adopted climate plans face cynicism, since their jurisdictions represent such a small fraction of the total global emissions that drive climate disruption. The rest of the world desperately waits for the America they know – the proud, powerful, solution-oriented America – to step forward and step up to the climate challenge. Individuals and mayors and governors and businesses and other nations CAN make a difference; they CAN do their part. But they know it's only part of something hopeful and realistic if and when the United States of America steps up to the kind of leadership and commitment of which it is uniquely capable.

Only a serious national climate policy can unleash America's greatness for climate solutions. Given the dimensions of the challenge and the lateness of the hour, we'll need every bit of that greatness.

Thank you. I look forward to any questions you may have.

United States Senate Environment and Public Works Committee
July 18, 2013
Follow-Up Questions for Written Submission
Submitted by KC Golden, Senior Policy Advisor, Climate Solutions

Questions from Senator Barbara Boxer:

1. *Mr. Golden, it has been suggested that U.S. reductions in carbon pollution will not make a significant difference in the projected rate of climate change because China, India, and some other nations are increasing their greenhouse gas emissions.*
    a. *Can you please describe why the role of U.S. greenhouse gas emission reductions is critical to global action to address climate change?*
    b. *Can you also please describe the role played by U.S. exports of fossil fuels like tar sands-derived fuels and coal in enabling China, India, and other countries to increase their carbon pollution?*

Answers to questions from Senator Boxer:

1.a. The United States has achieved unprecedented prosperity with an economic and energy system that relies heavily on fossil fuels, the primary cause of climate disruption. (The IPCCs exhaustive new report, *"Climate Change 2013: The Physical Science Basis,"*[1] documents the irrefutable evidence behind anthropogenic climate change, once again.) While China has surpassed the U.S. as the largest annual emitter, climate disruption is caused by cumulative, not annual emissions, and the U.S. is still the world's largest cumulative emitter by a wide margin. Our per capita emissions, of course, remain far higher than those in China and India. While no nation can solve the problem unilaterally, the U.S. clearly bears significant responsibility for playing a leading role in emission reduction.

And while the magnitude of our contribution to the problem confers a special *responsibility*, our culture and history of global leadership confers a special, and extraordinary, *opportunity*. The United States of America is still home to the world's foremost innovators, entrepreneurs, researchers, and technical problem-solvers. This is a challenge that calls for the best that America and Americans have to offer.

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[1] http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf

Rising to it with an ambitious clean energy mobilization will position us for technological advancement, economic prosperity, and global competitiveness for many decades to come.

Developing nations understandably worry that reducing their emissions would limit their access to the relative prosperity that America already enjoys. It would be neither right nor effective to say to China and India, "Sorry, the atmosphere is already full of the carbon that enabled our prosperity, so you're out of luck." However, if the developing world builds out the infrastructure for a fossil-fueled economy for another 2 billion people, we will be locked into a future of unrelenting climate crisis. The effects of that climate disruption will fall most catastrophically on the world's poor[2], so it is disingenuous to argue that the rampant expansion of fossil fuel infrastructure serves the cause of global economic justice.

The only fair way forward out of this bind is for nations that have emitted the most and achieved the most economic development to lead the way by breaking the link between emissions and prosperity. Our experience in Seattle confirms that this is possible. We provide 100% of our electricity with no carbon emissions, and we enjoy some of the cheapest power and one of the strongest urban economies in America.

This transition will take time, but it's achievable. We can reduce our emissions in the United States and pioneer a path to sustainable prosperity that works for us for the long haul, and for the billions who aspire to economic security. Contributing to solutions in accordance with our historic *responsibility* and our relative *ability* is a core principle of the UN Framework Convention on Climate Change, to which the U.S. is a signatory, and the key to a fair and durable global commitment to tackle the climate challenge. Promoting and locking in fossil fuel dependence around the world by expanding coal exports is flatly inconsistent with this responsibility.

Finally, as we consider the role and effect of U.S. action on global climate solutions, it is important to emphasize the moral dimensions of this issue. Accelerating climate disruption, and the grave human consequences it is already causing, is simply wrong. We believe that aggressive American action to reduce emissions and pioneer solutions will have a tremendously important impact around the world. Indeed, the world cannot possibly rise to this challenge without U.S. partnership and leadership. But

[2] "Climate Change Will Hit Poor Countries the Hardest, Study Says", *Guardian,* Sept. 27, 2013: http://www.theguardian.com/global-development/2013/sep/27/climate-change-poor-countries-ipcc

even if that were not true – even our actions had no effect on anyone else – we should do the right thing, no matter what anyone else does. Continuing to invest in fossil fuel infrastructure that guarantees a future of catastrophic climate disruption violates this basic ethical imperative.

1.b.

The most important factor affecting our ability to stabilize the climate before triggering catastrophic and irreversible climate disruption is the *pattern of investment in long-term energy infrastructure in the fast-growing developing economies*. This factor is analyzed in chilling detail in the International Energy Agency's 2011 World Energy Outlook[3]. IEA argues that further investment in such infrastructure will very quickly "lock in" dangerous emission trajectories, and humanity will "lose forever" the chance to avoid catastrophic disruption without a decisive redeployment of new capital toward carbon-free energy sources. "Lock-in" is the business strategy of the coal and oil industries, because it is the best and perhaps only way to ensure that their reserves -- on which their valuation is based -- actually get burned. But for the rest of us, it's a one-way ticket to climate catastrophe. We must not buy that ticket.

For capital investments in long-lived energy infrastructure (like, say, a coal-fired power plant), one of the most important decision factors is the expected price of fuel over the life of the investment. Because these investments earn their returns over such a long period of time, significant increases or volatility in fuel prices can render them uneconomic.

Predicting future fossil fuel costs is notoriously risky business. When evaluating the choice between energy resource investments, anything that provides long-term downward pressure on fuel prices, or limits their volatility, tips the decision toward investments that rely on those fuels. Since they would be committing themselves to many decades of fuel-purchasing, prospective investors in this capital infrastructure will be encouraged to the extent that they can count on more supply, cheaper supply, and a wider pool of competing suppliers that would give them greater economic leverage as buyers.

The Powder River Basin has some of the world's cheapest and most easily recoverable coal. One of two things is true: 1) This coal will price in to the relevant Asian markets, undercutting other sources of supply while earning a sufficient return for US suppliers. If this is the case, then US coal will be exerting

[3] http://www.worldenergyoutlook.org/publications/weo-2011/

significant downward pressure on coal prices in those markets, and encouraging marginal energy infrastructure investment decisions to tip toward coal. This would result in the construction of more coal plants[4], less clean energy, less energy efficiency, and higher emissions. And since these results would occur in the part of the world where the most energy infrastructure investment is planned, it would have a significant impact on global emission trajectories for at least the several decades that these coal plants will operate. Dr. Thomas Power, Professor Emeritus of Economics at the University of Montana, modeled a specific Powder River Basin coal export scenario and derived results that describe and quantify the magnitude of these effects in "The Impact of Powder River Basin Coal Exports on Global Greenhouse Gas Emissions."[5]

2) Alternatively, this coal will not prove to be competitive in the relevant Asian markets. Coal markets domestically and globally continue to sour, as cleaner energy sources and more efficient energy consumption make coal increasingly uncompetitive. Goldman-Sachs argues that, because of these market trends, the "window for profitable investment in thermal coal [and coal exports] is closing."[6] Given recent trends in coal markets and financing, I consider this the more likely scenario: coal export on the scale contemplated from the Pacific Northwest will not be a financially or economically viable enterprise, even if the industry managed to crush the overwhelming public opposition in our region. And if it doesn't happen, of course, it will have no adverse effect on emissions. Much public and private investment will be wasted, as it was in previous coal export schemes. But the worst – irrevocable lock-in to climate disruption caused by exporting American coal – will be averted.

It can be argued that the coal export business succeeds roughly in direct proportion to how much it disrupts the climate. The coal industry has indicated that, with domestic coal use declining, its financial future depends on the export market. Judging by their extensive campaign to overwhelm opposition to export in the Northwest, they are highly motivated. But the size of the opportunity depends on how competitive their coal is in Asian markets. Profits are a function of the difference between the cost of

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[4] The coal plants currently under construction or contemplated in the near future do not have carbon-capture and sequestration (CCS) technology. Nor do they meet the technical and geologic requirements for CCS should that technology prove economically viable. Proponents of this technology should be especially alarmed about the prospect that coal export would encourage significant construction of coal plants before CCS becomes commercially available, as such construction would lock in dangerous emission levels and significantly undercut the promise of the technology.

[5] http://www.powereconconsulting.com/WP/assets/GHG-Impact-PRB-Coal-Export-Power-Consulting-May-2013_Final.pdf

[6] http://thinkprogress.org/wp-content/uploads/2013/08/GS_Rocks__Ores_-_Thermal_Coal_July_2013.pdf

delivering to those markets and the expected price they can charge. This difference depends, in turn, on both prevailing prices and how cheaply the coal industry can deliver PRB coal to Asia. The more cheaply they can deliver it, the more of it will be burned, the higher the emissions will be, and the more capital will be diverted from cleaner energy sources and invested in long lived coal plants that lock in dangerous emission levels. There is, therefore, a direct correlation between the factors that would make coal export economically viable and the factors that ensure that coal export will drive up global emissions.

Question from Senator David Vitter

You cited in your testimony a 2011 report from the International Energy Agency (IEA) regarding your perception that the world needs to shift away from fossil fuel use. However, that same organization issued an analysis just this year that: "Coal's share of the global energy mix continues to grow... and... will catch oil within a decade" as the most utilized fuel source. Further, the IEA's Director stated in 2012 that: "Coal is a staple energy source [and] will remain a key primary energy source and an important part of fostering economic growth and alleviating energy poverty." Do you dispute these statements – that regardless of policies being considered here in the United States, developing nations around the globe will continue to utilize coal and other fossil fuels in pursuit of their own economic prosperity?

Answer to question from Senator Vitter

My testimony focused on an IEA finding that represented a simple, mathematical, factual conclusion: that continued investment in long-lived fossil fuel infrastructure would, within a few short years, "lock-in" emission levels exceeding the scientifically determined threshold for dangerous climate disruption. The IEA Director's quote, cited in the question above, is an energy forecast rather than a mathematical conclusion. It is a judgment about future energy trends. Goldman Sachs has a somewhat different view, having recently concluded, "the window for profitable investment in thermal coal is closing," and "thermal coal's current position atop the fuel mix for global power generation will be gradually eroded."[7]

Coal will continue to be used for many years, as the IEA director suggests. But the direction of current and future energy investment is moving, and must move, in a different direction: we will engineer a

[7] http://thinkprogress.org/wp-content/uploads/2013/08/GS_Rocks__Ores_-_Thermal_Coal_July_2013.pdf

transition from coal to cleaner energy sources, or face unimaginably grave human consequences from climate disruption – consequences that will fall most harshly on the world's poor. "Relieving energy poverty" is necessary as a matter of global economic justice, but so is stabilizing the climate. Clean energy sources and energy efficiency can do both. Expanded coal use cannot.

The two seemingly contradictory statements from IEA can be at least partially reconciled as follows: Coal use will not cease overnight, or quickly. Some existing coal-fired power plants will continue to operate for the foreseeable future, before they are retired. Coal may well remain a significant, but declining, part of the world's energy mix for some decades. However, it is a simple physical fact that if we *expand* coal-burning infrastructure and *lock in* emission increases, we will cause climate pollution to accumulate in the atmosphere at levels that will trigger catastrophic and irreversible climate consequences.

I am not an energy forecaster. The purpose of my testimony was not to predict energy market trends, but to suggest a path forward through this difficult situation, a path that is consistent with both the IEA report that I cited, and the IEA quotes in the above question: We must move steadily and unswervingly in the direction of reduced emissions, greater investment in clean energy, and long-term transition away from fossil fuels. This transition can and must be accomplished patiently and incrementally over the course of decades; we simply can't do it overnight. However, in the short term and from here forward, *we (meaning the people who share the Earth's atmosphere) must categorically avoid new investments in long-lived, capital-intensive fossil fuel infrastructure*. We can't solve the problem by making it better and worse simultaneously. We have to stop making it irrevocably, irreversibly worse, so we can indeed make it better.

Finally, I do strenuously dispute the implication of the final sentence of the question: the implication that what we do as Americans doesn't matter or affect what happens in the rest of the world with respect to climate solutions. We have emitted more climate pollution than any other nation. And while our contribution to the problem has been substantial, our contribution to the solutions can be even greater. America has an unparalleled capacity to innovate and engineer big solutions to big problems. We can and must pioneer a new, sustainable path to prosperity that doesn't result in catastrophic disruption of the climate and all the human and natural systems that depend on climate stability. That's our responsibility as Americans to the prospective victims of still-preventable climate disasters – the world's kids, and our own.

Senator BOXER. Thank you so very much.

Now we will hear from Ms. Diana Furchtgott-Roth, Senior Fellow, Manhattan Institute for Policy Research.

Welcome.

STATEMENT OF DIANA FURCHTGOTT-ROTH, SENIOR FELLOW, MANHATTAN INSTITUTE

Mr. FURCHTGOTT-ROTH. Thank you very much for inviting me to testify today.

So, we have heard a lot about climate change. I am an economist. I talk about the costs of these offsetting policies and the benefits. And I will leave the discussion as to whether CO2 is a pollutant, even though I am breathing it out right now, to other better-qualified people than myself.

But I think what is clear is that, even if greenhouse gas emissions are affecting the climate, actions by the United States, such as the one that President Obama has proposed, are not going to be helpful because U.S. emissions are about 17 percent of total global emissions. And if China and India are not going to follow suit, then we are going to be hurting ourselves and our economy for no good reason.

We are still 2.1 million jobs below the level of December, 2007 when the recession started and it is very important that we keep the economy active. We have had many companies move to the United States because of our low energy prices and for us to raise our energy prices, without having any affect on global emissions and climate change, is cutting off our nose to spite our face.

The costs of the Kerry-Lieberman and Waxman-Markey bills were too large for a Democratic Congress with a Democratic President to pass and the revenues from those bills, which would have been $646 billion over 8 years, would have been the largest in tax history.

And just recently, on March 22, 2013, the Senate rejected the White House amendment which you proposed, Mr. Senator, that would have had funds from a carbon tax be used to offset other kinds of taxes in the United States. So, just as recently as March the Senate rejected a carbon tax.

I think that what is important is that to reduce greenhouse gas emissions in the least costly manner, what it makes more sense to do is to assist China and India in reducing their carbon emissions. We just heard from Dr. Golden about coal exports. Well, in fact our coal is cleaner than the coal that is burnt in China.

So, if we were to export our coal to China, that might reduce Chinese emissions, or, if we helped China and India develop their sources of shale gas so that they could move from their coal fired plants and also wood-burning systems to more efficient natural gas power plants, that would have a bigger effect of decreasing global emissions than putting in place the measures that the President has proposed to do by regulation.

Congress could also fund research into geo-engineering solutions such as solar radiation management which potentially diminishes the warmth caused by the sun's rays. This is something that if we put into place here in the United States it would have global effect, it would reduce global temperatures, whereas if we put a CO2 tax, greenhouse gas taxes, into effect, it would not have any effect or only a marginal effect on global temperatures. These measures, geo-engineering and helping other countries transform their technology, would be a small fraction of what costs would be.

We have heard a lot about green jobs and President Obama talks a lot about green jobs and how this new technology creates jobs. But the Bureau of Labor Statistics, in its latest report this spring, just found 3.4 million green jobs, many of those have be relabeled from other kinds of jobs such as plumbers who installed low-flow toilets were considered to have green jobs whereas they had employed other kinds of technology.

The costs of energy falls disproportionately on low-income Americans. Data from the Bureau of Labor Statistics shows that the lowest fifth spend 24 percent of their income on energy whereas the highest percent spend 4 percent of their income. So, putting in place measures that increase the costs of energy falls disproportionately on lower-income Americans. They also fall disproportionately on lower-income regions all through the United States where coal fired plants and coal mining occurs.

Thank you very much for giving me the opportunity to testify.

[The prepared statement of Ms. Furchtgott-Roth follows:]

MANHATTAN INSTITUTE FOR POLICY RESEARCH

If Climate Change Is Happening Now, What Do We Do?

Diana Furchtgott-Roth
Senior Fellow, Manhattan Institute

Testimony before the Senate Environment and Public Works Committee

July 18, 2013

If Climate Change Is Happening Now, What Do We Do?

Chairman Boxer, Ranking Member Vitter, members of the Committee, I am honored to be invited to testify before you today on climate change.

I am a senior fellow at the Manhattan Institute. From 2003 until April 2005 I was chief economist at the U.S. Department of Labor. From 2001 until 2002 I served at the Council of Economic Advisers as chief of staff. I have served as Deputy Executive Secretary of the Domestic Policy Council under President George H.W. Bush and as an economist on the staff of President Reagan's Council of Economic Advisers.

Is climate change happening now? Since 2003 global temperatures appear to have reached a plateau.[1] With rising greenhouse gas emissions from Asia and other emerging economies, many predicted that temperatures would continue to rise. Why they have not done so is a puzzle.

With an apparent stall in global warming, the focus has switched to "climate change." For instance, on July 11, 2013, the Department of Energy issued a report entitled *U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather.* The report projects increases in storm and flood frequency.

However, a review of the data over the past 100 years does not show a steady increase in major storms such as hurricanes, nor a steady increase in the number of floods, even though greenhouse gas emissions increased. The National Oceanic and Atmospheric Administration shows the number of hurricanes over the past 100 years has been volatile, with no clear trend, see Figure 1. There were seven floods reported by the NOAA's Mid-Atlantic River Forecast Center in 2012, the precise number reported in 1912. In between, some years have shown higher numbers, others have shown lower numbers. The data have been sporadic at best, as shown in Figure 2.

Despite Congress's decision not to pass cap-and-trade legislation, on June 25, in a speech at Georgetown University, President Obama called for similar regulatory measures to reduce greenhouse gases. He announced that he will use his executive powers to reduce greenhouse emissions from existing power plants, as well as future plants. He also plans to increase efficiency standards for appliances and authorize the placement of wind farms and solar power plants on federal lands. He asked the Department of Defense to install 3 gigawatts of renewable power on bases. He

[1] National Aeronautics and Space Administration, *Global Land-Ocean Temperature Index*, http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.txt

announced that over the next 7 years, 20 percent of the energy the federal government will consume will come from renewable sources. He mentioned plans for federal tax dollars to fund building infrastructure, such as seawalls for communities.

The 111th Congress failed to pass legislation to regulate emissions in 2009-2010, when Democrats had majorities in the House and Senate. The cost of the legislation is a major reason for the failure of the Waxman-Markey and Kerry-Lieberman "cap-and-trade" bills, which would have capped emissions and encouraged firms to buy and sell rights to pollute.

The bill would have required EPA to shrink greenhouse gas allowances steadily to 2050. When any year's emissions would have exceeded a firm's cap, the firm would have to purchase allowances from the government or other companies. That is a tax under another name, driving up costs that would be passed on to consumers.

The costs of the Kerry-Lieberman and Waxman-Markey bills were too large for a Democratic Congress to support, even with Obama's backing. The revenues from the bills, about $646 billion over 8 years, would have at that time been the largest tax increase in history.

Even if rising greenhouse gas emissions are affecting the climate, actions by the United States will not be helpful in the absence of changes by China and India. The U.S. global share of greenhouse gases is 17 percent.

Other countries are increasing emissions. China, India, and Germany are expanding coal consumption, according to the International Energy Agency. Global coal use will rise by 1.2 billion tons in five years. "By 2017," according to a December 2012 IEA report, "coal will come close to surpassing oil as the world's top energy source."[2] Mr. Obama's reductions in U.S. emissions, with their associated costs, will just be a drop in the global bucket.

Polls show that many believe protecting the environment is less important to Americans than economic growth.[3] With the slowdown in many measures of global warming over the past decade, climate change is playing second fiddle to jobs. Americans know that no reduction in global warming will occur if America reduces greenhouse gases without similar action by China and India, and these countries have not agreed to comparable steps.

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[2] International Energy Agency, *Medium-Term Coal Market Report*, December 2012, http://www.iea.org/publications/medium-termreports/#coal.
[3] Gallup Poll, April 2013, http://www.gallup.com/poll/161594/americans-prioritize-economy-environment.aspx.

U.S. greenhouse gas emissions have been declining since 2007, and fell by 1.6 percent between 2010 and 2011, the Environmental Protection Agency announced earlier this year.[4] Required use of alternative energy technology might reduce greenhouse gas emissions further, but the new technologies make fuel and electricity more expensive, reducing economic growth and adversely affecting employment.

The message that government can create more total jobs by requiring more costly technology is seductive but empty. Yes, some Americans might be employed building the technology, but others lose jobs due to more expensive energy.

Although President Obama advocates green jobs, the Labor Department's green jobs survey for 2011, released in March 2013, found only 3.4 million such jobs, despite $500 million in the stimulus bill for green jobs training. By the end of 2011, combined expenditures of the Energy Training Partnership, Pathways out of Poverty, and State Energy Sector Partnership green jobs stimulus programs totaled $257.3 million. However, only 5,400 new jobs through the programs were retained at least 6 months, yielding a cost of $47,754 per job. The Bureau of Labor Statistics has announced that it will discontinue its green jobs survey due to the sequester.

However, the White House website writes in its 4th report on the stimulus "A central piece of the ARRA is more than $90 billion in government investment and tax incentives to lay the foundation for the clean energy economy of the future" and references "$3 billion for Green Innovation and Job Training to invest in the science, technology, and workforce needed for a clean energy economy."[5] The most recent quarterly report does not mention the Green Innovation and Job Training funding.[6]

The $90 billion includes items like the loan guarantee money (some of which will be recovered), and other items like grants for weatherizing and retrofitting.

The president's climate change measures will reduce economic growth by raising energy prices. As well as reducing jobs in the mining industry—over 100 coal-fired power plants have closed since the beginning of 2010—it will also discourage energy-intensive manufacturing.

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4 Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011*, April 12, 2013, http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf, p. 26.

5 Council of Economic Advisors, *Recovery Act Fourth Quarterly Report - The Public Investment Provisions of the Recovery Act*, 2010, http://www.whitehouse.gov/administration/eop/cea/factsheets-reports/economic-impact-arra-4th-quarterly-report/section-4#14.

6 Council of Economic Advisors, *The Economic Impact of the American Recovery And Reinvestment Act of 2009: Ninth Quarterly Report*, February 1, 2013, http://www.whitehouse.gov/sites/default/files/docs/cea_9th_arra_report_final_pdf.pdf

Manufacturers are returning to America due to low-cost energy, and the president's proposals will drive them away and discourage others. The new French Vallourec Star pipe mill in eastern Ohio is making tubes for the electric pipe industry. Other companies making similar investments are Luxembourg's Tenaris and China's Tanjin Pipe. Royal Dutch Shell is building a $4 billion ethane cracker plant in Pennsylvania, and is planning on hiring 5,000 construction workers.

Since 2009, the German chemical company BASF has invested more than $5.7 billion into North America, including a formic acid plant under construction in Louisiana. BASF officials say that energy prices in America are lower than in Europe, where fracking is discouraged.

Other European countries planning to invest in America due to low energy prices include Austrian steelmaker Voestalpine (an iron-ore processing plant in Texas), and South Africa-bases Sasol (a natural gas to diesel conversion plant in Louisiana).

If these companies run into difficulties, their investors and shareholders will bear the losses. But when the government picks investments in risky new technology, as the president recommends, taxpayers and the federal budget lose if the projects fail. Of the 33 energy loan guarantees made since 2009 under the Energy Department's programs, 30, or over 90 percent, have shown signs of trouble, ranging from missed production goals to bankruptcy filings.

Companies which received loans or grants from the Energy Department during the Obama administration then filed for bankruptcy include Solyndra, Abound Solar, A123, Ener1, Evergreen Solar, Solar Trust of America, Energy Conversion Devices, and Beacon Power. Grant recipients Ecototality, SunPower, and Smith Electric have reported losses.

The Inspector General of the Energy Department, Gregory Friedman, found that employees of LG Chem, a battery manufacturer in Holland, Michigan, "spent time volunteering at local non-profit organizations, playing games and watching movies during regular working hours." LG Chem, meanwhile, sold batteries made in South Korea to U.S. firms rather than producing the batteries in Michigan.

Raising the cost of energy at any time is poor economic policy, but especially when economic growth is slow. After four years of economic "recovery," U.S. annualized GDP growth was 1.8 percent in the first quarter of 2013. America has 2.1 million fewer nonfarm payroll jobs than in December, 2007, the start of the recession. Now is not the time for Obama to overrule Congress and slow the economy further.

Electricity from natural gas, of which America has a 200-year supply, is less expensive than electricity produced from alternative fuels. The U.S. Energy Information Administration has estimated that the average levelized cost for natural gas-fired plants entering service in 2018 is $67 per megawatt hour, compared to $144 per megawatt hour for solar-powered plants, $87 per megawatt hour for wind power, and $111 per megawatt hour for biomass. [7]

The bottom line: households have far higher electricity bills using alternative energy than natural gas.

This disproportionately affects low-income Americans, who spend a higher share of their income on energy, as shown in Table 1 and Figure 3. Data from the Labor Department released September 2012 show those in the lowest fifth of the income distribution spend an average of 24 percent of income on energy, compared to 10 percent of income for those in the middle fifth, and 4 percent of income for those in the top fifth.

A CBO report shows that emissions reduction programs would cause job losses in coal mining, oil and gas extraction, gas utilities, and petroleum refining. In addition, workers' wages adjusted for inflation would be lower than otherwise because of the increase in prices due to a cap and trade program. CBO concludes that some workers, therefore, would leave the labor market, because at the new lower wages they would prefer to stay home.[8]

Any reader of the CBO report would realize that it is not in the interests of American workers to embark on an emissions reduction program with our current high unemployment rate. According to CBO, "While the economy was adjusting to the emission-reduction program, a number of people would lose their jobs, and some of those people would face prolonged hardship." Workers laid off in declining industries would find it hard to get new jobs.

The CBO report points out that "In cases in which a shrinking industry was the primary employer in a community, the entire community could suffer." The tax base would dwindle and real estate would lose its value as unemployed workers moved elsewhere. The community's personal income would diminish and real estate values would fall as the jobless moved away.

That is why a carbon tax would harm the U.S. economy.

A $15 tax per metric ton of carbon would result in an increase in gasoline prices of $.15 cents per gallon, 75 cents per thousand cubic feet of natural gas, $6.45 cents per barrel of oil, and $28.50 per ton of coal. A $50 carbon tax rate would raise the price of gasoline by

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[7] U.S. Energy Information Administration, *Levelized Cost of New Generation Resources in the Annual Energy Outlook 2013*, January 28, 2013, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.
[8] Congressional Budget Office, *How Policies to Reduce Greenhouse Gas Emissions Could Affect Employment*, May 5, 2010, http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/105xx/doc10564/05-05-capandtrade_brief.pdf.

50 cents per gallon, natural gas by $2.50 per thousand cubic feet, oil by $21.50 per barrel, and coal by $95 per ton.[9]

The carbon tax is a favorite of many academic economists for restructuring the tax system.[10] Proponents suggest that the tax be used to replace other taxes, such as the individual income tax, the corporate income tax, or a Kerry-Lieberman-style cap-and-trade system.

However, as tax practitioners know, a carbon tax is complex to set up. It requires adjustments to make sure that the tax is not unduly regressive and does not encourage consumption of imports relative to domestic production. A carbon tax without such offsets would be another add-on levy, with exemptions for friends and punishments for enemies.

A carbon tax raises the price of energy and so discourages consumption and production, as manufacturers choose to locate elsewhere.

One major problem with the carbon tax is that it is regressive. Since low-income people use more energy as a percent of their income than high-income people, a switch to a carbon tax would have to be accompanied by transfers to low-income groups.

Academics suggest that offsets be returned to taxpayers through lower income taxes, perhaps with the proceeds going chiefly to low-income households (individuals and families), which are disproportionately hurt by what is in essence an energy consumption tax. This could be done by adjustments of the income tax.

However, low-income earners are not required to file returns, and they would have to do so in order to be identified and compensated. That means extra work for them, and for the Internal Revenue Service.[11] And, as recent events have shown, the IRS is not prepared to take on more responsibilities with its current level of funding.

Another problem is that carbon-intensive sectors, such as coal, would be the biggest losers under the new tax. Politicians from coal-producing regions are influential in Congress and they would demand a share of revenues.

Finally, a carbon tax would raise the prices of energy-intensive goods relative to imports from countries without carbon taxes. So Americans would prefer to buy imports, and American firms would lose business. Proponents of the tax suggest

[9] Ramseur, Jonathan L., Jane A. Leggett, and Molly F. Sherlock, Carbon Tax: Deficit Reduction and Other Considerations, Congressional Research Service, September 17, 2012, p. 11, http://www.fas.org/sgp/crs/misc/R42731.pdf.

[10] Carbon Tax Center, "Supporters," March 24, 2012, http://www.carbontax.org/who-supports/.

[11] Dinan, Terry, *Offsetting a Carbon Tax's Costs on Low-Income Households*, Congressional Budget Office Working Paper Series, November 2012, http://www.cbo.gov/sites/default/files/cbofiles/attachments/11-13LowIncomeOptions.pdf.

putting tariffs on imports in proportion to their carbon content so that American companies will not be at a disadvantage. But the precise quantities are complex to calculate, and such tariffs might be illegal under World Trade Organization regulations.

So for a carbon tax to make our tax system more efficient, its revenues would have to be used to offset other taxes in the economy. Its negative effects on low-income Americans and on energy-intensive regions would have to be ameliorated. Some border adjustment would have to be made so that domestic goods were not disfavored.

But the legislative process makes it difficult to craft a carbon tax with these attributes. It is more likely that any tax on carbon would be an additional tax. It would hurt the poor and raise domestic prices relative to prices of imports.

To reduce global greenhouse gas emissions in a less costly manner, America could assist China and India develop shale gas from hydrofracturing and build natural-gas fired plants to reduce their reliance on coal. Or, America could ship coal to China, because U.S. coal burns cleaner than Chinese coal. The majority of China's coal (54 percent) is bituminous, which has a carbon content ranging from 45 to 86 percent.[12] On the other hand, 47 percent of the U.S.'s coal, a plurality, is subbituminous, which contains a carbon content of only 35 to 45 percent.[13]

Congress could fund research into geoengineering measures. More needs to be done to study solar radiation management, which potentially diminishes the warmth caused by the sun's rays. This could be done by injecting fine sulfur particles or other reflective aerosols into the upper atmosphere to reflect incoming radiation, or spraying clouds with salt water to increase their reflectance.

Clouds seeded with salt water would be thicker, and would reflect more heat back toward the sun, away from Earth. Cooling effects — as well as other, adverse consequences — have been observed after volcanic eruptions.

Another avenue of research is to explore making the surface of the planet more reflective, by brightening structures and painting roofs white, as well as increasing the reflectivity of deserts and oceans.

Such measures would cost a fraction of what cap-and-trade regulations and therefore do less damage to the economy.

Thank you for allowing me to testify today. I would be glad to answer any questions.

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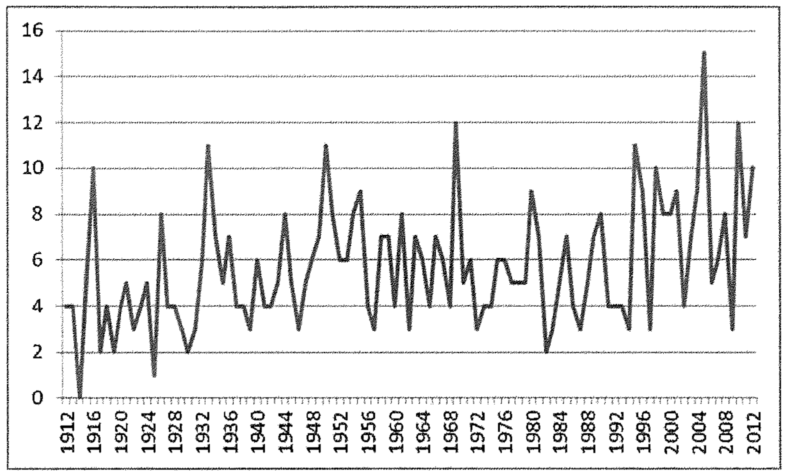
[12] U.S Energy Information Administration, *International Energy Outlook 2011*, Table 10, http://www.eia.gov/forecasts/ieo/table10.cfm.

[13] U.S. Energy Information Administration, *Subbituminous and bituminous coal dominate U.S. coal production*, 2011, http://www.eia.gov/todayinenergy/detail.cfm?id=2670/.

Figure 1: Atlantic Basin hurricanes by year, 1851-2012

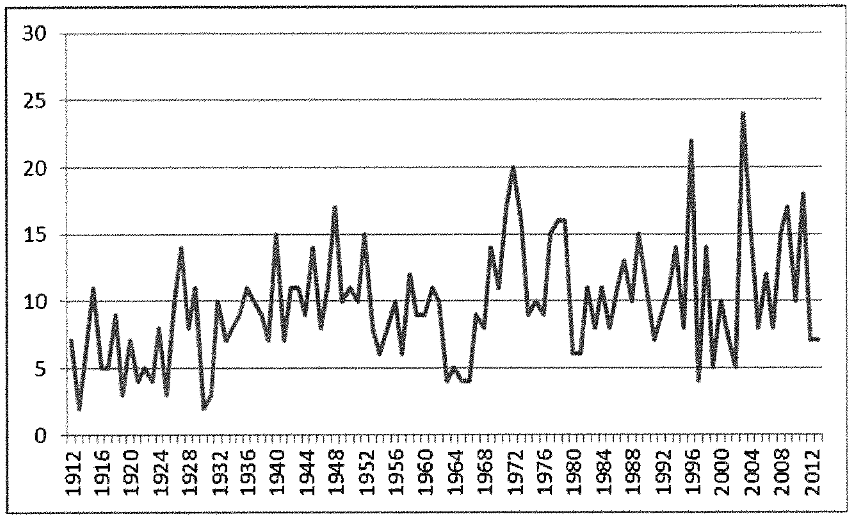
(number)



Note: Hurricanes using Saffir-Simpson Hurricane Scale 1 to 5.

Source: National Oceanic & Atmospheric Administration, Atlantic Oceanographic & Meteorological Laboratory, Hurricane Research Division, July 2, 2013, http://www.aoml.noaa.gov/hrd/tcfaq/E11.html.

Figure 2: Number of floods per year, 1912-2012



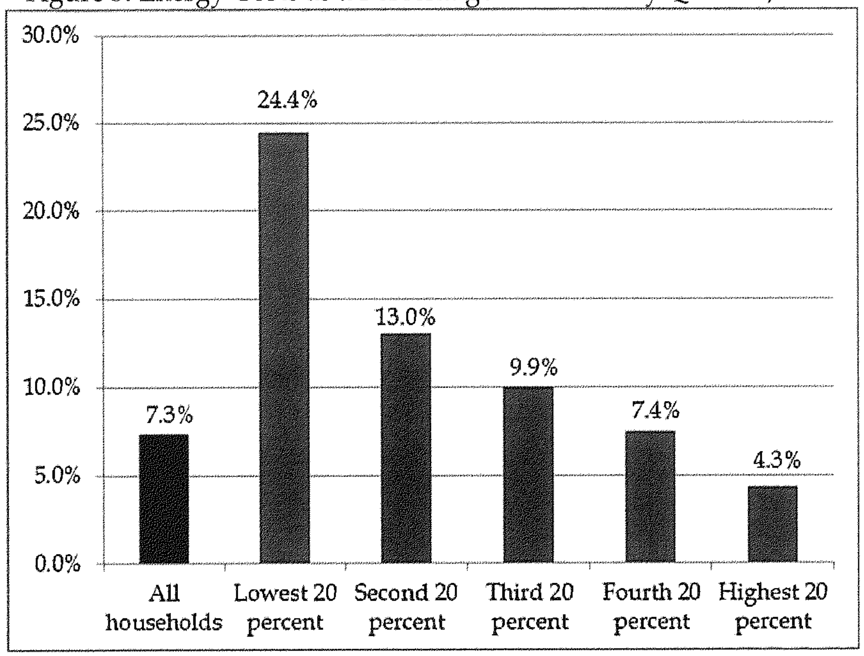
Source: National Oceanic and Atmospheric Administration, *MARFC Flood Events Yearly Summary 1687-2013*, 2013, http://www.erh.noaa.gov/marfc/Rivers/FloodClimo/1687-2013FloodSummaries/1687-2013-Year-Decade-Total-Table.pdf.

Table 1: Energy Costs as a Share of Income by Income Quintile, 2011

	All households	**Lowest 20 percent**	**Second 20 percent**	**Third 20 percent**	**Fourth 20 percent**	**Highest 20 percent**
Income after taxes	$61,673	$10,074	$27,230	$45,563	$72,169	$153,326
Natural gas	$420	$243	$338	$386	$472	$659
Share of income	0.7%	2.4%	1.2%	0.8%	0.7%	0.4%
Electricity	$1,423	$985	$1,234	$1,429	$1,603	$1,863
Share of income	2.3%	9.8%	4.5%	3.1%	2.2%	1.2%
Gasoline and motor oil	$2,655	$1,227	$1,981	$2,694	$3,295	$4,073
Share of income	4.3%	12.2%	7.3%	5.9%	4.6%	2.7%
Sum of natural gas, electricity, and gasoline and motor oil	$4,498	$2,455	$3,553	$4,509	$5,370	$6,595
Share of income	7.3%	24.4%	13.0%	9.9%	7.4%	4.3%

Note: Not all percentages sum because of rounding.
Source: Department of Labor, Bureau of Labor Statistics, *Consumer Expenditure Survey, 2011*, September 25, 2012, and Manhattan Institute calculations.

Figure 3: Energy Costs as a Percentage of Income by Quintile, 2011



Source: Department of Labor, Bureau of Labor Statistics, *Consumer Expenditure Survey, 2011*, September 25, 2012, and Manhattan Institute calculations.

Senator BOXER. Thank you.

And last, but not least, Dr. Robert P. Murphy, Senior Economist, Institute for Energy Research.

STATEMENT OF ROBERT P. MURPHY, SENIOR ECONOMIST, INSTITUTE FOR ENERGY RESEARCH

Mr. MURPHY. Chairman Boxer, Ranking Member Vitter and Members of the Committee, thank you for the opportunity to testify today on this important topic.

The social cost of carbon is a concept that was developed in the academic literature on the economics of climate change. So far, it has been used to help justify over 35 Federal regulations or sometimes more than 20 percent of the alleged benefits of these regulations are derived from the social cost of carbon.

Now, as I will explain, the Administration's calculation or estimate of the social cost of carbon is malleable and arbitrary and therefore is not appropriate for the Federal Government to use to justify regulations. A large fraction of the alleged benefits from reducing carbon dioxide emissions are incredibly speculative as they occur in 50, 100 or even 250 years in the future.

As I will explain, the estimated size of the social cost of carbon is heavily dependent on the discount rate that is used in the analysis, and the Administration on this point has ignored OMB's guidance.

In fact, this concept is so open-ended that we can generate estimated social cost of carbon that are very high, or close to zero, or even negative just by adjusting some key parameters. What this means is that the economists can produce just about any estimate of the social cost of carbon desired.

Now, in theory, the social cost of carbon quantifies in dollar terms the damages from emitting an additional unit of carbon dioxide because of its presumed acceleration of future climate change. As I have said, it has been used to justify policies so it is imposing stricter fuel economy standards by giving quantifiable benefits in dollar terms from these policies' impact on emissions.

The social cost of carbon has been in the news lately because just recently, in May, the Administration's working group, without public comment or notice, dramatically increased its headline estimate of the social cost of carbon by around 50 percent from its previous estimate that was made back in 2010. Back then, it estimated about $22 per ton of CO2 and then now it just bumped it up to $33 a ton, just in May.

Now, to understand where these numbers come from, let me briefly explain how the working group generates its figures. First, they selected three popular models, computer models, from the literature of the Global Economic and Climate System, and then they used those models to run thousand of simulations through the year 2300.

Now, what may surprise you is in these computer simulations chosen by the working group under certain scenarios common dioxide emitted today can sometimes produce net benefits to humanities because, just for example, modest warming can boost agricultural productivity, reduce coal-related deaths in the winter and lower heating bills.

But eventually in these models, they assume that an extra ton of emissions today will start producing net damages. The social cost of carbon then is an estimate of that flow of possible up-front benefits then followed by a flow of damages through the year 2300.

So, given this set up of how they compute this number, the discount rate that we use in the analysis will have a huge impact. Just to give you an example, in the working group's May estimate, the current social cost of carbon is only $11 per ton if we use a 5 percent discount rate, but it is $52 ton if we use a 2.5 percent discount rate.

So, I want to stress that this range in the estimate from $11 up to $52 a ton, that has nothing to do with the climate science. That range itself is driven entirely by just changing the discount rate from 5 percent down to 2.5 percent.

So, you can see in this context how important that choice of discount rate is. And on this matter, it is relevant that the working group explicitly disregarded OMB's clear guidance that when providing cost benefit analysis of Federal regulations, one of the estimates should be computed with a discount rate of 7 percent.

Now, without seeing the actual underlying data we cannot know for sure what the results would have been from the working group's analysis had they reported it at 7 percent, but it probably would have produced a social cost of carbon again following all of their other procedures and just reporting it using 7 percent, a social cost of carbon close to zero, in which case the Administration's rationale for limiting emissions would collapse.

OMB also required that cost benefit analysis be conducted in terms of domestic impacts with the global impacts merely being optional. Yet again, the working group disregarded this clear guidance and just reported the global figure.

Just to give you an example of the impact of that choice, the recent headline figure from the May report of $33 a ton is a global figure. Had they reported just the domestic social cost of carbon, it could have been as low as $2 per ton using the working group's own range of adjustment factors to go from global to domestic.

So, in summary, the social cost of carbon is not an objective feature of the world that is out there that we are waiting for economists to go measure and then give feedback to policymakers. Rather, it is generated within computer simulations that make projections centuries into the future.

Even more troubling, the working group disregarded two OMB guidelines on how to compute and report these figures. Clearly, Federal policy should not be formed on the basis of such a dubious concept.

Thank you.

[The prepared statement of Mr. Murphy follows:]

IER

Written Testimony of

Robert P. Murphy, Senior Economist,

Institute for Energy Research

Before the

Senate Committee on Environment and Public Works

On the Matter of

"The 'Social Cost of Carbon': Some Surprising Facts"

July 18, 2013

1. About IER

The Institute for Energy Research (IER) is a not-for-profit organization that conducts intensive research and analysis on the functions, operations, and government regulation of global energy markets. IER maintains that freely-functioning energy markets provide the most efficient and effective solutions to today's energy and environmental challenges and, as such, are critical to the well-being of individuals and society.

Founded in 1989 from a predecessor nonprofit organization, IER is a public foundation under Section 501(c)(3) of the Internal Revenue Code and is funded entirely by contributions from individuals, foundations, and corporations. Headquartered in Washington, D.C., IER supports public policies that simultaneously promote the welfare of energy consumers, energy entrepreneurs, and taxpayers.

2. Robert P. Murphy Resumé

Robert Murphy earned his Ph.D. in economics from New York University in 2003. From 2003 – 2006 he taught economics at Hillsdale College. After three years teaching, Murphy left academia for the private sector, taking a job with Laffer Investments. In this capacity, Murphy maintained and improved stock selection models, and also helped write research papers for clients.

In the summer of 2007 Murphy joined IER as an economist. His academic research has focused on climate change economics, specifically the proper discount rate to use when evaluating mitigation policies. He has published an academic paper analyzing the assumptions of William Nordhaus' "DICE" integrated assessment model of the global climate and economic system,[1] and has prepared a study for IER on carbon "tax swap" proposals.[2]

3. The "Social Cost of Carbon": Definition and Importance

According to the White House Interagency Working Group assigned to the project, the social cost of carbon is defined as

> an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. [Working Group May 2013, p. 2][3]

The quantitative estimates of the social cost of carbon (SCC) are extremely significant. The Working Group document itself states that the purpose of the SCC estimates "is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions." Some obvious examples of the application of the SCC estimates are fuel economy standards, EPA greenhouse gas regulations, efficiency standards for household appliances, and programs to subsidize so-called "alternative" energy sources and transportation technologies. Critics of the Keystone XL pipeline have recently called for a second look into the environmental impact of the project, citing the SCC as one of the justifications for a revised assessment.

Through its role in justifying regulations and other policy actions that will restrict carbon dioxide emissions, the estimate of the SCC could have profound impacts on both industry and consumers.

4. The "Social Cost of Carbon" Is Not an "Objective" Measurement But Instead a Malleable Concept Dependent on Modeling Assumptions

Because of the significant impact it could have on energy prices and other economic conditions, it is crucial that citizens and policymakers alike realize that the SCC is a very malleable figure. It is *not* analogous to a physical constant such as the charge on an electron or the boiling point of water, with scientists coming up with ever more precise estimates of a feature of nature that is "out there" to be measured. Instead, the estimation of the SCC relies on computer simulations of the economy and climate system for hundreds of years into the future, and furthermore depends on many subjective modeling assumptions. As I will demonstrate, these assumptions can have an enormous impact on the final number, meaning that an analyst can generate just about any SCC he or she wishes by adjusting certain parameters.

Perhaps more significant, when reporting various estimates of the SCC, the White House Working group explicitly disregarded two default guidelines provided by the Office of Management and Budget (OMB) for cost/benefit analysis. Had the Working Group heeded both guidelines, the officially reported SCC would be virtually \$0 if not negative, meaning that there would be no justification for government restriction of carbon dioxide emissions.

A. Choice of Discount Rate

When estimating the social cost of carbon (SCC), the choice of discount rate is crucial, because the computer simulations of large climate change damages occur decades and even centuries in the future, and also because some models show net *benefits* from global warming through the year 2050. Indeed, the patterns in the output of the Working Group's own computer runs suggest that their approach shows net external *benefits* from global warming in the early years. Therefore, the rate at which we discount future impacts (both positive and negative) into present monetary terms will have an enormous impact on the estimated SCC. For example, in the May 2013 Working Group update, the SCC in the year 2010 was reported as $11/ton at a 5% discount rate, but $52/ton at a 2.5% discount rate. In other words, cutting the discount rate in half caused the reported SCC to more than quadruple. Policymakers and citizens should realize just how influential the choice of discount rate is, when it comes to the SCC.

The Office of Management and Budget writes instructions for federal agencies in regulatory analysis. These are called "OMB Circulars." OMB Circular A-4[4] (relying in turn on Circular A-94) states that "a real discount rate of 7 percent should be used as a base-case for regulatory analysis," as this is the average before-tax rate of return to private capital investment. However, Circular A-4 acknowledges that in some cases, the displacement of consumption is more relevant, in which case a real discount rate of 3 percent should be used. Thus it states: "For regulatory analysis, you should provide estimates of net benefits using both 3 percent and 7 percent." Note that Circular A-4 does *not* say that a discount rate should be chosen based on the impacts; instead it says quite clearly that estimates should be made using both rates.

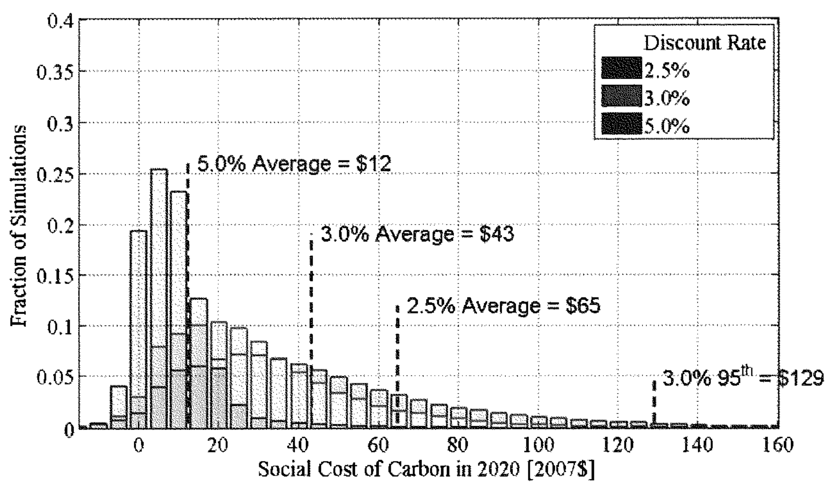
In the economics of climate change academic literature, there are disputes over the proper discount rate, with some economists arguing that very low rates should be used in order to place future generations on a nearly equal footing with the present generation in policy analysis. Circular A-4 and the White House's primer on Circular A-4,[5] explicitly cited the work of Martin Weitzman, one of the leading scholars in the field on this issue, who argues for a low discount rate in climate change analysis.[6] Nonetheless, after this discussion the 2011 primer still concluded:

> If the regulatory action will have important intergenerational benefits or costs, the agency might consider a sensitivity analysis using a lower but positive discount rate, ranging from 1 to 3 percent, **in addition to calculating net benefits using discount rates of 3 percent and 7 percent.** ["Regulatory Impact Analysis: A Primer," p. 12, bold added.]

Yet even though the guidance from OMB was quite explicit on this point, both the initial White House Working Group report from 2010, as well as the recent update in May, did *not* report the SCC using a 7 percent discount rate; they only used discount rates of 2.5, 3, and 5 percent.

This omission of a 7 percent figure masks just how dependent the SCC is on discount rates. As indicated in Figure 1 from the May 2013 update, when the Working Group used a discount rate of 5 percent, more than a fifth of the computer simulations reported a SCC that was near-zero or even *negative*, and that was for the year 2020. (See the three left-most blue bars in Figure 1 below.) If the Working Group ran the computer models again, this time using a 7 percent discount rate and an earlier reference year such as 2015, presumably a larger fraction of simulations would register zero or negative values for the SCC, so that the mean result would itself be closer to zero—or conceivably even negative, meaning that carbon dioxide emissions conferred extra *benefits* on humanity.

FIGURE 1. SOCIAL COST OF CARBON AT VARIOUS DISCOUNT RATES.



SOURCE: Figure 1 in May 2013 White House Working Group on Social Cost of Carbon.

My point in this discussion is not to argue for or against a particular discount rate. Rather, I am demonstrating how crucial this apparently innocuous modeling choice is. Further, in neglecting the clear guidance from OMB on reporting costs and benefits using a 7 percent discount rate, the Working Group on Social Cost of Carbon has misled policymakers, most of whom probably had no idea of the significance of this parameter. If the choice of discount rate means the difference between a SCC of $50/ton versus zero, this is clearly a matter that should not be left to a handful of regulators to decide. It underscores my claim that the "social cost of carbon" is not an objective empirical feature of the world, but is rather a very malleable figure dependent on subjective modeling assumptions, and can be made large, small, or even negative depending on parameter choices.

B. Domestic versus Global Social Cost of Carbon

Related to its decision regarding discount rates, the Working Group has also neglected clear OMB guidance to report costs and benefits from a *domestic* perspective. As the original 2010 Working Group report admits: "Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional" (p. 10). Nonetheless, the Working Group goes on to explain why it will instead use a global perspective in reporting its estimates of the SCC.

Were the Working Group to present its main findings from the domestic perspective, the impact would be striking. Using two different approaches, the Working Group in 2010 "determined that a range of values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic effects. Reported domestic values should use this range" (p. 11).

When the May 2013 update came out, the headline media reports typically focused on the SCC figure for the year 2010 at a 3 percent discount rate, which was $33/ton; this value was often reported as "the" social cost of carbon. Yet this was a *global* estimate of the SCC. If instead the default reports were expressed from the *domestic* perspective, then the same 2010 figure at a 3 percent discount rate would only have been in the range of $2 to $8 per ton.

To see the significance of this decision by the Working Group, consider the following scenario: Suppose the EPA issues a new regulation that causes private industry to restrict carbon emissions, and that the compliance costs (in terms of forfeited economic output in the U.S. because of the new regulation) work out to $25/ton. Using the Working Group's recent headline SCC estimate of $33/ton, this regulation would apparently pass a cost/benefit test, because the $25 cost to American industry for every ton of restricted emissions would be counterbalanced by $33 in avoided future climate change damage. However, *Americans* would still on net be hurt by the regulation, as they would only receive $2 to $8 of the stipulated benefits (i.e. avoiding the *domestic* social cost of carbon on each ton no longer emitted), while suffering the full $25 in compliance costs.

To be sure, as with the discount rate, here too the Working Group gave a justification for its decision to report only the global SCC, rather than following OMB guidelines. I am bringing up this issue merely to show the huge impact their decision has, so that policymakers understand this decision will allow regulations to appear to pass cost/benefit tests when they actually do not confer net benefits on Americans.

5. Conclusion

The American public and policymakers alike have been led to believe that the social cost of carbon is an objective scientific concept akin to the mass of the moon or the radius of the sun. However, although there are inputs from the physical sciences into the calculation, estimates of the social cost of carbon are heavily dependent on modeling assumptions. In particular, if the White House Working Group had followed OMB guidance on *either* the choice of discount rate *or* reporting from a domestic perspective, then the official estimates of the current SCC would probably be close to zero, or possibly even negative—a situation meaning that (within this context) the federal government should be subsidizing coal-fired power plants because their activities confer external benefits on humanity.

The reason for this outcome is that some computer models show significant benefits of global warming through mid-century, and moreover the United States is poised to reap a larger share of the global benefits than the stipulated global damages from climate change. This is why following standard OMB guidelines—by at least providing an estimate of the SCC that uses a 7 percent discount rate and looks at only domestic impacts—would paint a completely different picture from the one that Americans have thus far seen.

Clearly, the public and policymakers have not been fully informed on what the economics profession actually has to say about climate change. Before justifying economically damaging regulations by reference to "the" social cost of carbon, policymakers must realize the dubious nature of this concept.

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[1] Murphy, Robert P. (2009) "Rolling the DICE: William Nordhaus' Dubious Case for a Carbon Tax." *The Independent Review*, vol. 14, no. 2, Fall 2009, pp. 197-217. Available at: http://www.independent.org/pdf/tir/tir_14_02_03_murphy.pdf.
[2] Murphy, Robert P. (2012) "Carbon 'Tax Swap' Deals: A Review and Critique." Institute for Energy Research, November 2012. Available at: http://www.instituteforenergyresearch.org/wp-content/uploads/2012/11/IER-Murphy-Carbon-Tax-Swap-Deals-A-Review-and-Critique.pdf.
[3] Interagency Working Group on Social Cost of Carbon. (2013) "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." May 2013.
[4] OMB Circular A-4 available at: http://www.whitehouse.gov/omb/circulars_a004_a-4.
[5] "Regulatory Impact Analysis: A Primer," available at: http://www.whitehouse.gov/sites/default/files/omb/inforeg/regpol/circular-a-4_regulatory-impact-analysis-a-primer.pdf.
[6] See: http://www.whitehouse.gov/sites/default/files/omb/inforeg/regpol/circular-a-4_regulatory-impact-analysis-a-primer.pdf.

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Response to

Follow-Up Questions Concerning

Dr. Robert P. Murphy's 7/18/13 Testimony Before

Senate Environmental Public Works Committee

On "Climate Change: It's Happening Now" Panel

August 21, 2013

The following is Robert P. Murphy's responses to the follow-up questions from the EPW Committee. The following answers reflect Murphy's views as an economist, and do not necessarily reflect the views of the Institute for Energy Research.

Questions from Senator Sheldon Whitehouse

1. Who has funded the Institute for Energy Research since 2006, and in what amounts? Please supply a full list for the record.

A: Please access and review at your discretion all publicly available IRS Form 990s for the dates you specify. The Institute for Energy Research complies with all disclosure requirements, consistent with federal and state laws governing tax-exempt non-profit organizations.

2. In addition to the Institute for Energy Research, who has funded your policy research since 2005 and in what amounts? Please supply a full list for the record.

A: Please access and review at your discretion all publicly available disclosure forms pertaining to grants, awards, and other compensation I have received from various corporations, foundations, and research organizations.

Questions from Senator David Vitter

1. Dr. Murphy, could you comment on the transparency of the Working Group's reports? For example, can you easily reproduce their results or see what the SCC [social cost of carbon—RPM] would be using a higher discount rate while holding everything else the same?

A: In response to email inquiries, economists who worked on the Working Group report provided me with the necessary inputs to re-run the thousands of computer simulations (on the three different models) that they performed, in order to replicate their results. However, this would mean literally doing all of the work, from scratch, that the Working Group had to perform. Consequently, it would take a professional programmer (working with my oversight) perhaps a month of full-time work to be able to perform a simple calculation such as altering the discount rate and seeing how this changes the computed SCC. In the future, it would be much easier if the Working Group saves intermediate results, to make such permutations far simpler to perform by outside analysts.

2. Can you explain the significance of the choice of discount rate? Can you explain the significance of using the global rather than the domestic perspective?

A: As I explained in my testimony, the Working Group ignored two clear guidelines from OMB on how to report cost/benefit calculations. The first was that an analysis with both a 3% and a 7% discount rate should be used (instead the Working Group offered estimates for 2.5%, 3% and 5%). The second guideline was that cost/benefit calculations should be expressed from a domestic perspective, but instead the Working Group exclusively reported the estimate from a global perspective.

These decisions (to ignore the OMB guidelines) have very significant impacts on the end results publicized by the Working Group. In particular, each decision inflates the social cost of carbon, meaning that federal regulations that reduce carbon dioxide emissions will have larger apparent benefits (using the higher SCC values) than if the SCC had been calculated in accordance with OMB guidelines.

To get a sense of the significance of these factors, consider that the Working Group in its May 2013 update[1] reported the SCC in the year 2015 at a 3% discount rate is at \$38/ton of CO2. Yet the SCC in 2015 (the same year) at a 5% discount rate drops down to a mere \$12/ton, a fall of 68 percent. We can't know precisely what would happen to the SCC if we increased the discount rate by yet another 2 percentage points to 7%, but it would be much closer to \$0/ton, removing the entire rationale for federal regulation of carbon emissions.

(The reason the discount rate has such a dramatic effect on the measured SCC is that the computer models chosen by the Working Group show either modest damage or even outright *benefits* from global warming for the first two degrees Celsius. Thus the harm of a ton of extra CO2 emitted today, actually doesn't "kick in" for a few decades. By using a higher discount rate, these distant damages weigh less heavily in present-dollar calculations.)

As far as the domestic/global perspective, here the issue is that the alleged benefit of reducing carbon dioxide emissions is the reduction in future climate change damages. Since global warming is a global issue, the damage of projected climate change doesn't

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[1] See http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf.

just affect Americans, but the entire world. Consequently, when asking what are the (computer simulated) benefits of reducing emissions, the answer will be smaller if we restrict attention to the benefits that accrue *to Americans*.

In practice, what this means is that a federal regulation that reduces carbon dioxide emissions could appear to pass a cost/benefit test when in reality *Americans* are hurt by it. This is because the benefits would be global, while the costs would largely be suffered by American firms and households.

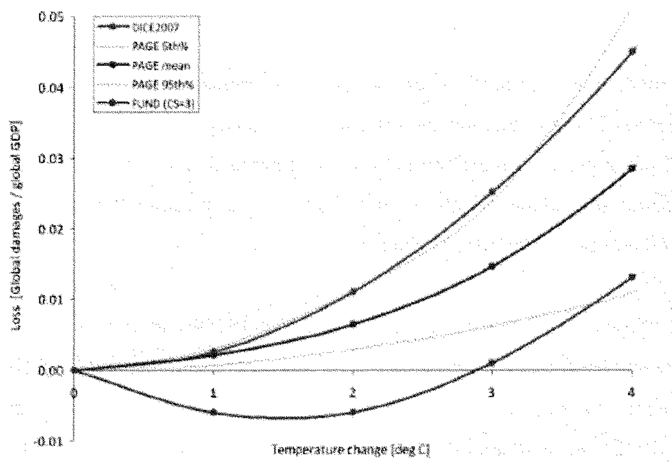
3. You have made a passing reference to a "negative" SCC? What does this mean? Are you saying the Working Group's own simulations show benefits of carbon emissions?

A: A negative SCC means that emitting an extra ton of carbon dioxide confers net social benefits on the world, above and beyond the benefits to the individual doing the emitting. It is the mirror image of the claim that emitting a ton of carbon dioxide confers net damages on other people, that the emitter does not recognize.

In my testimony I pointed out that if the Working Group used a 7% discount rate, it conceivably could have derived a negative SCC. This is possible because one of their models, the FUND model, shows net benefits from global warming through about 2.7 or 2.8 degrees Celsius. This is clear in the 2010 Working Group report,[2] in Figure 1B on page 10 (reproduced below):

[2] See: http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

Figure 1B: Annual Consumption Loss for Lower Temperature Changes in DICE, FUND, and PAGE -



To be clear, the green line in the figure above shows negative losses (i.e. gains) from global warming for temperature changes up to about 2.8 degrees Celsius. Thus, although the DICE and PAGE models show only damages for *any* amount of global warming, the FUND model (chosen by the Working Group because it is a leader in the peer-reviewed literature) shows net benefits for a modest temperature increase. This is why the discount rate plays such a large role in the estimated SCC, since the serious damages are not projected to occur until decades from now.

4. Dr. Murphy, Lloyd's of London recently surveyed almost 600 corporate executives about the risks faced by their businesses. Climate change was ranked #32, behind "piracy" but ahead of "space weather." High taxation was ranked #1. Regulation was ranked #5.

a. Why do you think businesses placed high taxation as #1?

b. *Why do you think they placed taxation, the sort of taxation that Chairman Boxer and Senator Feinstein propose, as the #1 risk they face?*

As the remarks above indicate, even the Obama Administration Working Group's own chosen approach doesn't show significant (net) damages from climate change until decades from now. It is therefore entirely reasonable that businesses would be more worried about immediate threats to their bottom line, meaning taxes loom far more heavily in their minds than climate change.

Taxes are particularly worrisome for business leaders because there is little one can do to prepare for sudden shifts. Businesses can make forecasts about demand for their products, the world price of oil, and so forth, but there is little they can do if the government suddenly decides to raise tax rates. A sudden shift in the tax code can cripple what was otherwise a healthy business model.

5. Do carbon emissions have benefits? Are they quantifiable? If so, were these benefits included in the development of the Social Cost of Carbon?

A: Carbon dioxide emissions clearly have benefits to those responsible for the emissions—for example, the power plants generating electricity, or the motorists driving to work. However, these are "private" benefits that are already accounted for.

In the academic treatment of public policy over climate change, the relevant issue is "social" costs and benefits, meaning costs and benefits that accrue to third parties. As explained above, there *are* indeed "social benefits" of carbon dioxide emissions, according to some leading models—including the FUND model, chosen by the Working Group to include in its suite of models.

Some of these "social benefits" include improved agricultural productivity, and lower heating bills as well as heat-related deaths in the winter (among the elderly, for example).

Indeed, it would be quite a coincidence if there were *no* "social benefits" from carbon dioxide emissions, since that would imply that the earth had been at the optimal (from a human viewpoint) level of CO2 concentrations at the dawn of the Industrial Revolution. There is little reason to think that. Instead, a changing climate has many ramifications, some positive and some negative.

The Working Group included some of these benefits implicitly with its inclusion of the FUND model. However, I would argue that in the climate change literature, there is a tendency to focus on the "negative externalities" rather than the "positive externalities," meaning that in practice the SCC is skewed to focus on the downsides rather than the potential benefits of CO2 emissions.

Senator BOXER. Thank you very, very much.

So, I want to fill everybody in on what is happening on the floor. We are trying to get an agreement, apparently, for a vote at 12:15. This puts a lot of pressure on us. We have got to get to our next panel.

I talked to Senator Vitter and he and I agreed, if each of us could hold our questions to 4 minutes? So, hone in on the one issue that you care about, and the panel can answer succinctly, because we need to move on.

I am going to say this. I am always interested in how these various organizations you represent are funded. So I always look up all the five and obviously the Insurance Association is behind what you said and we looked at all of the others.

I think it is important to note that the two Republican witnesses, there is nothing wrong with this, but I think it is important to note where the funding for your organizations comes from. In the case of Dr. Murphy, it is a, and I will put these documents into the record, it is the ExxonMobil Foundation and one of the main directors on that board of directors is the Managing Director for Federal Affairs at the Koch Brothers.

And Ms. Diane Furchtgott-Roth, who said she was not going to talk about carbon but she was definitely breathing it out which I think we knew but it was good to remind us of that, the Manhattan Institute has accepted almost $2 million from the Koch foundations and also huge amounts of money from ExxonMobil.

I think it is just important to note because I take up what Senator Sanders said and I do not think that it could be overlooked, that 98 percent of the scientists are saying one thing and 2 percent are saying something else. And yet, we have endless money behind the 2 percent, the few. And the tobacco companies tried that. They fought it. They took an oath to tell the truth. They lied. OK? And eventually, the truth came out. And eventually the truth will come out here.

But my point is really repeating what my colleagues have stated. This is not a game. We are playing with the lives of the future generations. I was at that wonderful dedication of the William Jefferson Clinton Building yesterday and I was researching what Teddy Roosevelt said over and over again in different ways. I do not have the exact quote. But what he said is we owe it to our children not to steal their resources. It is dangerous. It is wrong. He said it in a far more eloquent way that I am.

So, I am taken with what you said, Mr. Golden, about doing things that make things worse. The Hippocratic Oath, do no harm. And I want to hone in on the Keystone XL Pipeline, but not really on the pipeline, the pipeline does not do any harm itself, it is what goes into it.

So, I wanted you to explain to us about tar sands. To me, I have been told it is one of the dirtiest fuels on the planet and it would create at least 17 percent more carbon pollution than domestic oil and it could create 30 percent more carbon than domestic oil if the full range of products produced from tar sands crude, such as petroleum coke, is taken into account.

I wanted to ask you, when you say, do not do anything to make it worse, are you thinking about that, tar sands?

Mr. GOLDEN. That is a classic example and one of the most important ones before us right now. That would tap into one of the largest carbon reserves on the planet. Yes, it is dirtier than conventional oil but conventional oil is already causing the climate disruption that we are seeing now. It would prolong the world's addiction to fossil fuels and to oil in particular in ways that would make it impossible to solve climate change in the future by locking in long-term infrastructure decisions that prevent us from reducing our emissions as ambitiously as we need to.

Senator BOXER. Thank you. Senator Vitter.

Senator VITTER. Thank you very much.

I want to go back to a focus of Senator Sessions which is a statement of President Obama and asking for the data, the science behind it. And again, President Obama said "The temperature around the globe is increasing faster than was predicted even 10 years ago.' Do any of the witnesses agree with that statement and, if so, what is the data set you rely on?

Ms. CULLEN. I think right now we need to focus on the fact that the warming is happening very, very quickly and as with respect to the projections of the future, we expect it to warm even more quickly as we go forward. So, with respect to President Obama's specific statement, I cannot comment on that. But the bottom line is that greenhouse gases have continued to move quickly in the atmosphere and the warming has continued.

Senator VITTER. And so you think the surface temperature increase has continued in the last 10 to 15 years?

Ms. CULLEN. Well, as I mentioned in my testimony, I think it is important not to focus specifically on the atmosphere. So, as I said, warming has, the temperature rise has slowed in the atmosphere despite continued warm decades, record-setting decades, the warming over the past 15 years has slowed but, it is——

Senator VITTER. And what would explain that?

Ms. CULLEN. Sir, explaining the fact that the atmosphere temperature rise has slowed is because the warming has gone into other component of our climate system, most notably the deep ocean. So, the warming has by no means stopped. It is merely penetrating into other aspects of our climate system and that is really important to note.

Senator VITTER. OK. And Ms. Cullen, one narrative of this hearing seems to be that extreme weather is dramatically accelerating. Now, most of the folks telling that story and most of your testimony were about examples, anecdotal evidence. And that is relevant but that is obviously not a trend, that is not data, that is not science. So, what scientific trend would you point to with regard to extreme weather?

Ms. CULLEN. Sir, I think there are very clear trends that we can point to, both with respect to heat waves, for example, and heavy downpours. So, for example, in my part of the world, in the Northeast, here was seen a roughly 73 percent increase in heavy downpours. Those heavy downpours have increased across the United States.

Senator VITTER. Over what period of time?

Ms. CULLEN. Starting in the 1950's, moving forward. So, a very significant increase in heavy downpours that we can see in the observational record.

Senator VITTER. Would you point to any other metric besides heavy downpours?

Ms. CULLEN. I would say that we could point to several different metrics. We can see an increasing trend in flood magnitude. When we look at the U.S. as well, we can see that there has been an increase toward drought in the Southwest and that is being pushed by the fact that we are seeing less precipitation out West and we are seeing this increased heat in the West.

Senator VITTER. Well, let me just show you some long-term trends that I think was made available to you because it is part of the testimony of one of our other panelists on panel two. And it seems to suggest a significantly different story and I just wanted you to react. Put those up, quickly.

So, this is heat waves long term. This is drought, long term, the whole 20th Century.

Ms. CULLEN. Sir, I think this is an important issue.

Senator VITTER. Let me just walk through it.

Ms. CULLEN. Sure.

Senator VITTER. These are wildfires, obviously peak here but recently a change.

Senator BOXER. We are going to have to keep it moving, David.

Senator VITTER. Sure. These are cyclone landfalls globally and these are hurricane landfalls in the U.S.

Senator BOXER. We have to move it on.

Senator VITTER. OK, I would just like Dr. Cullen's reaction to that.

Senator BOXER. OK, Dr. Cullen, would you respond?

Ms. CULLEN. Yes. I think there is a really quick response to this and that is it is really important for us to not look at the Nation as this average, that what we are seeing now is how the warming is in specific regions. So, in the Southwest we are seeing this increase in drought and wildfires, in the Midwest and in the Northeast we are seeing this increase in flooding.

So, I think of the observational data record, which you just showed, annually and nationally averaged, but we also have to think of the physical mechanisms so that we know, that as it warms the Southwest will be particularly impacted as we have more moisture in the atmosphere, the Northern tier will see this shift in more storm tracks. So, think of it as a regional signal.

Senator BOXER. OK. I ask unanimous consent to place in the document a NOAA document, Billion Dollars Weather Climate Disasters from 1980 to 2012, which I think everyone will find instructive.

[The referenced information follows:]

Billion-Dollar U.S. Weather/Climate Disasters 1980-2012
National Climatic Data Center Asheville, NC

http://www.ncdc.noaa.gov/billions/

The U.S. has sustained 144 weather/climate disasters since 1980 in which overall damages/costs reached or exceeded $1 billion. Values in parentheses represent the 2013 Consumer Price Index (CPI) cost adjusted value (if different than original value). The total cost of these 144 events exceeds $1 trillion.

2012

U.S. Drought/Heatwave - *2012*: The 2012 drought is the most extensive drought to affect the U.S. since the 1930s. Moderate to extreme drought conditions affected more than half the country for a majority of 2012. The following states were affected: CA, NV, ID, MT, WY, UT, CO, AZ, NM, TX, ND, SD, NE, KS, OK, AR, MO, IA, MN, IL, IN, GA. Costly drought impacts occurred across the central agriculture states resulting in widespread harvest failure for corn, sorghum and soybean crops, among others. The associated summer heatwave also caused 123 direct deaths, but an estimate of the excess mortality due to heat stress is still unknown. Total Estimated Costs: $30.0 (30.3) Billion; 123 Deaths

Western Wildfires - *Summer-Fall, 2012*: Wildfires burned over 9.2 million acres across the U.S. in 2012. This is the 3rd highest annual total since the year 2000. The most damaging wildfires occurred in the western states (CO, ID, WY, MT, CA, NV, OR, WA). Colorado experienced the most costly wildfires (e.g., Waldo Canyon fire) where several hundred residences were destroyed. Total Estimated Costs: $1.0 Billion; 8 Deaths

Sandy - *October 2012*: Extensive damage across several northeastern states (MD, DE, NJ, NY, CT, MA, RI) due to high wind and coastal storm surge, particularly NY and NJ. Damage from wind, rain and heavy snow also extended more broadly to other states (NC, VA, WV, OH, PA, NH), as Sandy merged with a developing Nor'easter. Sandy's impact on major population centers caused widespread interruption to critical water / electrical services and also caused 159 deaths (72 direct, 87 indirect). Sandy also caused the New York Stock Exchange to close for two consecutive business days, which last happened in 1888 due to a major winter storm. Total Estimated Costs: $65.0 (65.7) Billion; 159 Deaths

Hurricane Isaac - *August 2012*: Category 1 hurricane made landfall over Louisiana. Isaac's slow motion and large size led to a large storm surge and flooding rains. This created damage across several southeastern states (LA, MS, AL, FL) including 9 deaths (5 direct, 4 indirect). Total Estimated Costs: $2.3 Billion; 9 Deaths

Plains/East/Northeast Severe Weather - *June 29-July 2 2012*: Sustained outbreak of thunderstorms / high winds from a strong derecho event over the central, eastern, and northeastern states (IL, IN, KY, OH, WV, SC, NC, VA, MD, DC, NJ). Total Estimated Costs: $2.9 Billion; 28 Deaths

Rockies/Southwest Severe Weather - *June 6-12 2012*: Severe storms and damaging hail over several states (CO, NM, TX) with 25 confirmed tornadoes. Colorado experienced over $1.0 billion in damage due to hail. Total Estimated Costs: $2.6 Billion

Southern Plains/Midwest/Northeast Severe Weather - *May 25-30 2012*: Severe storms over the southern plains, midwest and northeast (TX, OK, KS, MN, PA, NY) with 27 confirmed tornadoes. Significant damage also from severe hail and straight-line winds. Total Estimated Costs: $2.3 Billion; 1 Deaths

Midwest/Ohio Valley Severe Weather - *April 28-May 1 2012*: Severe weather over the midwest and Ohio Valley (TX, OK, KS, MO, IL, IN, KY) with 38 confirmed tornadoes. Considerable damage resulting from hail. Total Estimated Costs: $3.3 Billion; 1 Deaths

Midwest Tornadoes - *April 13-14 2012*: Outbreak of tornadoes and severe weather over the midwest (OK, KS, NE, IA) with 98 confirmed tornadoes including many tornadoes that remained on the ground for an extended time - traveling tens of miles. Total Estimated Costs: $1.1 Billion; 6 Deaths

Texas Tornadoes - *April 2-3 2012*: Outbreak of tornadoes across the greater Dallas-Ft. Worth metropolitan area. Several moderate strength tornadoes (EF-2 and EF-3) affected towns in this area with a total of 22 confirmed tornadoes. Total Estimated Costs: $1.0 Billion

Southeast/Ohio Valley Tornadoes - *March 2-3 2012*: Outbreak of tornadoes and severe weather over the southeast and Ohio Valley (AL, GA, IN, OH, KY, TN) with 75 confirmed tornadoes. Total Estimated Costs: $3.1 Billion; 42 Deaths

2011

Southern Plains/Southwest Drought & Heat Wave - *2011*: Drought and heat wave conditions created major impacts across Texas, Oklahoma, New Mexico, Arizona, southern Kansas, and western Louisiana. In Texas and Oklahoma, a majority of range and pastures were classified in "very poor" condition for much of the 2011 crop growing season. Total Estimated Costs: $12.0 (12.4) Billion; 95 Deaths

Texas, New Mexico, Arizona Wildfires - *Summer 2011*: Continued drought conditions and periods of extreme heat provided conditions favorable for a series of historic wildfires across Texas, New Mexico and Arizona. The Bastrop Fire in Texas was the most destructive fire in Texas history destroying over 1,500 homes. The Wallow Fire consumed over 500,000 acres in Arizona making it the largest on record in Arizona. The Las Conchas Fire in New Mexico was also the state's largest wildfire on record scorching over 150,000 acres while threatening the Los Alamos National Laboratory. Over 3 million acres have burned across Texas this wildfire season. Total Estimated Costs: $1.0 Billion; 5 Deaths

Tropical Storm Lee - *September 2011*: Wind and flood damage across the southeast (LA, MS, AL, GA, TN) but considerably more damage from record flooding across the northeast (PA, NY, NJ, CT, VA, MD). Pennsylvania and New York were most affected. Total Estimated Costs: $1.3 Billion; 21 Deaths

Hurricane Irene - *August 2011*: Category 1 hurricane made landfall over coastal NC and moved northward along the Mid-Atlantic Coast (NC, VA, MD, NJ, NY, CT, RI, MA, VT) causing torrential rainfall and flooding across the Northeast. Wind damage in coastal NC, VA, and MD was moderate with considerable damage resulting from falling trees and power lines, while flooding caused extensive flood damage across NJ, NY, and VT. Over seven million homes and businesses lost power during the storm. Numerous tornadoes were also reported in several states further adding to the damage. Total Estimated Costs: $9.8 (10.1) Billion; 45 Deaths

Rockies and Midwest Severe Weather - *July 10-14, 2011*: An outbreak of tornadoes, hail, and high wind caused damage east of the Rockies and across the central plains (CO, WY, IA, IL, MI, MN, OH). Total Estimated Costs: $1.0 Billion; 2 Deaths

Missouri River flooding - *Summer 2011*: Melting of an above-average snow pack across the Northern Rocky Mountains combined with above-average precipitation caused the Missouri and Souris Rivers to swell beyond their banks across the Upper Midwest (MT, ND, SD, NE, IA, KS, MO). An estimated 11,000 people were forced to evacuate Minot, North Dakota due to the record high water level of the Souris River, where 4,000 homes were flooded. Numerous levees were breached along the Missouri River, flooding thousands of acres of farmland. Total Estimated Costs: $2.0 (2.1) Billion; 5 Deaths

Midwest/Southeast Tornadoes and Severe Weather - *June 18-22, 2011*: Outbreak of tornadoes over central states (OK, TX, KS, NE, MO, IA, IL) with an estimated 81 tornadoes. Additional wind end hail damage across the Southeast (TN, GA, NC, SC). Total Estimated Costs: $1.3 Billion; 3 Deaths

Mississippi River flooding - *May 2011*: Persistent rainfall (nearly 300 percent normal precipitation amounts in the Ohio Valley) combined with melting snowpack caused historical flooding along the Mississippi River and its tributaries. Examples of economic damage include: $500 million to agriculture in Arkansas; $320 million in damage to Memphis, Tennessee; $800 million to agriculture in Mississippi; $317 million to agriculture and property in

Missouri's Birds Point-New Madrid Spillway; $80 million for the first 30 days of flood fighting efforts in Louisiana. Total Estimated Costs: $3.0 (3.1) Billion; 7 Deaths

Midwest/Southeast Tornadoes - *May 22-27, 2011*: Outbreak of tornadoes over central and southern states (MO, TX, OK, KS, AR, GA, TN, VA, KY, IN, IL, OH, WI, MN, PA) with an estimated 180 tornadoes. Notably, an EF-5 tornado struck Joplin, MO resulting in at least 160 deaths, making it the deadliest single tornado to strike the U.S. since modern tornado record keeping began in 1950. Total Estimated Costs: $9.1 (9.4) Billion; 177 Deaths

Southeast/Ohio Valley/Midwest Tornadoes - *April 25-28, 2011*: Outbreak of tornadoes over central and southern states (AL, AR, LA, MS, GA, TN, VA, KY, IL, MO, OH, TX,OK) with an estimated 343 tornadoes. The deadliest tornado of the outbreak, an EF-5, hit northern Alabama, killing 78 people. Several major metropolitan areas were directly impacted by strong tornadoes including Tuscaloosa, Birmingham, and Huntsville in Alabama and Chattanooga, Tennessee, causing the estimated damage costs to soar. Total Estimated Costs: $10.2 (10.5) Billion; 321 Deaths

Midwest/Southeast Tornadoes - *April 14-16, 2011*: Outbreak of tornadoes over central and southern states (OK, TX, AR, MS, AL, GA, NC, SC, VA, PA) with an estimated 177 tornadoes. Total Estimated Costs: $2.1 (2.2) Billion; 38 Deaths

Southeast/Midwest Tornadoes - *April 8-11, 2011*: Outbreak of tornadoes over central and southern states (NC, SC, TN, AL, TX, OK, KS, IA, WI) with an estimated 59 tornadoes. Total Estimated Costs: $2.2 (2.3) Billion

Midwest/Southeast Tornadoes - *April 4-5, 2011*: Outbreak of tornadoes over central and southern states (KS, MO, IA, IL, WI, KY, GA, TN, NC, SC) with an estimated 46 tornadoes. Total Estimated Costs: $2.8 (2.9) Billion; 9 Deaths

Groundhog Day Blizzard - *February 1-3, 2011*: A large winter storm impacted many central, eastern and northeastern states. The city of Chicago was brought to a virtual standstill as between 1 and 2 feet of snow fell over the area. Total Estimated Costs: $1.8 (1.9) Billion; 36 Deaths

2010

Arizona Severe Weather - *October 2010*: An unusual series of severe thunderstorms across Arizona produced numerous tornadoes and widespread, severe hail damage. Over one-hundred buildings were damaged or destroyed by tornadoes while thousands of automobiles and buildings were damaged by large hail across Phoenix and surrounding cities. Total Estimated Costs: $2.0 (2.1) Billion

East/South Flooding and Severe Weather - *May 2010*: Flooding, hail, tornadoes, and severe thunderstorms occurred across many Southern states (TN, AR, AL, KY, MS, GA) on April 30-May 2. Flooding in the Nashville, TN area alone contributed > $1.0 billion in damages. Western and Middle Tennessee were hardest hit with local rainfall amounts of 18-20 inches to the south and west of Greater Nashville. Total Estimated Costs: $2.3 (2.5) Billion; 32 Deaths

Oklahoma, Kansas, and Texas Tornadoes and Severe Weather - *May 2010*: An outbreak of tornadoes, hail, and severe thunderstorms occurred across Oklahoma, Kansas, and Texas in mid-May. Oklahoma was hardest hit with > $1.5 billion in damages. Total Estimated Costs: $3.0 (3.2) Billion; 3 Deaths

Northeast Flooding - *March 2010*: Heavy rainfall over portions of the Northeast in late March caused extensive flooding across several states (RI, CT, MA, NJ, NY, PA). The event caused the worst flooding in Rhode Island's history. Total Estimated Costs: $1.5 (1.6) Billion; 11 Deaths

2009

Southwest/Great Plains Drought - *2009*: Drought conditions occurred during much of the year across parts of the Southwest, Great Plains, and southern Texas causing agricultural losses in numerous states (TX, OK, KS, CA, NM, AZ). The largest agriculture losses occurred in TX and CA. Total Estimated Costs: $5.0 (5.4) Billion

Western Wildfires - *Summer/Fall 2009*: Residual and sustained drought conditions across western and south-central states resulted in thousands of wildfires. Most affected states include CA, AZ, NM, TX, OK, and UT. National acreage burned exceeding 5.9 million. Over 200 homes and structures destroyed in the California "Station" fire alone. Total Estimated Costs: $1.0 (1.1) Billion; 10 Deaths

Midwest, South and East Severe Weather - *June 2009*: Sustained outbreak of thunderstorms and high winds from a strong derecho event over the central, southern, and eastern states (TX, OK, MO, NE, KS, AR, AL, MS, TN, NC, SC, KY, PA). Total Estimated Costs: $1.1 (1.2) Billion

South/Southeast Severe Weather & Tornadoes - *April 2009*: Outbreak of tornadoes, hail and severe thunderstorms over the south and southeastern states (AL, AR, GA, KY, MO, SC, TN) with 85 confirmed tornadoes. Total Estimated Costs: $1.2 (1.3) Billion; 6 Deaths

Midwest/Southeast Tornadoes - *March 2009*: Outbreak of tornadoes over central and southern states (NE, KS, OK, IA, TX, LA, MS, AL, GA, TN, KY) with 56 tornadoes confirmed. Total Estimated Costs: $1.0 (1.1) Billion

Southeast/Ohio Valley Severe Weather - *February 2009*: Complex of severe thunderstorms and high winds across the region (TN, KY, OK, OH, VA, WV, PA). Total Estimated Costs: $1.4 (1.5) Billion; 10 Deaths

2008

Widespread Drought - *2008*: Severe drought and heat caused agricultural losses in areas of the south and west. Record low lake levels also occurred in areas of the southeast. Includes states of CA, TX, NC, SC, GA, and TN. Total Estimated Costs: $2.0 (2.2) Billion

U.S. Wildfires - *Fall 2008*: Drought conditions across numerous western, central and southeastern states (AK, AZ, CA, NM, ID, UT, MT, NV, OR, WA, CO, TX, OK, NC, FL) resulted in thousands of wildfires; national acreage burned exceeding 5.2 million acres (mainly in the west) and over 1,000 homes and structures destroyed in California fires alone. Total Estimated Costs: $2.0 (2.2) Billion; 16 Deaths

Hurricane Ike - *September 2008*: Category 2 hurricane makes landfall in Texas, as the largest (in size) Atlantic hurricane on record, causing considerable storm surge in coastal TX and significant wind and flooding damage in TX, LA, AR, TN, IL, IN, KY, MO, OH, MI and PA. Severe gasoline shortages occurred in the southeast U.S. due to damaged oil platforms, storage tanks, pipelines and off-line refineries. Total Estimated Costs: $27.0 (29.2) Billion; 112 Deaths

Hurricane Gustav - *September 2008*: Category 2 hurricane makes landfall in Louisiana causing significant wind, storm surge, and flooding damage in AL, AR, LA, and MS. Total Estimated Costs: $5.0 (5.4) Billion; 53 Deaths

Hurricane Dolly - *July 2008*: Category 2 hurricane makes landfall in southern Texas causing considerable wind and flooding damage in TX and NM. Total Estimated Costs: $1.2 (1.3) Billion; 3 Deaths

Midwest Flooding - *Summer 2008*: Heavy rain and flooding caused significant agricultural loss and property damage in IA, IL, IN, MO, MN, NE, and WI with IA being hardest hit with widespread rainfall totals ranging from 4 to over 16 inches. Total Estimated Costs: $15.0 (16.2) Billion; 24 Deaths

Midwest/Mid-Atlantic Severe Weather - *June 2008*: An outbreak of tornadoes and thunderstorms over the Midwest/Mid-Atlantic states (IA, IL, IN, KS, NE, MI, MN, MO, OK, WI, MD, VA, WV). Total Estimated Costs: $1.1 (1.2) Billion; 18 Deaths

Midwest Tornadoes and Severe Weather - *May 2008* : Outbreak of tornadoes over the Midwest/Ohio Valley regions (IL, IN, IA, KS, MN, NE, OK, WY, CO) with 235 tornadoes confirmed. Total Estimated Costs: $2.4 (2.6) Billion; 13 Deaths

Southeast Tornadoes and Severe Weather - *February 2008*: Series of tornadoes and severe thunderstorms across the Southeast and Midwest states (AL, AR, IN, KY, MS, OH, TN, TX) with 87 tornadoes confirmed. Total Estimated Costs: $1.0 (1.1) Billion; 57 Deaths

2007

Plains/Eastern Drought - *Summer/Fall 2007*: Severe drought with periods of extreme heat over most of the southeast and portions of the Great Plains, Ohio Valley, and Great Lakes area, resulting in major reductions in crop yields, along with very low stream-flows and lake levels. Includes states of ND, SD, NE, KS, OK, TX, MN, WI, IA, MO, AR, LA, MS, AL, GA, NC, SC, FL, TN, VA, WV, KY, IN, IL, OH, MI, PA, NY. Total Estimated Costs: $5.0 (5.6) Billion; 15 Deaths

Western Wildfires - *Summer 2007*: Continued drought conditions and high winds over much of the western U.S. (AK, AZ, CA, ID, UT, MT, NV, OR, WA) resulting in numerous wildfires; with national acreage burned exceeding 8.9 million acres (mainly in the west) and over 3,000 homes and structures destroyed in southern California alone. Total Estimated Costs: $1.0 (1.1) Billion; 12 Deaths

East/South Severe Weather - *April 2007*: Flooding, hail, tornadoes, and severe thunderstorms across numerous states (CT, DE, GA, LA, ME, MD, MA, MS, NH, NJ, NY, NC, PA, RI, SC, TX, VT, VA) in mid-April, including 3 "killer" tornadoes. Total Estimated Costs: $1.5 (1.7) Billion; 9 Deaths

Spring Freeze - *April 2007*: Widespread severe freeze over much of the east and midwest (AL, AR, GA, IL, IN, IA, KS, KY, MS, MO, NE, NC, OH, OK, SC, TN, VA, WV), causing significant losses in fruit crops, field crops (especially wheat), and the ornamental industry. Temperatures in the teens/20s accompanied by rather high winds nullified typical crop-protection systems. Total Estimated Costs: $2.0 (2.2) Billion

California Freeze - *January 2007*: Widespread agricultural freeze -- for nearly two weeks in January, overnight temperatures over a good portion of California dipped into the 20s, destroying numerous agricultural crops; with citrus, berry, and vegetable crops most affected. Total Estimated Costs: $1.4 (1.6) Billion; 1 Deaths

2006

Numerous Wildfires - *2006*: Numerous wildfires mainly over the western half of the country due to dry weather and high winds, burning nearly 10 million acres (new record for period since 1960), with the most affected states being AK, AZ, CA, CO, FL, ID, MT, NM, NV, OK, OR, TX, WA, WY. Total Estimated Costs: $1.0 (1.2) Billion; 28 Deaths

Widespread Drought - *Spring-Summer 2006*: Rather severe drought affected crops especially during the spring-summer, centered over the Great Plains region with other areas affected across portions of the south and far west -- including states of ND, SD, NE, KS, OK, TX, MN, IA, MO, AR, LA, MS, AL, GA, FL, MT, WY, CO, NM, CA. Total Estimated Costs: $6.0 (6.9) Billion

Northeast Flooding - *June 2006*: Severe flooding over portions of the northeast due to several weeks of heavy rainfall, affecting the states of NY, PA, DE, MD, NJ, and VA. Total Estimated Costs: $1.0 (1.2) Billion; 20 Deaths

Midwest/Southeast Tornadoes - *April 6-8, 2006*: Severe weather and numerous tornadoes affecting the states of OK, KS, MO, NE, KY, OH, TN, IN, MS, GA, and AL on April 6-8 with 3 "killer" tornadoes in TN. Total Estimated Costs: $1.5 (1.7) Billion; 10 Deaths

Midwest/Ohio Valley Tornadoes - *April 2-3, 2006*: Significant outbreak of tornadoes and severe weather affecting the states of IL, IN, IA, AR, MO, KY, and **TN** on April 2nd with 5 "killer" tornadoes. Total Estimated Costs: $1.1 (1.3) Billion; 27 Deaths

Severe Storms and Tornadoes - *March 2006*: Outbreak of tornadoes over portions of the midwest and south during a week-long period-affecting the states of AL, AR, KY, MS, TN, TX, IN, KS, MO, and OK. Total Estimated Costs: $1.0 (1.2) Billion; 10 Deaths

2005

Hurricane Wilma - *October 2005*: Category 3 hurricane hits SW Florida resulting in strong damaging winds and major flooding across southeastern Florida. Prior to landfall, Wilma as a Category 5 recorded the lowest pressure (882 mb) ever recorded in the Atlantic basin. Total Estimated Costs: $16.0 (19.0) Billion; 35 Deaths

Hurricane Rita - *September 2005*: Category 3 hurricane hits Texas-Louisiana border coastal region, creating significant storm surge and wind damage along the coast, and some inland flooding in the FL panhandle, AL, MS, LA, AR, and TX. Prior to landfall, Rita reached the third lowest pressure (897 mb) ever recorded in the Atlantic basin. Total Estimated Costs: $16.0 (19.0) Billion; 119 Deaths

Midwest Drought - *Spring, Summer 2005*: Rather severe localized drought causes significant crop losses (especially for corn and soybeans) in the states of AR, IL, IN, MO, OH, and WI. Total Estimated Costs: $1.0 (1.2) Billion

Hurricane Katrina - *August 2005*: Category 3 hurricane initially impacts the U.S. as a Category 1 near Miami, FL, then as a strong Category 3 along the eastern LA-western MS coastlines, resulting in severe storm surge damage (maximum surge probably exceeded 30 feet) along the LA-MS-AL coasts, wind damage, and the failure of parts of the levee system in New Orleans. Inland effects included high winds and some flooding in the states of AL, MS, FL, TN, KY, IN, OH, and GA. Total Estimated Costs: $125.0 (148.8) Billion; 1,833 Deaths

Hurricane Dennis - *July 2005*: Category 3 hurricane makes landfall in western Florida panhandle resulting in storm surge and wind damage along the FL-AL coasts, along with scattered wind and flood damage in GA, MS, and TN. Total Estimated Costs: $2.0 (2.4) Billion; 15 Deaths

2004

Hurricane Jeanne - *September 2004*: Category 3 hurricane makes landfall in east-central Florida, causing considerable wind, storm surge, and flooding damage in FL, with some flood damage also in the states of GA, SC, NC, VA, MD, DE, NJ, PA, and NY. Puerto Rico also affected. Total Estimated Costs: $7.0 (8.6) Billion; 28 Deaths

Hurricane Ivan - *September 2004*: Category 3 hurricane makes landfall on Gulf coast of Alabama, with significant wind, storm surge, and flooding damage in coastal AL and FL panhandle, along with wind/flood damage in the states of GA, MS, LA, SC, NC, VA, WV, MD, TN, KY, OH, DE, NJ, PA, and NY. Total Estimated Costs: $14.0 (17.2) Billion; 57 Deaths

Hurricane Frances - *September 2004*: Category 2 hurricane makes landfall in east-central Florida, causing significant wind, storm surge, and flooding damage in FL, along with considerable flood damage in the states of GA, SC, NC, and NY due to 5-15 inch rains. Total Estimated Costs: $9.0 (11.1) Billion; 48 Deaths

Hurricane Charley - *August 2004*: Category 4 hurricane makes landfall in southwest Florida, resulting in major wind and some storm surge damage in FL, along with some damage in the states of SC and NC. Total Estimated Costs: $15.0 (18.5) Billion; 35 Deaths

Severe Storms, Hail, Tornadoes - *May 2004*: Midwest, South, Southeast, North, Northeast hit by severe weather and tornadoes; Total Estimated Costs: $1.0 (1.2) Billion; 4 Deaths

2003

California Wildfires - *October-November 2003*: Dry weather, high winds, and resulting wildfires in Southern California. More than 743,000 acres of brush and timber burned, over 3,700 homes destroyed. Total Estimated Costs: $2.5 (3.2) Billion; 22 Deaths

Hurricane Isabel - *September 2003*: Category 2 hurricane makes landfall in eastern North Carolina, causing considerable storm surge damage along the coasts of NC, VA, and MD, with wind damage and some flooding due to 4-12 inch rains in NC, VA, MD, DE, WV, NJ, NY, and PA. Total Estimated Costs: $5.0 (6.3) Billion; 55 Deaths

Severe Weather - *July 2003*: Severe storms move across the South, Southeast, Midwest, North, Northeast; Total Estimated Costs: $1.0 (1.2) Billion; 7 Deaths

Severe Storms/Tornadoes - *May 2003*: Numerous tornadoes over the midwest, Mississippi valley, OH/TN valleys, and portions of the southeast, with a modern record one-week total of approximately 400 tornadoes reported; Total Estimated Costs: $3.4 (4.3) Billion; 51 Deaths

Severe Storms/Hail Early - *April 2003*: Severe storms and large hail over the southern plains and lower MS valley, with Texas hardest hit, and much of the monetary losses due to hail. Total Estimated Costs: $1.6 (2.0) Billion; 3 Deaths

2002

Western Fire Season - *September 2002*: Major fires over 11 western states from the Rockies to the west coast, due to drought and periodic high winds, with over 7.1 million acres burned. Total Estimated Costs: $2.0 (2.6) Billion; 21 Deaths

Widespread Drought - *September 2002*: Moderate to extreme drought over large portions of 30 states, including the western states, the Great Plains, and much of the eastern U.S. Total Estimated Costs: $10.0 (12.9) Billion

Severe Storms and Tornadoes - *May 2002*: Numerous tornadoes over the Central and Eastern states (NC, GA, VA, TX, AR, MO, MS, TN, IL, IN, KY, PA, MD, NY, OH, WV, KS). Total Estimated Costs: $1.7 (2.2) Billion; 7 Deaths

2001

Tropical Storm Allison - *June 2001*: The persistent remnants of Tropical Storm Allison produce rainfall amounts of 30-40 inches in portions of coastal Texas and Louisiana, causing severe flooding especially in the Houston area, then moves slowly northeastward; fatalities and significant damage reported in TX, LA, MS, FL, VA, and PA Total Estimated Costs: $5.0 (6.6) Billion; 43 Deaths

Midwest/Ohio Vallley Hail and Tornadoes - *April 2001*: Storms, tornadoes, and hail in the states of TX, OK, KS, NE, IA, MO, IL, IN, WI, MI, OH, KY, WV, and PA, over a 6-day period. Total Estimated Costs: $1.9 (2.5) Billion; 3 Deaths

2000

Drought/Heat Wave - *Spring-Summer 2000*: Severe drought and persistent heat over south-central and southeastern states causing significant losses to agriculture and related industries; Total Estimated Costs: $4.0 (5.4) Billion; 140 Deaths

Western Fire Season - *Spring-Summer 2000*: Severe fire season in western states due to drought and frequent winds, with nearly 7 million acres burned. Total Estimated Costs: $2.0 (2.7) Billion

1999

Hurricane Floyd - *September 1999*: Large, category 2 hurricane makes landfall in eastern NC, causing 10-20 inch rains in 2 days, with severe flooding in NC and some flooding in SC, VA, MD, PA, NY, NJ, DE, RI, CT, MA, NH, and VT. Total Estimated Costs: $6.0 (8.4) Billion; 77 Deaths

Drought/Heat Wave - *Summer 1999*: Very dry summer and high temperatures, mainly in eastern U.S., with extensive agricultural losses. Total Estimated Costs: $1.0 (1.4) Billion; 502 Deaths

OK-KS Tornadoes - *May 1999*: Outbreak of F4-F5 tornadoes h t the states of Oklahoma and Kansas, along with Texas and Tennessee, Oklahoma City area hardest hit. Total Estimated Costs: $1.6 (2.2) Billion; 55 Deaths

AR-TN Tornadoes - *January 1999*: Two outbreaks of tornadoes in 6-day period strike Arkansas and Tennessee; Total Estimated Costs: $1.3 (1.8) Billion; 17 Deaths

Winter Storm - *January 1999*: South, Southeast, Midwest, Northeast affected by damaging winter storm; Total Estimated Costs: $1.0 (1.4) Billion; 25 Deaths

1998

California Freeze - *December 1998*: A severe freeze damaged fruit and vegetable crops in the Central and Southern San Joaquin Valley. Extended intervals of sub 27° F temperatures occurred over an 8-day period. Total Estimated Costs: $2.5 (3.6) Billion

Texas Flooding - *October 1998*: Severe flooding in southeast Texas from 2 heavy rain events, with 10-20 inch rainfall totals; Total Estimated Costs: $1.0 (1.4) Billion; 31 Deaths

Hurricane Georges - *September 1998*: Category 2 hurricane strikes Puerto Rico, Florida Keys, and Gulf coasts of Louisiana, Mississippi, Alabama, and Florida panhandle, 15-30 inch 2-day rain totals in parts of AL/FL; Total Estimated Costs: $5.9 (8.4) Billion; 16 Deaths

Southern Drought/Heat Wave - *Summer 1998*: Severe drought and heat wave from Texas/Oklahoma eastward to the Carolinas; Total Estimated Costs: $7.5 (10.7) Billion; 200 Deaths

Hurricane Bonnie - *August 1998*: Category 3 hurricane strikes eastern North Carolina and Virginia, extensive agricultural damage due to winds and flooding, with 10-inch rains in 2 days in some locations. Total Estimated Costs: $1.0 (1.4) Billion; 3 Deaths

Severe Storms, Tornadoes - *late May-early June 1998*: Severe storms in late May through early June hit the Midwest, North, Northeast, and Southeast; Total Estimated Costs: $1.0 (1.4) Billion; 20 Deaths

Minnesota Severe Storms/Hail - *May 1998*: Very damaging severe thunderstorms with large hail over wide areas of Minnesota; Total Estimated Costs: $1.5 (2.1) Billion; 1 Deaths

Southeast Severe Weather - *Winter-Spring 1998*: Tornadoes and flooding in southeastern states; Total Estimated Costs: $1.0 (1.4) Billion; 132 Deaths

Northeast Ice Storm - *January 1998*: Intense ice storm hits Maine, New Hampshire, Vermont, and New York, with extensive forestry losses; Total Estimated Costs: $1.4 (2.0) Billion; 16 Deaths

1997

Northern Plains Flooding - *Spring 1997*: Severe flooding in Dakotas and Minnesota due to heavy spring snowmelt; Total Estimated Costs: $3.7 (5.4) Billion; 11 Deaths

MS & OH Valleys Flood/Tornadoes - *March 1997*: Tornadoes and severe flooding hit the states of AR, MO, MS, TN, IL, IN, KY, OH, and WV, with over 10 inches of rain in 24 hours in Louisville. Total Estimated Costs: $1.0 (1.5) Billion; 67 Deaths

West Coast Flooding - *December 1996-January 1997*: Torrential rains (10-40 inches in 2 weeks) and snowmelt produce severe flooding over portions of CA, WA, OR, ID, NV, and MT. Total Estimated Costs: $3.0 (4.4) Billion; 36 Deaths

1996

Hurricane Fran - *September 1996*: Category 3 hurricane strikes North Carolina and Virginia, over 10-inch 24-hour rains in some locations and extensive agricultural and other losses. Total Estimated Costs: $5.0 (7.4) Billion; 37 Deaths

Southern Plains Drought - *Fall 1995-Summer 1996*: Severe drought in agricultural regions of southern plains--Texas and Oklahoma most severely affected; Total Estimated Costs: $5.0 (7.4) Billion

Pacific Northwest Severe Flooding - *February 1996*: Very heavy, persistent rains (10-30 inches) and melting snow over OR, WA, ID, and western MT. Total Estimated Costs: $1.0 (1.5) Billion; 9 Deaths

Blizzard/Floods - *January 1996*: Very heavy snowstorm (1-4 feet) over Appalachians, Mid-Atlantic, and Northeast; followed by severe flooding in parts of same area due to rain and snowmelt. Total Estimated Costs: $3.0 (4.4) Billion; 187 Deaths

1995

Hurricane Opal - *October 1995*: Category 3 hurricane strikes Florida panhandle, Alabama, western Georgia, eastern Tennessee, and the western Carolinas, causing storm surge, wind, and flooding damage. Total Estimated Costs: $3.0 (4.6) Billion; 27 Deaths

Hurricane Marilyn - *September 1995*: Category 2 hurricane devastates U.S. Virgin Islands; Total Estimated Costs: $2.1 (3.2) Billion; 13 Deaths

South Plains Severe Weather - *May 1995*: Torrential rains, hail, and tornadoes across Texas-Oklahoma and southeast Louisiana-southern Mississippi, with Dallas and New Orleans areas (10-25 inch rains in 5 days) hardest hit. Total Estimated Costs: $5.5 (8.4) Billion; 32 Deaths

California Flooding - *January-March 1995*: Frequent winter storms cause 20-70 inch rainfall and periodic flooding across much of California; Total Estimated Costs: $3.0 (4.6) Billion; 27 Deaths

1994

Western Fire Season - *Summer-Fall 1994*: Severe fire season in western states due to dry weather; Total Estimated Costs: $1.0 (1.6) Billion

Texas Flooding - *October 1994*: Torrential rain (10-25 inches in 5 days) and thunderstorms cause flooding across much of southeast Texas; Total Estimated Costs: $1.0 (1.6) Billion; 19 Deaths

Tropical Storm Alberto - *July 1994*: Remnants of slow-moving Alberto bring torrential 10-25 inch rains in 3 days, widespread flooding and agricultural damage in parts of Georgia, Alabama, and panhandle of Florida. Total Estimated Costs: $1.0 (1.6) Billion; 32 Deaths

Tornadoes - *April 1994*: South, Southwest, Southeast, Midwest hit by tornadoes. Total Estimated Costs: $(1.5)* Billion; 3 Deaths

Southeast Ice Storm - *February 1994*: Intense ice storm with extensive damage in portions of TX, OK, AR, LA, MS, AL, TN, GA, SC, NC, and VA. Total Estimated Costs: $3.0 (4.7) Billion; 9 Deaths

Winter Damage, Cold Wave - *January 1994*: Winter storm affects Southeast and Northeast; Total Estimated Costs: $1.0 (1.6) Billion; 70 Deaths

1993

California Wildfires - *Fall 1993*: Dry weather, high winds and wildfires in Southern California; Total Estimated Costs: $1.0 (1.6) Billion; 4 Deaths

Southeast Drought/Heat Wave - *Summer 1993*: Southeast Drought and heat wave across Southeastern U.S. Total Estimated Costs: $1.0 (1.6) Billion; 16 Deaths

Midwest Flooding - *Summer 1993*: Severe, widespread flooding in central U.S. due to persistent heavy rains and thunderstorms. Total Estimated Costs: $21.0 (33.8) Billion; 48 Deaths

Storm/Blizzard - *March 1993*: Storm of the Century hits entire eastern seaboard with tornadoes (FL), high winds, and heavy snows (2-4 feet). Total Estimated Costs: $5.5 (8.9) Billion; 270 Deaths

1992

Nor'easter - *December 1992*: Slow-moving storm batters northeast U.S. coast, New England hardest hit. Total Estimated Costs: $1.5 (2.5) Billion; 19 Deaths

Hurricane Iniki - *September 1992*: Category 4 hurricane hits Hawaiian island of Kauai; Total Estimated Costs: $1.8 (3.0) Billion; 7 Deaths

Hurricane Andrew - *August 1992*: Category 4 hurricane hits Florida and Louisiana, high winds damage or destroy over 125,000 homes; Total Estimated Costs: $27.0 (44.8) Billion; 61 Deaths

Severe Storms, Hail - *June 1992*: Severe storms with hail hit Kansas and Oklahoma; Total Estimated Costs: $(1.2)* Billion

Hail, Tornadoes - *April 1992*: Severe Storms hit Oklahoma and Texas with tornadoes and hail; Total Estimated Costs: $1.0 (1.6) Billion

Severe Storms - *March 1992*: Severe storms affect the South, Southeast; Total Estimated Costs: $(1.3)* Billion

1991

Oakland Firestorm - *October 1991*: Oakland, California firestorm due to low humidities and high winds; Total Estimated Costs: $2.5 (4.3) Billion; 25 Deaths

Hurricane Bob - *August 1991*: Hurricane affecting coastal North Carolina, Long Island, and New England. Total Estimated Costs: $1.5 (2.6) Billion; 18 Deaths

Severe Storms, Tornadoes - *March 1991*: Severe storms hit the Midwest, Southeast, Northeast; Total Estimated Costs: $(1.1)* Billion

1990

California Freeze - *December 1990*: Severe freeze in the Central and Southern San Joaquin Valley caused the loss of citrus, avocado trees, and other crops in many areas. Several days of subfreezing temperatures occurred, with some valley locations in the teens. Total Estimated Costs: $3.4 (6.1) Billion

Hail Storm - *July 1990*: Denver, CO (including airport) hit by hail storm; Total Estimated Costs: $(1.4)* Billion

Southern Flooding - *May 1990*: Torrential rains cause flooding along the Trinity, Red, and Arkansas Rivers in TX, OK, LA, and AR; Total Estimated Costs: $1.0 (1.8) Billion; 13 Deaths

1989

Winter Damage, Cold Wave, Frost - *December 1989*: Northeast, Southeast hit by winter storms. Total Estimated Costs: $(1.2)* Billion; 100 Deaths

Hurricane Hugo - *September 1989*: Category 4 hurricane devastates South and North Carolina with ~20 foot storm surge and severe wind damage after hitting Puerto Rico and the U.S. Virgin Islands; Total Estimated Costs: $9.0 (16.9) Billion; 86 Deaths

Northern Plains Drought - *August 1989*: Severe summer drought over much of the northern plains with significant losses to agriculture; Total Estimated Costs: $1.0 (1.9) Billion

Severe Storms - *May 1989*: South, Southeast damaged by severe storms; Total Estimated Costs: $(1.1)* Billion; 21 Deaths

1988

Drought/Heat Wave - *Summer 1988*: 1988 drought in central and eastern U.S. with very severe losses to agriculture and related industries; Total Estimated Costs: $40.0 (78.8) Billion; 7,500 Deaths

1986

Southeast Drought Heat Wave - *Summer 1986*: Severe summer drought in parts of the southeastern U.S. with severe losses to agriculture; Total Estimated Costs: $1.3 (2.8) Billion; 100 Deaths

1985

Hurricane Juan - *October 1985*: Category 1 hurricane--Louisiana and Southeast U.S.-- severe flooding; Total Estimated Costs: $1.5 (3.2) Billion; 63 Deaths

Hurricane Gloria - *September 1985*: Hurrican Gloria moved along the eastern seaboard affecting states from North Carolina to Maine. Total Estimated Costs: $1.0 (2.1) Billion; 11 Deaths

Hurricane Elena - *September 1985*: Category 3 hurricane--Florida to Louisiana; Total Estimated Costs: $1.3 (2.8) Billion; 4 Deaths

Florida Freeze - *January 1985*: Severe freeze central/northern Florida; Total Estimated Costs: $1.2 (2.6) Billion

Winter Damage, Cold Wave - *January 1985*: Extreme cold and winter storms in the Southeast, South, Southwest, Northeast, Midwest, and North; Total Estimated Costs: $(1.2)* Billion; 150 Deaths

1984

Tornadoes, Severe Storms, Floods - *Spring 1984*: Southeast, Northeast hit by tornadoes, severe storms, and floods; Total Estimated Costs: $(1.1)* Billion; 80 Deaths

1983

Florida Freeze - *December 1983*: Severe freeze central/northern Florida; Total Estimated Costs: $2.0 (4.7) Billion

Hurricane Alicia - *August 1983*: Category 3 hurricane--Texas; Total Estimated Costs: $3.0 (7.0) Billion; 21 Deaths

Gulf States Storms and Flooding - *early March 1983*: Severe storms and flooding, especially in the states of TX, AR, LA, MS, AL, GA, and FL; Total Estimated Costs: $1.1 (2.6) Billion; 45 Deaths

Western Storms & Flooding - *late February 1983*: Severe storms and flooding, especially in the states of WA, OR, CA, AZ, NV, ID, UT, and MT; Total Estimated Costs: $1.1 (2.6) Billion; 50 Deaths

1982

Severe storms - *June 1982*: South, Midwest, Southeast and Northeast affected by severe stomrs; Total Estimated Costs: $(1.2)* Billion; 30 Deaths

1981

Severe Storms, Flash Floods, Hail, Tornadoes - *May 1981*: Severe storms in the South, Southeast, and Midwest; Total Estimated Costs: $(1.0)* Billion; 20 Deaths

1980

Drought/Heat Wave - *June-September 1980*: Central and eastern U.S. drought/heat wave caused damage to agriculture and other related industries. Total Estimated Costs: $20.0 (56.4) Billion; 10,000 Deaths

Hurricane Allen - *August 1980*: Hurricane Allen hits Louisanna and Texas; Total Estimated Costs: $(1.7)* Billion; 13 Deaths

**Exceeds one-billion dollar threshold after 2013 Consumer Price Index adjustment*

Caveat for economic loss estimates:

These statistics were taken from a wide variety of sources and represent, to the best of our ability, the estimated total costs of these events -- that is, the costs in terms of dollars that would not have been incurred had the event not taken place. Insured and uninsured losses are included in damage estimates. These estimates are likely to change as damage assessments become more complete. Estimates are periodically updated as more data/information become available. Sources include the National Weather Service, the Federal Emergency Management Agency, US Department of Agriculture, other U.S. government agencies, individual state emergency management agencies, state and regional climate centers, media reports, and insurance industry estimates including Property Claim Services and Munich Re. This report is also available at http://www.ncdc.noaa.gov/billions/ and includes links to detailed technical reports on many of these events.

Authors: Neal Lott, Adam Smith, Tamara Houston, Karsten Shein, Jake Crouch.

Senator Whitehouse.

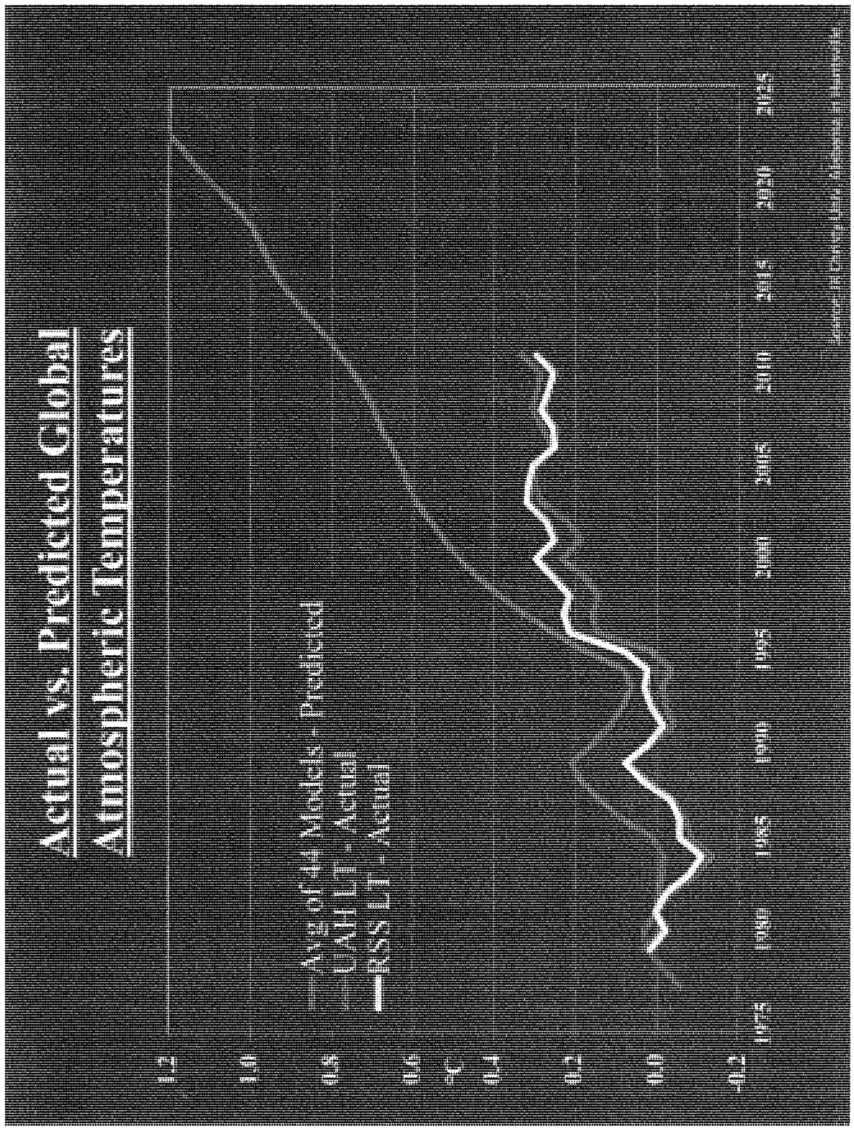
Senator WICKER. Observing the right to object, can Senator Vitter's reduced, well, let me ask unanimous consent that the 8.5 by 11 copy of Senator Vitter's documents also be included in the record.

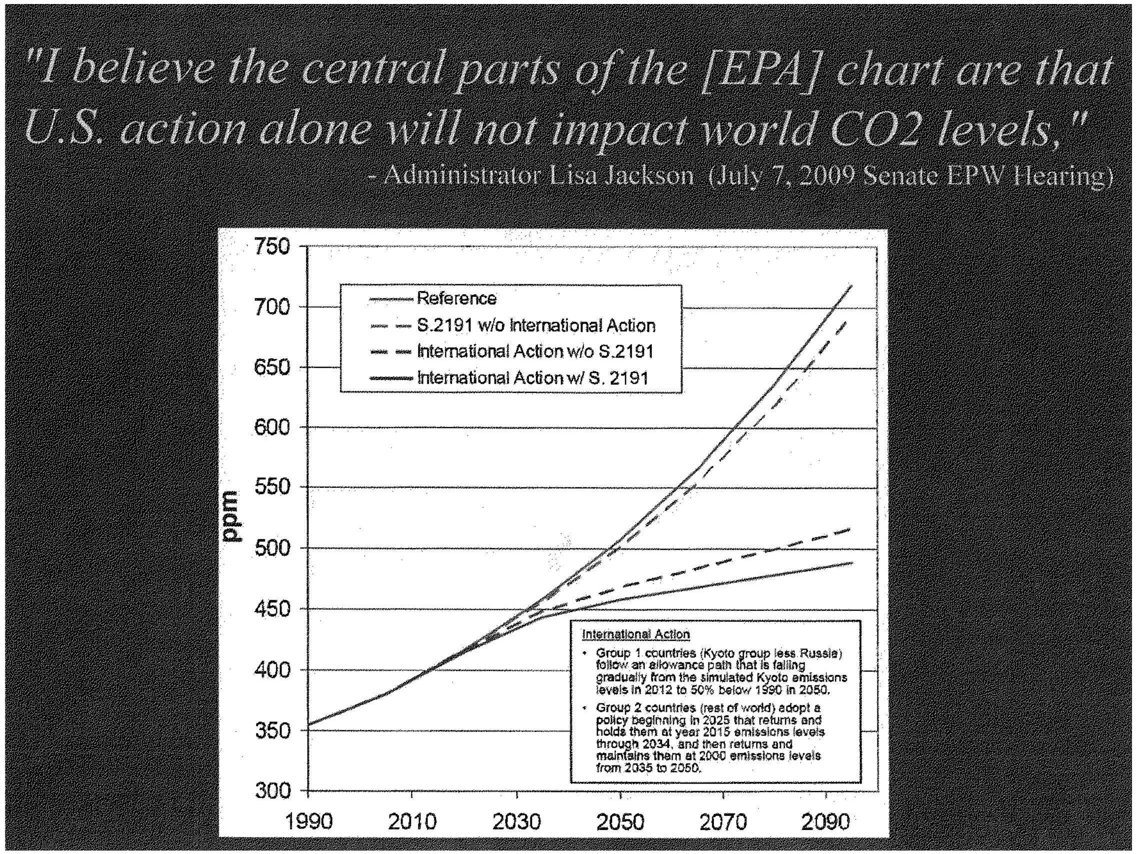
Senator BOXER. Not only can he put it into the record, we will, if I could just say, we will put in any document. We will leave the record open until tomorrow at 10 a.m. Put in anything you want.

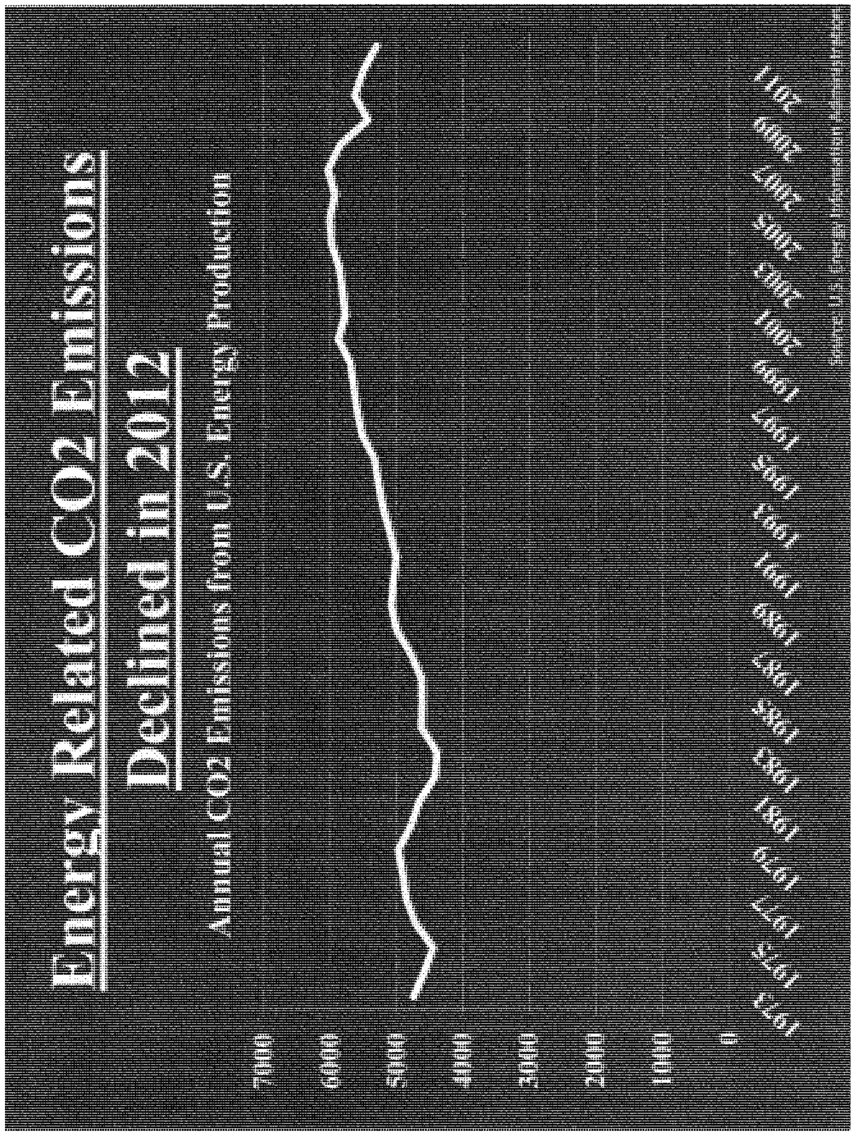
Senator WICKER. I just wanted to make sure that it got in at the same time.

Senator BOXER. Just put in anything that you want, Alice in Wonderland, anything you want.

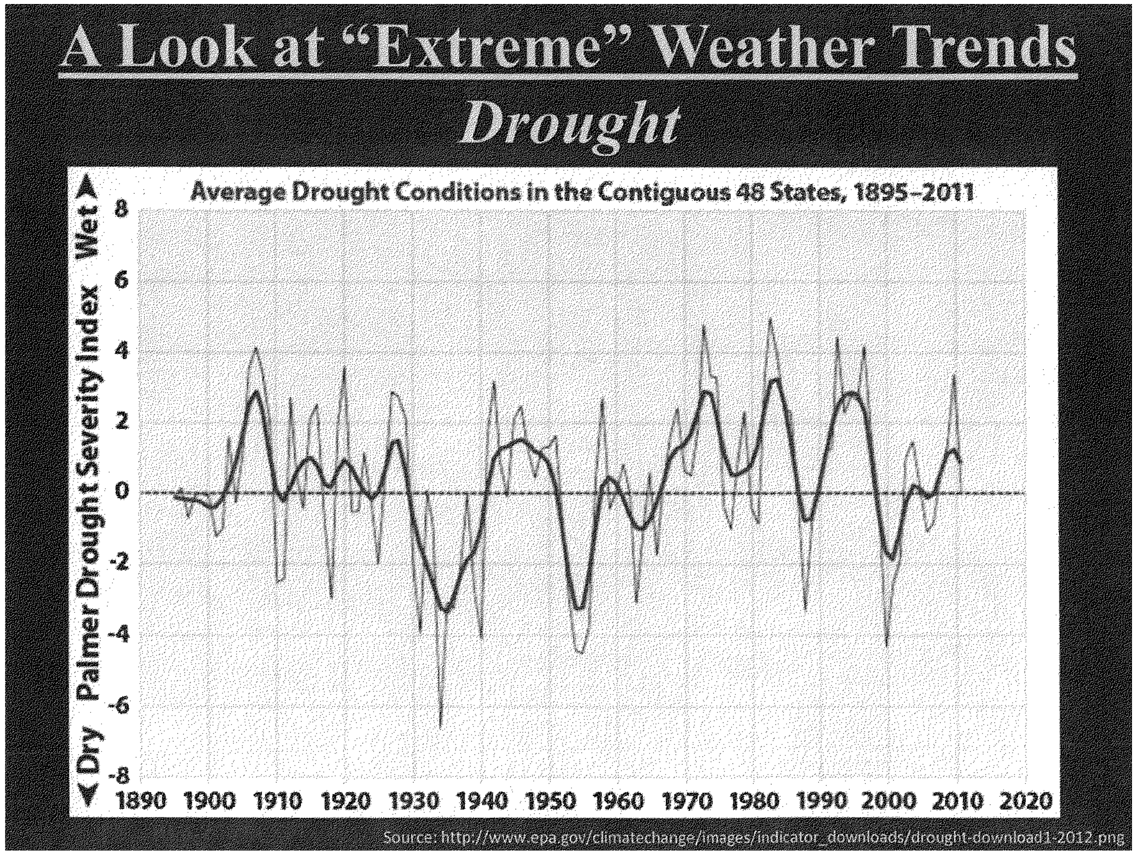
[The referenced information follows:]


Actual vs. Predicted Global
Atmospheric Temperatures
Avg of 44 Models - Predicted
UAH LT - Actual
RSS LT - Actual
°C
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025

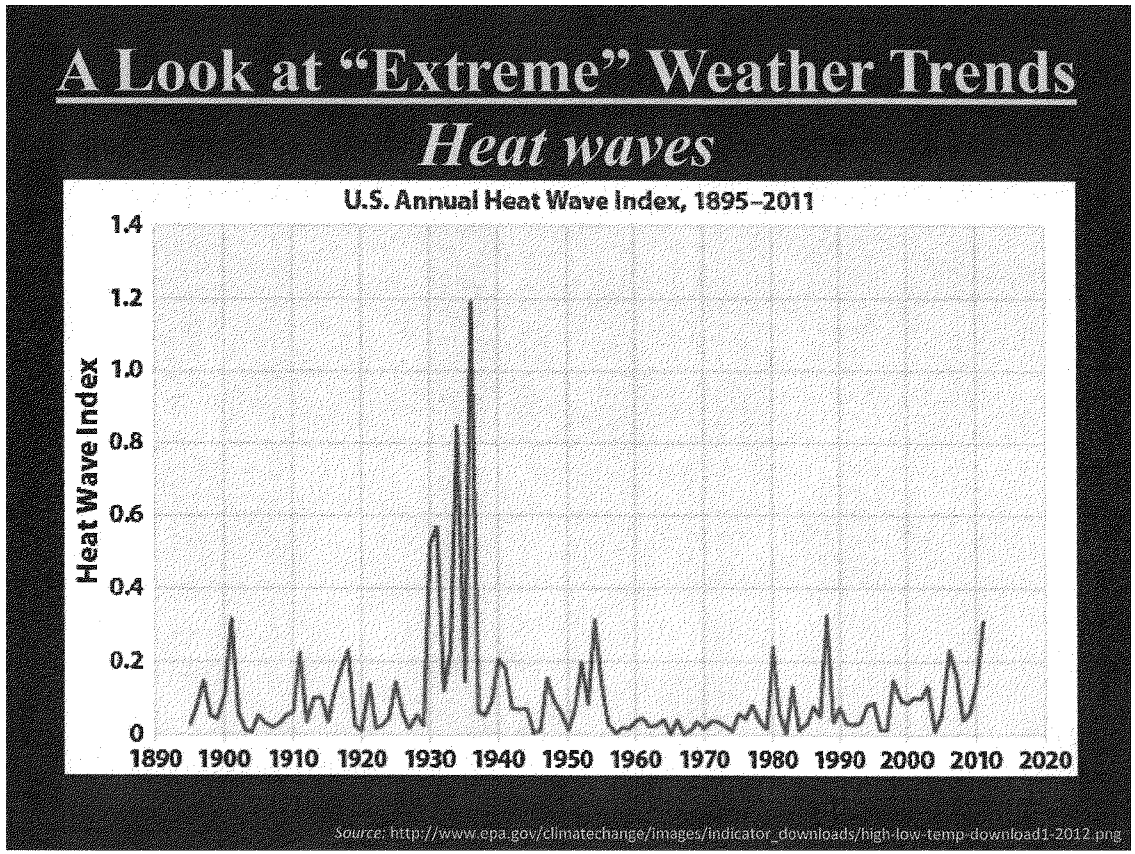

"I believe the central parts of the [EPA] chart are that U.S. action alone will not impact world CO2 levels,"
- Administrator Lisa Jackson (July 7, 2009 Senate EPW Hearing)
ppm
750
700
650
600
550
500
450
400
350
300
1990
2010
2030
2050
2070
2090
Reference
S.2191 w/o International Action
International Action w/o S.2191
International Action w/ S. 2191
International Action
Group 1 countries (Kyoto group less Russia) follow an allowance path that is falling gradually from the simulated Kyoto emissions levels in 2012 to 50% below 1990 in 2050.
Group 2 countries (rest of world) adopt a policy beginning in 2025 that returns and holds them at year 2015 emissions levels through 2034, and then returns and maintains them at 2000 emissions levels from 2035 to 2050.

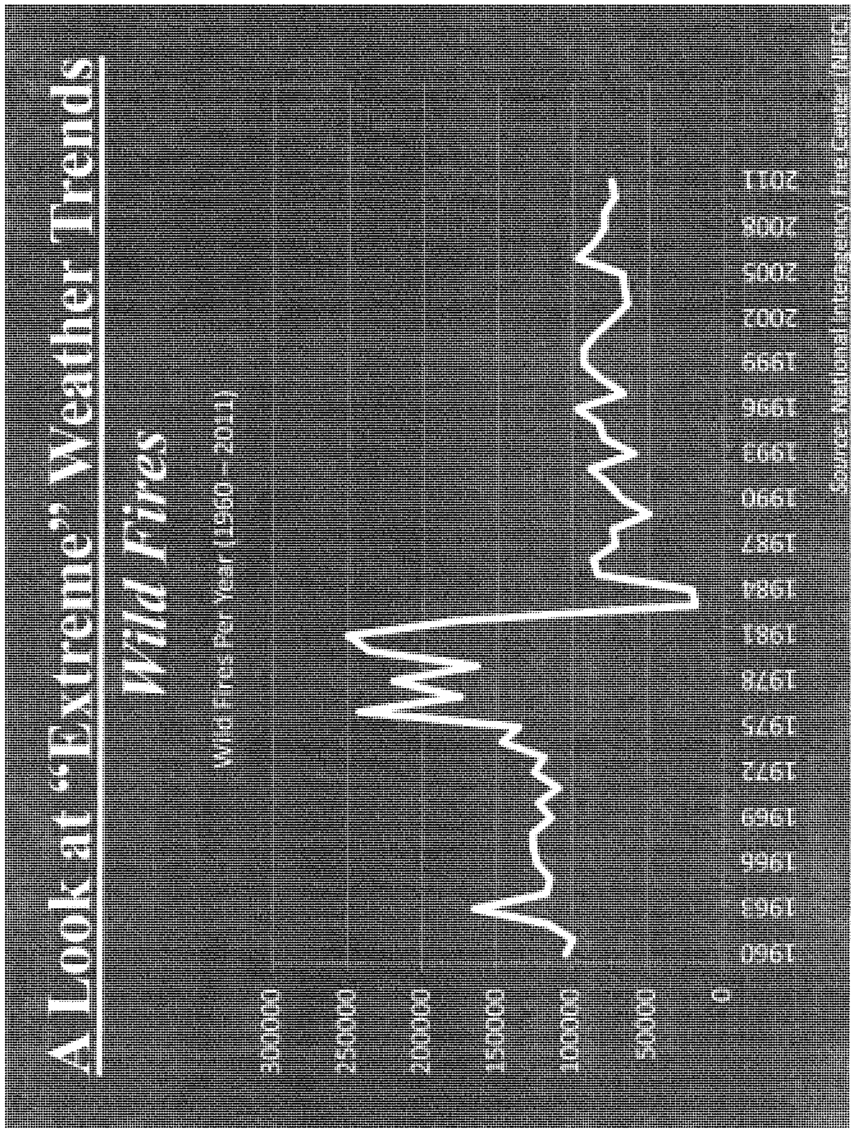


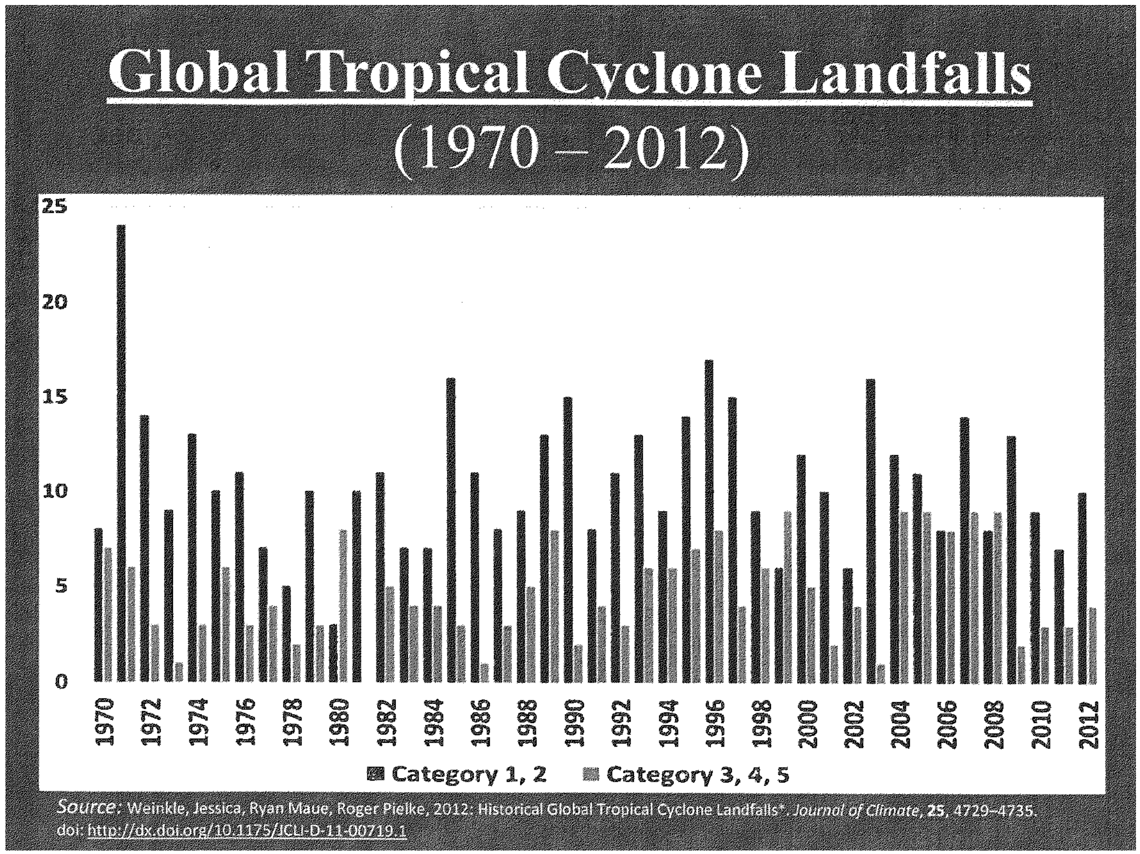
Energy Related CO2 Emissions
Declined in 2012
Annual CO2 Emissions from U.S. Energy Production
7000
6000
5000
4000
3000
2000
1000
0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Source: U.S. Energy Information Administration

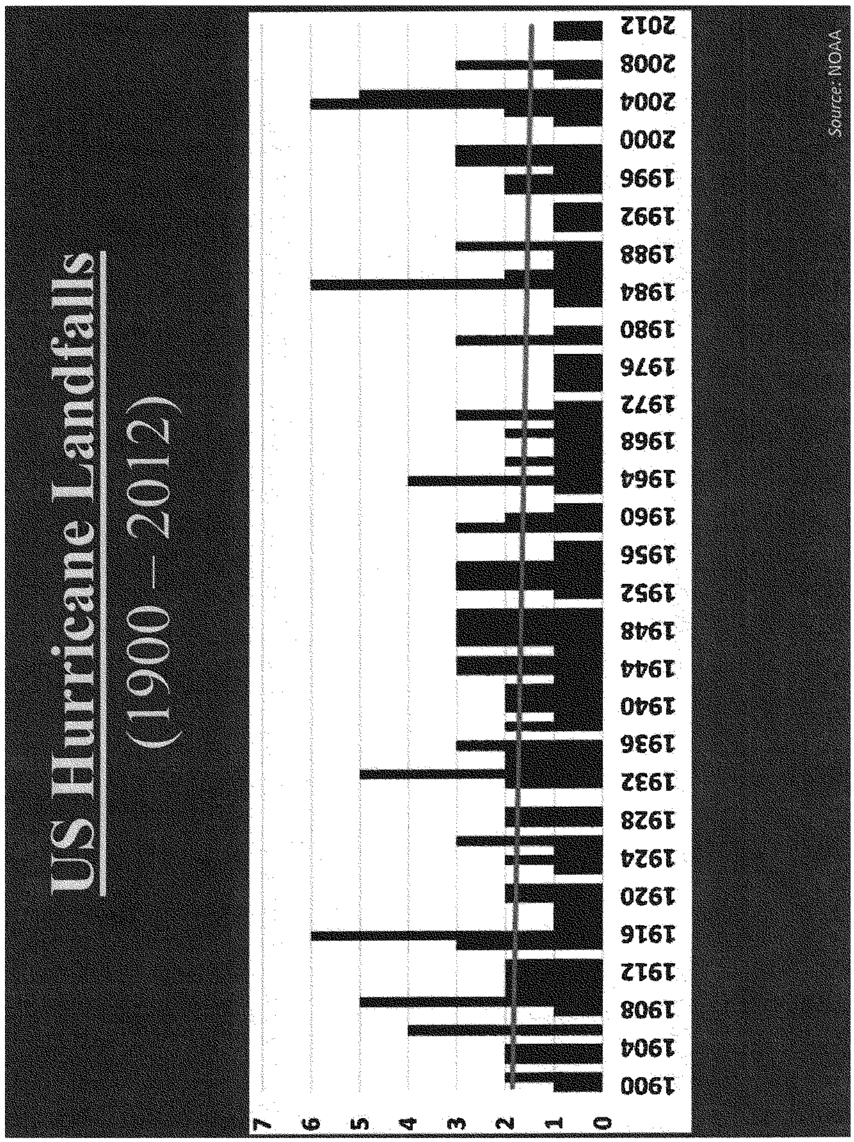


A Look at "Extreme" Weather Trends
Drought
Average Drought Conditions in the Contiguous 48 States, 1895–2011
Dry Palmer Drought Severity Index Wet
8
6
4
2
0
-2
-4
-6
-8
1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020
Source: http://www.epa.gov/climatechange/images/indicator_downloads/drought-download1-2012.png


A Look at "Extreme" Weather Trends
Heat waves
U.S. Annual Heat Wave Index, 1895–2011
Heat Wave Index
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020
Source: http://www.epa.gov/climatechange/images/indicator_downloads/high-low-temp-download1-2012.png


A Look at "Extreme" Weather Trends
Wild Fires
Wild Fires Per Year (1960 – 2011)
300000
250000
200000
150000
100000
50000
0
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
Source: National Interagency Fire Center (NIFC)


Global Tropical Cyclone Landfalls
(1970 – 2012)
25
20
15
10
5
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Category 1, 2
Category 3, 4, 5
Source: Weinkle, Jessica, Ryan Maue, Roger Pielke, 2012: Historical Global Tropical Cyclone Landfalls*. Journal of Climate, 25, 4729–4735.
doi: http://dx.doi.org/10.1175/JCLI-D-11-00719.1


US Hurricane Landfalls
(1900 – 2012)
Source: NOAA
0
1
2
3
4
5
6
7
1900
1904
1908
1912
1916
1920
1924
1928
1932
1936
1940
1944
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
2008
2012

[Laughter.]

Senator BOXER. Senator Whitehouse.

Senator WHITEHOUSE. Well, let me ask my first question of Mr. Nutter. You, in your testimony on pages 5 and 6, show graphs that demonstrate substantial increases in natural catastrophes worldwide and in natural catastrophes in the U.S.A. The change in them, according to the graphs on pages 5 and 6, are demonstrably different for the weather-related catastrophes than for earthquakes which seem to be relatively constant.

We also have testimony in the coming panel from Republican witnesses who all are skeptical about the increase in storm activity. One, for instance, says it is the most indefensible claim regarding climate change, that severe weather has increased.

Could you tell me how confident you are in your data, react to their concerns? And if you do not mind, also give us an estimate of how much money you have riding on getting this right in your industry.

Mr. NUTTER. Thank you, Senator, for the question.

The data that was reflected in the chart that was held up comes from a data base that Munich Re monitors worldwide. There are 33,000 actual events reflected in that. These are real events. It reflects a clear trend in weather and climate-related events. So, these are not, it is not research, it is not models, it is not studies. It is actual real events.

And the reconciliation, in part, I think, comes from what the Congress has done to fund flood control measures. So, for example, the legend, the model or the suggestion that you do not have increases in floods over the last few years is a function in part of what the Army Corps does with levees and dams and water management kinds of things. So, it does not mean that there are not greater precipitation events, as Dr. Cullen refers to, or greater thunderstorms, it just means that we are managing them in a way that has reduced the number of such events.

I also cited in my testimony a study published just in June by AECOM for FEMA and it suggested in forward-looking way that this trend of increased flood plains, as Senator Carper suggested, is pretty clear. Their estimate is that the flood plain areas are going to increase by 45 percent in this Country, the 100-year flood.

So, the data does reflect the real world experience. It is not academic research. And, in fact, you would look at the kind of, the oscillation changes in hurricane patterns reflecting the fact that there is a natural variability in the climate that is probably reflected in some of the analysis by some of the other witnesses.

But indeed you really need to look at this on a forward looking basis, not just a historic basis.

Senator WHITEHOUSE. And what kind of money do you have riding on getting this right in your industry?

Mr. NUTTER. Well, I can give you a number. The reinsurance industry has $312 billion of insurance coverage in place as we speak for natural catastrophe risk on a global basis. The number is the United States is probably $150 billion of that.

Senator WHITEHOUSE. Can you think of any incentive that anybody has in your industry to fake or gimmick this data?

Mr. NUTTER. Absolutely not. Our industry is a risk assessment, risk pricing industry. Our financial success is dependent on getting it right. And we are science-based. We are really dependent upon the scientific assessment that comes from people looking at this on a truly nonpartisan basis.

Senator WHITEHOUSE. Thank you.

Senator BOXER. Thank you. We turn to Senator Sessions next.

Senator SESSIONS. Thank you.

I just noticed that NOAA's report on hurricanes, major hurricanes, for example, per decade show by far the highest number was 41 to 50, with 10 in the last 40 years. The average is 5 major hurricanes a year and the previous 40 years averaged 8 major hurricanes a year. Do you dispute that, Mr. Nutter?

Mr. NUTTER. I would not dispute it if it is hard science. I certainly do not dispute that.

Senator SESSIONS. Well, exactly right. You ask, people talk about we have had more storms and I do not think that is accurate.

Senator BOXER. Can he answer? Could you let him answer, please?

Senator SESSIONS. All right.

Mr. NUTTER. Senator Sessions, I think that everyone would say that in fact what you have is the CATO oscillations in hurricane activity where you have warm periods and less warm periods. So, in the mid–1900's, you clearly had more hurricane activity and then a period without that and now you have a greater hurricane.

Senator SESSIONS. So, in the 1950's, we had clearly greater hurricane activity. I am glad you have indicated that. With regard to tornadoes, this is Dr. Cullen's written testimony, tornado data do not reveal any obvious trends in tornado occurrence or death that would suggest a clear link to global warming. That is your quote, is it not, Dr. Cullen?

Ms. CULLEN. Yes.

Senator SESSIONS. Well, I just think when you change, when your temperature numbers do not hold up, like the models do, we go to things that start, every time there is a drought on the Weather Channel somebody complains about that. We are going to have testimony from a witness in the next panel that pretty much discounts all of those storm data and weather change data as being significantly impacted by the temperature.

So, Senator Vitter asked you about the President's comment and quote. He has repeated it twice. On May 25th he said we also know that the climate warming, that the climate is warming faster than anybody anticipated five or 10 years ago. Do any of you support that statement?

All right. The Economist recently stated "The temperatures have not risen over the past 10 years.' The Economist also stated "Over the past 15 years, air temperatures at the earth's surface have been flat.' The BBC reported "Since 1998, there has been an unexplained standstill in the heating of the earth's atmosphere.'

Now, this chart shows this and the reason, I do not suggest that there is no global warming and the numbers might not go back up next year. I do not know where the numbers are going. What I want to point out is the that the red line averages is the average of the models and what they predict and have been predicting for the last 15 years instead of surging upward like the red line says it has been basically flat as the Economist and the actual temperature data shows.

So, any of you want to comment on that? I think it is an important question. Are the models that we are investing in correct or not?

Senator BOXER. Dr. Cullen wanted to answer and then we are going to move on.

Ms. CULLEN. Thank you.

Senator Sessions, it is an important point. And I just want to point out with respect to that prop that you show in the background, first of all, the warming has continued. The rate of increase has slowed and what you are showing with the red line is the average of 44 models. And I think it is really important to make the point that while we have seen this slow down in warming in the past 15 years, the warming increases, it is still increasing, and it is going into other parts of our climate system.

And so, to make a statement about the climate models here, it is important to say that there are many climate models that still capture what we have witnessed over the past 15 years. It is the lower end of the warming, but it is not to say that the models have been incorrect. Those are two very different things. So, the warming has, indeed, continued.

Senator SESSIONS. For the past 15 years the earth temperatures have been flat, they have not continued to increase.

Ms. CULLEN. Atmospheric temperatures have——

Senator BOXER. I am sorry to cut you both off but we must move because we have a vote at 12:15.

We are going to turn now to Senator Cardin.

Senator CARDIN. Thank you, Madam Chair, and let me thank all of the witnesses for participating in this hearing.

I stepped out for a moment to take a phone call. It was from someone from Baltimore who informed me that the heat index today in Baltimore is 104 degrees for those who might be interested.

I understand that there may be some who question of the negative impact of global warming, that there could be some positive effects from warmer climate, fewer blankets that we need in the wintertime. But let me just point out what is happening in the Chesapeake Bay because of warming is real.

The loss of sea grasses by warmer water is affecting the ecology of the Chesapeake Bay. Rising sea level is creating a security problem for us as we are losing more and more of our shoreline. It is going to cause a problem for national security, the Naval Academy and other facilities that are located along the water. It is also affecting the safety and security of our Country.

So, I know we can debate the impact of global climate change, but it is happening. The question is what impact are we having on that global climate change?

Let me just ask Dr. Cullen, if I might, Senator Sessions talked about the number of hurricanes. I want to talk about the extreme weather conditions and whether we are seeing an increase in extreme conditions. We have had hurricanes that seemed to be of greater intensity that I ever can remember. We are having droughts. We are having floods.

Can you just tell us what impact the rising temperature is having, average temperature is having, on extreme weather conditions, whether they are extremely cold, extremely wet or extremely dry?

Ms. CULLEN. Thank you, Senator Cardin. It is such an important point to just begin to explain how the warming makes its way into the kinds of extremes that we experience every day.

So, you warm the planet about 1.5 degrees, which is what we have seen. We then can expect to see more heat extremes, which we have observed, more heavy downpours because there is now more moisture in the atmosphere being evaporated from the oceans so storms rain down heavier. So, more heat extremes we have observed, more heavy downpours we have observed.

In the North Atlantic Basin, we have seen an increase in hurricane intensity. We are seeing an increase in flood magnitudes specifically in the Northeast and Midwest, and in the Southwest we have seen an increase in droughts and wildfires, an increasing trend.

So, the average temperature's warming is indeed having in impact on extremes that we experience right now.

Senator CARDIN. Well, I think that is an extremely important point. People say, oh, 1 degree, what does that mean? But when you see the types of storms that we have seen and the damage that is has caused, you see the type of moisture and lack of moisture, globally.

We are involved, I serve on the Senate Foreign Committee with Senator Boxer and others on this Committee, and we look at our development assistance and we look at parts of the world where people are fleeing because of the weather causing refugees because of, what we call weather refugees. They have to leave because it is not safe for them to be, their lands are being flooded, their lands are drought, etcetera.

Is the global climate change having an impact globally on vulnerable communities from the point of view of sustainability?

Ms. CULLEN. We absolutely see that those populations that are most vulnerable, and that is true here in the United States as well, are being disproportionately impacted by this warming. So, we need to think about it as a global problem. And there was recent report that came out by the National Academy that showed that we have to prepare for more climate surprises. Climate change, ultimately, it increases our odds of being unlucky. So, we can begin to see these extreme events happen at the same time all over the world which leads us back to Mr. Nutter's point about the incredible costs of these events.

Senator CARDIN. Thank you.

Senator BOXER. Thank you so much.

So, here is where we are. If it is OK with the panel, these will be our last three speakers no matter who walks in the door because we need to move on to the oceans panel. So, if it is OK with everyone, we will go to Senator Fischer, then we will go to Senator Hirono, Senator Wicker, Senator Sanders, and then we will go to the next panel.

Is that OK with everyone? OK. So, we will now turn to Senator Fischer.

Senator FISCHER. Thank you, Madam Chair.

Dr. Murphy, in your testimony you discussed the domestic versus the global social cost of carbon and you note that the working group neglected clear OMB guidance to report costs and benefits from a domestic perspective. This is significant. It is not a wonderland moment. Because Americans are suffering the full costs of complying with new regulations in the name of reducing carbon emissions while only receiving a small portion of the supposed benefits.

Do you believe this issue is being manipulated so that regulations will appear to pass the cost benefit test when they do not actually confer benefits on Americans?

Mr. MURPHY. Well, what I can say is that the working group itself acknowledged in its report saying OMB's guidance says you should report it from a domestic perspective, that is mandatory, and if you want, report your cause benefit from a global, and then they went on to say but we are not going to do that.

So, to answer your question, my guess would be yes, that if they did report because they themselves say only multiplied by 7 to 23 percent if it were to be a domestic calculation. So, what that means is that they justify a regulation and it passes the global cost benefit. In effect, Americans would be suffering the full compliance costs whereas they would only be capturing 7 to 23 percent of even the alleged benefits.

Could I just very briefly talk about the, very quickly, some were suggesting that perhaps these ideas of benefits from warming are outlying estimates and so forth. Everything I said in my testimony is coming just from me explaining what the working group itself says in its reports. The model is showing benefits up through about 2.7 degree Celsius of warming. That was the fund model chosen by the working group. So, that is not me speculating. I am just reporting what their own figures show.

Senator FISCHER. Thank you, Doctor. And Dr. Furchtgott-Roth, when you talked about the green jobs and creating green jobs, what way does that end up costing Americans? You talked about, I took it as manipulating numbers. And yet, what are the benefits from that?

Ms. FURCHTGOTT-ROTH. Right. So, the important thing is that is used as a justification for increases in employment that would occur from using, for example, more solar power, more wind power, whereas really, the higher costs of these energies reduces employment in the United States.

And in my testimony I mentioned a CBO study called How Policies to Reduce Greenhouse Gas Emissions Could Affect Employment and CBO said while the economy was adjusting to the emissions reduction program, a number of people would lose their jobs and some of these people would face prolonged hardship. And the CBO says in cases where a shrinking industry was the primary employer in a community, the entire community would suffer.

So, there are clear negative employment effects from raising a factor for the cost of the factor of reduction. And since the United States in only responsible for 17 percent of global greenhouse gas emissions, and greenhouse gas emissions are shrinking in the United States but they are rising elsewhere, we would put these measures in place, we would not impact global climate change.

To impact global climate change, we need to get China and India to change their emissions which we could do perhaps by persuading them to use different technology, nuclear plants, natural gas powered, electricity generating plants. That would be a far more effective use of funds and it might have an effect in reducing global greenhouse gas emissions.

Senator FISCHER. Thank you very much. And I did appreciate the examples that you gave where we may take a different direction that would have an impact. Thank you.

Ms. FURCHTGOTT-ROTH. Thank you.

Senator BOXER. Thank you so much. We will go to Senators Hirono, Wicker and Sanders. Senator Hirono.

Senator HIRONO. Thank you. Well, regardless of the cause and effect of these extreme weather changes and changes to our ecosystem based on temperature changes, it is happening. We know this. But we obviously have a very strong difference of opinion as to what we ought to do to prevent, mitigate, adapt to these changes.

So, one thing that struck me was Mr. Nutter's testimony because, Mr. Nutter, you represent an industry that is highly, highly sensitive to any events that occur that will cause the insurance companies to have to pay out claims based on events. And you clearly say that there is a trend, that there will be more of these kinds of natural disasters and that the severity will be extreme. That is a fact. Your industry operates on that basis.

You charge your, you set your premiums based on that kind of information. This is hard-nosed decisions that your industry has made. So, knowing all of this, have you not already raised, in terms of both the property side, have insurance companies not already set their rates higher, especially for people who live in coastal areas? Is it not harder to get reinsurance for these areas? That is one.

And then you list a number of suggestions in the last part of your testimony some, I do not know, 20 suggestions of Federal action. Could you talk a little bit about what you consider maybe your top two or three suggestions that you would ask us to pass?

Mr. NUTTER. Certainly. Thank you, Senator. There is no question that the financial success of this industry is dependent upon its appropriate risk pricing and risk assessment process. And, therefore, the industry looks at the scientific elements of sea level rise, greater precipitation events, those kinds of things.

There is no question that in a number of particularly coastal areas that insurance markets have been distressed. Consumers are facing higher premiums as a result of all of that and that is that balance between providing a financial product that is affordable for consumers. So, it is a difficult challenge which is why, in many ways, I focused as you suggest on the kinds of adaptation measures that perhaps would reduce the potential losses of property and life in these areas, a way to also mitigate the costs associated with all of that.

If I were to highlight some of these, I did mention tax credits to individuals that take action to protect their property and their lives as a way to provide incentives for people to do the right thing. I also think that Congress has an opportunity to provide incentives for communities to be more resilient, to prepare better and to respond better.

So, whether it is funding incentives or whether it is conditions associated with disaster assistance when that is paid into these communities, to make certain that in any rebuilding or reconstruction or preparation that indeed the communities are provided with assistance that are going to improve mitigation, setbacks, better building codes, the kinds of things that will reduce damage from these increasing events.

Senator HIRONO. Do you think that the counties that do the zoning and development decisions, that they are taking into consideration that they should very much limit, perhaps, development in the coastal areas?

Mr. NUTTER. My inclination is to think that after events that communities do that. Before events, they do not do enough of that. Communities obviously are driven by tax revenue from development and real eState development and therefore there is that incentive. It creates a moral hazard and the moral hazard is that the risk is being created at the local level but it is really being passed on at the national level in disaster assistance.

Senator HIRONO. Very much so, and the State level also because we experienced Hurricane Iniki in Hawaii in 1982, huge losses and the homeowners' insurance companies just pulled up stakes and said aloha to all of the homeowners. And the State, the State had to step forward and create an insurance fund.

So, this is happening more and more and more and I think that we all need to recognize the realities as your industry has done. Thank you.

Senator BOXER. Thank you. Senator Wicker.

Senator WICKER. Thank you, Madam Chair.

Let me point out in response to what Mr. Nutter said, in the second panel Dr. Pielke will reference a peer-reviewed study which he says is extensive and robust. The Neumayer and Barthel study of 2011 conducted at the London School of Economics and supported financially by Munich Reinsurance conclude "Based on historical data, there is no evidence so far that climate change has increased the normalized economic loss from natural disasters.' That will be in the second panel and for people who will be tuning out, I just wanted to point that out.

Mr. Golden, you talk about climate pollution. You and other people who have spoken in the room today have talked about carbon dumping. Now, when we talk about that, we are talking about carbon dioxide being emitted into the atmosphere. Is that correct?

Mr. GOLDEN. Among other greenhouse gases, yes.

Senator WICKER. Among other greenhouse gases. And Ms. Diana Furchtgott-Roth, you mentioned that you are actually breathing out carbon dioxide as we speak.

Ms. FURCHTGOTT-ROTH. Right. And trees emit it also, plants and trees emit it.

Senator WICKER. That is right. And we are glad of that, are we not?

Ms. FURCHTGOTT-ROTH. We are.

Senator WICKER. So, it would just seem, let me observe that it seems to me that when we talk about carbon dumping or climate pollution as a way to make carbon dioxide sound a little more sinister, I just think it is important to explain what we are talking about when we say greenhouse gases.

Now is it true, Dr. Cullen, that carbon dioxide emissions from most developed countries including the United States have actually dropped in the past decade?

Ms. CULLEN. As a result of the recession here in the U.S., among other things we saw a small tick down in the amount of CO2 being.

Senator WICKER. OK, so that is true. You have said it is because of the recession. I have only got 4 minutes. So, that is actually true.

I would also point out that EPA announced earlier this year that greenhouse gas emissions have been declining since 2007 including a decrease by 1.6 percent between 2010 and 2011, and again we are talking about the very dioxide that I am breathing out at this point.

Now, Ms. Diane Furchtgott-Roth, Mr. Golden talked about an ounce of prevention. And what I want to ask you in my remaining time, is what we are talking about with the Obama administration really just an ounce of prevention? As I understand, what you are saying, these actions will be harmful to the economy, they will raise our energy prices, they will hurt our economy in a way that hits particularly hard at the people at the bottom of the economic spectrum. Is that correct?

Ms. FURCHTGOTT-ROTH. Yes, yes, that is correct. And by the way, I meant to say plants absorb carbon rather than emit it. We emit it, they absorb it. So, I misspoke.

Senator WICKER. And actually plants love it, do they not? They do better with more carbon dioxide.

Ms. FURCHTGOTT-ROTH. Exactly, yes.

But what President Obama is talking about is very wide-ranging regulation on our industries. That is going to effect the lowest fifth of the population greatest.

Senator BOXER. Thank you. Senator Sanders.

Senator SANDERS. Thank you, Madam Chair. I note that I find it interesting that in this discussion of global warming the two Republican representatives admittedly tell us that they are not climatologists, they are economists. And that is fine. But I do find that interesting as we debate how we go forward in addressing the planetary crisis of global warming that neither of the Republican representatives here are talking about global warming.

A second point, and this is not disparaging to either one of these fine panelists here, I am concerned, as you said, Madam Chair, that the Koch Brothers, ExxonMobil and others are pouring well over $100 million into organizations, including both of their organizations, trying to do what the tobacco industry did many, many years ago at such tremendous cost. How many people died because we had doctors coming to Congress raising their hands swearing that tobacco had no impact on cancer, et cetera.

Ms. FURCHTGOTT-ROTH. I have no idea where my organization gets its funds. But I have been writing these materials way before I joined——

Senator SANDERS. OK. I was not disparaging you but I am telling it is a fact.

Senator BOXER. I will put that in the record, where we got that.

Senator SANDERS. All right. We will document where the Manhattan Institute gets its money from.

[The referenced information follows:]

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Subtotal	**$180,000**
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National Bureau of Asian Research*, Seattle, Washington	
General Support	50,000
NBR Chairman's Council	30,000
Pacific Energy Summit	100,000
Subtotal	**$ 180,000**
National Bureau of Economic Research*, Cambridge, Massachusetts	25,000
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General Support	25,500
Subtotal	**$ 46,500**
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Subtotal	**$ 55,000**
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2010 Conference on Arbitration and National Courts: Conflict and Cooperation	5,000
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Other Contributions, each under $5,000	1,300
Total Public Policy Contributions made through the United States	**$7,488,166**
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XTO Energy, Inc.[X]	**$ 6,300**
Total Public Information and Policy Research[#]	**$7,626,366**

Grants made by ExxonMobil Foundation except where indicated by:

* Exxon Mobil Corporation, its divisions and affiliates
x XTO Energy, Inc.

May include cash and in-kind contributions to nonprofit and NGO organizations; direct spending on community-serving projects; social bonus projects required under agreements with host governments by Exxon Mobil Corporation, its divisions and affiliates; and, ExxonMobil's share of community expenditures paid by joint ventures operated by other companies.

Exxon Mobil Corporation
2011 Worldwide Contributions and Community Investments

Public Information and Policy Research

Alliance for Sustainable Energy, LLC*, Golden, Colorado	
Joint Institute for Strategic Energy Analysis	$ 50,000
Alliance To Save Energy*, Washington, D.C.	
2011 Evening with the Stars of Energy Efficiency Awards	20,000
General Support	25,000
American Association of Blacks in Energy*, Washington, D.C.	20,000
American Enterprise Institute for Public Policy Research*, Washington, D.C.	
2011 Annual Dinner	10,000
Energy and Environmental Studies Program	50,000
General Support	235,000
Subtotal	**$295,000**
American Iranian Council, Inc.*, Princeton, New Jersey	15,000
American Legislative Exchange Council*, Washington, D.C.	
General Support	74,000
ALEC States and Nation Policy Summit	12,500
American National Standards Institute*, Washington, D.C.	
International Organization for Standardization	25,000
Americas Society*, New York, New York	15,000
Asia Society Texas Center*, Houston, Texas	25,000
Aspen Institute, Inc.*	
2011 Washington Ideas Forum – Queenstown, Maryland	150,000
Global Energy Forum – Washington, D.C.	100,000
Partners for a New Beginning – Washington, D.C.	100,000
Subtotal	**$350,000**
Atlantic Council of the United States*, Washington, D.C.	25,000
Atlantic Legal Foundation*, New York, New York	5,000
Baker Institute For Public Policy - Rice University*, Houston, Texas	
Energy Forum	50,000
Beacon State Fund*, Austin, Texas	
Governor's Commission for Women	10,000
Bipartisan Policy Center, Inc.*, Washington, D.C.	
Russia Project ($50,000:2011-2012)	25,000
Brookings Institution*, Washington, D.C.	
Corporate Council	265,000
Foreign Policy Conference on the Artic	40,000
Global Economy and Development Program	10,000
Subtotal	**$315,000**
Business Council for International Understanding*, New York, New York	
2011 Dwight D. Eisenhower Global Awards Gala	50,000
General Support	18,000
Global Chiefs of Mission Conference	26,000
Training in Commercial Diplomacy	25,000
Subtotal	**$119,000**
Caribbean-Central American Action*, Washington, D.C.	10,000
Carnegie Mellon University*, Pittsburgh, Pennsylvania	
Electricity Industry Center	50,000
Center for American and International Law, Plano, Texas	
Institute for Energy Law*	8,000
Institute for Transnational Arbitration*	6,500
International and Comparative Law*	5,000
Other Contributions[X], each under $5,000	2,500
Subtotal	**$ 22,000**

Exxon Mobil Corporation
2011 Worldwide Contributions and Community Investments

Public Information and Policy Research

Center for Clean Air Policy*, Washington, D.C.	
Climate Policy Initiative	$ 35,000
Center for Corporate Citizenship at Boston College*, Chestnut Hill, Massachusetts	10,000
Center for Strategic and International Studies*, Washington, D.C.	
Africa Initiative	20,000
Captial Campaign ($5,000,000: 2009-2013)	1,000,000
Conference Support for 2012	50,000
General Support	235,000
Subtotal	**$1,305,000**
Committee Encouraging Corporate Philanthropy*, New York, New York	10,000
Communications Institute*, Northridge, California	75,000
Conference Board, Inc.*, New York, New York	80,000
Congressional Black Caucus Foundation, Inc.*, Washington, D.C.	275,000
Congressional Hispanic Caucus Institute Inc.*, Washington, D.C.	
Annual Legislative Dinner & Golf Tournament	275,000
Corporate Council on Africa*, Washington, D.C.	
8th Annual U.S.- Africa Business Summit	150,000
Luncheon in Honor of Gabonese Republic President Bongo	15,000
Dinner in Honor of South Sudan President Kiir	25,000
General Support	25,000
Subtotal	**$ 215,000**
Council of State Governments*, Lexington, Kentucky	6,000
Council on Foreign Relations, Inc.*	
Africa Initiative – Washington, D.C.	50,000
New York, New York	100,000
Council on Foundations, Inc.*, Arlington, Virginia	15,000
Executive Council on Diplomacy, Inc.*, Washington, D.C.	20,000
Faith & Politics Institute*, Washington, D.C.	50,000
Federalist Society for Law and Public Policy Studies*, Washington, D.C.	15,000
Financial Executives Research Foundation, Inc.*, Morristown, New Jersey	50,000
Florida International University*, Miami, Florida	
Global Energy Outlook	5,000
Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment*, Bozeman, Montana	40,000
Fund for Peace*, Washington, D.C.	
Human Rights & Business Roundtable	15,000
George C. Marshall Research Foundation*, Lexington, Virginia	
2011 George C. Marshall Awards Dinner	25,000
George Mason University Foundation*, Fairfax, Virginia	
Judicial Training Program	20,000
Law & Economics Center	30,000
George Washington University*, Washington, D.C.	
Middle East Policy Forum	50,000
Regulatory Studies Center	50,000
Georgetown University*, Washington, D.C.	
Center for Contemporary Arab Studies	50,000
Science in the Public Interest	100,000
Global Environmental Management Initiative Inc.*, Washington, D.C.	
Local Water Sustainability Tool	10,000
Harvard University*, Cambridge, Massachusetts	
Corporate Social Responsibility Initiative ($200,000: 2010-2011)	100,000

Exxon Mobil Corporation
2011 Worldwide Contributions and Community Investments

Public Information and Policy Research

Henry L. Stimson Center*, Washington, D.C.	$ 25,000
Heritage Foundation, Washington, D.C.	50,000
Institute for Policy Innovation*, Lewisville, Texas	
Annual Dinner	5,000
Institute for Research on the Economics of Taxation*, Washington, D.C.	10,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	5,000
Inter-American Dialogue*, Washington, D.C.	7,200
International Financial Reporting Standards Foundation*, London, United Kingdom	150,000
IPAA Educational Foundation[X], Washington, D.C.	
15th Annual Wildcatters Ball	5,000
Johns Hopkins University, School for Advanced International Studies*, Washington, D.C.	
Foreign Studies Programs	95,000
Global Energy & Environmental Initiative	50,000
Joint Center for Political and Economic Studies*, Washington, D.C.	30,000
Kuwait-America Foundation*, Washington, D.C.	400,000
Latino Leaders Network*, Washington, D.C.	
Latino Leaders Luncheon Series	20,000
Manhattan Institute for Policy Research*, New York, New York	95,000
Massachusetts Institute of Technology*, Cambridge	
Energy Policy Studies	75,000
Mentor Group*, Boston, Massachusetts	
Forum for EU-US Legal-Economic Affaris	35,000
Mercatus Center, Inc.*, Arlington, Virginia	25,000
Meridian International Center*, Washington, D.C.	30,000
Mexican Cultural Institute*, Washington, D.C.	5,000
Middle East Institute*, Washington, D.C.	50,000
Middle East Policy Council*, Washington, D.C.	20,000
Mountain States Legal Foundation*, Lakewood, Colorado	10,000
National Black Chamber of Commerce*, Washington, D.C.	150,000
National Bureau of Asian Research*, Seattle, Washington	
General Support	50,000
NBR Chairman's Council	30,000
Pacific Energy Summit	100,000
Subtotal	**$180,000**
National Bureau of Economic Research*, Cambridge, Massachusetts	25,000
National Center for State Courts*, Williamsburg, Virginia	25,000
National Committee on United States-China Relations*, New York, New York	25,000
National Conference of State Legislatures Foundation*, Denver, Colorado	12,500
National Council on US-Arab Relations*, Washington, D.C.	50,000
National Foreign Trade Council Foundation*, Inc., Washington, D.C.	
World Trade Dinner	15,000
National Foundation for Judicial Excellence*, Chicago, Illinois	10,000
National Governors Association Center for Best Practices*, Washington, D.C.	20,000
National Judicial College*, Reno, Nevada	45,000
National Organization of Black Elected Legislative Women, Inc.*, Denver, Colorado	5,000
National Summit on Africa*, Washington, D.C.	10,000
National Taxpayers Union Foundation*, Alexandria, Virginia	75,000
National Woman's Party*, Washington, D.C.	
Sewell-Belmont House – 2011 Alice Award Luncheon	5,000

Exxon Mobil Corporation
2011 Worldwide Contributions and Community Investments

Public Information and Policy Research

Nicholls State University*, Thibodaux, Louisiana	
National Women's Leadership Summit	$ 10,000
Oxford Institute for Energy Studies*, United Kingdom	35,000
Pacific Legal Foundation*, Sacramento, California	10,000
Peterson Institute for International Economics*, Washington, D.C.	50,000
Pittsburgh Middle East Institute, Inc.*, Pennsylvania	
4th Annual Conference	5,000
Public Affairs Research Council of Louisiana, Inc.*, Baton Rouge	25,000
RAND Corporation*, Santa Monica, California	
Business Leaders Forum	25,000
Rand Institute for Civil Justice*, Santa Monica, California	85,000
Regents of the University of California*, Berkeley	
Lawrence Berkley Laboratory	35,000
Royal United Services Institute*, London, United Kingdom	
Defense and Security Studies	6,527
Seeds of Peace*, New York, New York	
Annual Benefit Dinner	15,000
General Support	75,000
Senate Hispanic Research Council, Inc.*, Austin, Texas	
Luna Scholars Gala	10,000
Southern Governors' Association*, Washington, D.C.	5,000
Stanford University*, California	
Center for International Development	35,000
Institute for Economic Policy Research	50,000
Tax Council Policy Institute*, Washington, D.C.	20,500
Tax Foundation*, Washington, D.C.	
Annual Conference & Dinner	6,000
General Support	25,500
Temple University*, Philadelphia, Pennsylvania	
Judicial Training Program	75,000
Texas Appleseed*, Austin	
Good Apple Dinner	10,000
Texas Equal Access to Justice Foundation*, Austin	
Event Support	15,000
Texas Judicial Foundation*, Austin	20,000
Texas Public Policy Foundation*, Austin	20,000
Texas Southern University*, Houston	
Texas Legislative Internship Program	10,000
Texas Wesleyan University[X], Fort Worth	
Third Annual Energy Symposium	10,000
Transparency International USA*, Washington, D.C.	50,000
U.S. Department of State*, Washington, D.C.	
Experience America – Alaska	25,000
U.S. Ukraine Foundation*, Washington, D.C.	
Ukrainian Independence Day Celebration	5,000
Uniform Law Foundation*, Chicago, Illinois	5,000
United Nations Foundation*, Washington, D.C.	
United Nations Business Council	25,000
United States-Indonesia Society*, Washington, D.C.	100,000
University of Texas at Austin*, Houston	
Center for Energy Economics	5,000

Exxon Mobil Corporation
2011 Worldwide Contributions and Community Investments

Public Information and Policy Research

University of Texas at Dallas*, Richardson	
Corporate Governance Conference	$ 7,500
University of Texas Law School Foundation*, Austin	
2011 Law School Reunion	10,000
General Support	25,000
University of Wyoming Foundation*, Laramie	
Conversations on Democracy	10,000
Washington Legal Foundation*, Washington, D.C.	40,000
Western Governors' Association*, Denver, Colorado	15,000
Women In Government*, Washington, D.C.	
Business Council	20,000
Woodrow Wilson International Center for Scholars*, Washington, D.C.	
Annual Dinner	5,000
Kennan Center	5,000
World Affairs Council*	
Ambassador Luncheons – Dallas, Texas	25,000
Conversations with History – Houston, Texas	15,000
H. Neil Mallon Award Dinner – Dallas, Texas	25,000
Houston, Texas	5,700
Jones Award – Houston, Texas	10,000
Washington, D.C.	35,000
Subtotal	**$ 115,700**
Exxon Mobil Corporation*	
Other Contributions, each under $5,000	17,983
Total Public Policy Contributions made through the United States	**$7,667,910**
Contributions Benefiting Communities in the United States#	**$7,396,950**
Contributions Benefiting Communities outside the United States#	**$ 394,460**
Total Worldwide Public Policy Contributions#	**$7,791,410**
Exxon Mobil Corporation*	**$7,723,910**
ExxonMobil Foundation	**$ 50,000**
XTO Energy, Inc.[X]	**$ 17,500**
Total Public Information and Policy Research#	**$7,791,410**

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x XTO Energy, Inc.

\# May include cash and in-kind contributions to nonprofit and NGO organizations; direct spending on community-serving projects; social bonus projects required under agreements with host governments by Exxon Mobil Corporation, its divisions and affiliates; and, ExxonMobil's share of community expenditures paid by joint ventures operated by other companies.

Exxon Mobil Corporation
2012 Worldwide Contributions and Community Investments

Public Information and Policy Research

American Association of Blacks in Energy*, Washington, D.C.	$ 40,000
American Australian Association*, New York, New York	
2012 Annual Benefit Dinner	100,000
American Enterprise Institute for Public Policy Research*, Washington, D.C.	
2012 Annual Dinner and Irving Kristol Lecture	10,000
General Support	250,000
American Iranian Council*, Princeton, New Jersey	15,000
American Legislative Exchange Council*, Washington, D.C.	
2012 Annual Conference	25,000
Private Sector and Energy and Tax Task Force	34,000
American National Standards Institute*, Washington, D.C.	29,250
Americas Society*, New York, New York	15,000
Asia Society Texas Center*, Houston	
Tiger Ball	25,000
Aspen Institute, Inc.*	
2012 Washington Ideas Forum – Queenstown, Maryland	150,000
Aspen Strategy Group Summer Workshop – Washington, D.C.	25,000
Global Energy Forum and Socrates Program – Washington, D.C.	75,000
Partners for a New Beginning – Washington, D.C.	100,000
Subtotal	**$350,000**
Atlantic Council of the United States*, Washington, D.C.	
2012 Energy and Economic Summit	35,000
President's Circle Corporate Membership	25,000
Atlantic Legal Foundation*, New York, New York	5,000
Baker Institute For Public Policy - Rice University*, Houston, Texas	
Energy Forum	50,000
Beacon State Fund*, Austin, Texas	
Governor's Commission for Women	5,000
Bipartisan Policy Center, Inc.*, Washington, D.C.	
Russia Project ($50,000: 2011-2012)	25,000
Brookings Institution*, Washington, D.C.	
Africa Growth Initiative	15,000
Corporate Council	265,000
Business Civic Leadership Center*, Washington, D.C.	25,000
Business Council for International Understanding*, New York, New York	
Dwight D. Eisenhower Global Awards Gala	25,000
General Support	18,000
Global Chiefs of Mission Conference Programs	30,000
Training in Commercial Diplomacy	25,000
Other Contributions, each under $5,000	1,500
Subtotal	**$ 99,500**
Carnegie Endowment for International Peace*, Washington, D.C.	25,000
Carnegie Mellon University*, Pittsburgh, Pennsylvania	
Electricity Industry Center	100,000
Center for American and International Law*, Plano, Texas	
Institute for Energy Law	8,000
Institute for Transnational Arbitration	6,500
International and Comparative Law	5,000
Other Contributions, each under $5,000	3,000
Subtotal	**$ 22,500**

Exxon Mobil Corporation
2012 Worldwide Contributions and Community Investments

Public Information and Policy Research

Center for Clean Air Policy*, Washington, D.C.	
Climate Policy Initiative	$ 35,000
Center for Corporate Citizenship at Boston College*, Chestnut Hill, Massachusetts	10,000
Center for National Policy*, Washington, D.C.	25,000
Center for Strategic and International Studies*, Washington, D.C.	
Africa Initiative	25,000
Capital Campaign ($5,000,000: 2009-2013)	1,000,000
General Support	235,000
Subtotal	**$1,260,000**
China Business Forum, Inc.*, Washington, D.C.	
U.S. China Legal Cooperation Fund	25,000
Colorado School of Mines*, Golden, Colorado	
Unconventional Hydrocarbon Resources Education and Training Program	333,334
Committee Encouraging Corporate Philanthropy*, New York, New York	10,000
Conference Board, Inc.*, New York, New York	80,000
Congressional Black Caucus Foundation, Inc.*, Washington, D.C.	275,000
Congressional Hispanic Caucus Institute*, Washington, D.C.	
Annual Legislative Dinner	200,000
Corporate Council on Africa*, Washington, D.C.	35,000
Council of State Governments*	
General Support – Lexington, Kentucky	6,000
Midwestern Legislative Conference – Lombard, Illinois	10,000
Toll Fellowship Program – Lexington, Kentucky	25,000
Council on Foreign Relations, Inc.*, New York, New York	
Africa Initiative – Washington, D.C.	50,000
New York, New York	100,000
Council on Foundations, Inc.*, Arlington, Virginia	15,000
Durham University*, United Kingdom	
Middle East Studies	7,848
Eisenhower Exchange Fellowships Inc.*, Philadelphia, Pennsylvania	
Chairman's Circle Membership	250,000
Eurasia Foundation, Inc.*, Washington, D.C.	
Sarah Carey Dinner	25,000
Executive Council on Diplomacy, Inc.*, Washington, D.C.	20,000
Faith & Politics Institute*, Washington, D.C.	25,000
Federalist Society for Law and Public Policy Studies*, Washington, D.C.	15,000
Financial Executives Research Foundation, Inc.*, Morristown, New Jersey	50,000
Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment*, Bozeman, Montana	40,000
Fund for Peace*, Washington, D.C.	
Human Rights & Business Roundtable	15,000
George Mason University Foundation*, Fairfax, Virginia	
Law & Economics Center	50,000
George Washington University*, Washington, D.C.	
Middle East Policy Forum	50,000
Regulatory Studies Center	95,000
Georgetown University*, Washington, D.C.	
Center for Contemporary Arab Studies	50,000
Science in the Public Interest	50,000

Exxon Mobil Corporation
2012 Worldwide Contributions and Community Investments

Public Information and Policy Research

Heritage Foundation*, Washington, D.C.	$ 50,000
Institute for Research on the Economics of Taxation*, Washington, D.C.	10,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	5,000
Inter-American Dialogue*, Washington, D.C.	7,560
International Conservation Caucus Foundation*, Washington, D.C.	25,000
International Financial Reporting Standards Foundation*, London, United Kingdom	150,000
Johns Hopkins University, School for Advanced International Studies*, Washington, D.C.	
Foreign Studies Programs	65,000
2012Conference on U.S.-Vietnam Relations	10,000
Joint Center for Political and Economic Studies*, Washington, D.C.	30,000
Kuwait-America Foundation*, Washington, D.C.	400,000
Latino Leaders Network*, Washington, D.C.	
Luncheon Speaker Series	20,000
Manhattan Institute for Policy Research*, New York, New York	35,000
Massachusetts Institute of Technology*, Cambridge	
Energy Policy Studies	85,000
Mercatus Center, Inc.*, Arlington, Virginia	25,000
Meridian International Center*, Washington, D.C.	25,000
Mexican Cultural Institute*, Washington, D.C.	5,000
Middle East Institute*, Washington, D.C.	50,000
Middle East Policy Council*, Washington, D.C.	20,000
Mountain States Legal Foundation*, Lakewood, Colorado	10,000
National Black Chamber of Commerce*, Washington, D.C.	125,000
National Bureau of Asian Research*, Seattle, Washington	
Center for Health and Aging	50,000
NBR Chairman's Council	30,000
Pacific Energy Summit	100,000
Presidential Campaign Debate on Asia Policy	5,000
Subtotal	**$185,000**
National Bureau of Economic Research*, Cambridge, Massachusetts	25,000
National Center for State Courts*, Williamsburg, Virginia	25,000
National Conference of State Legislatures Foundation*, Denver, Colorado	
NCSL Foundation Support	12,500
Women's Network Alliance	5,000
National Council on US-Arab Relations*, Washington, D.C.	50,000
National Foreign Trade Council Foundation, Inc.*, Washington, D.C.	
Global Innovation Forum Steering Committee	25,000
World Trade Dinner	15,000
National Foundation for American Policy*, Arlington, Virginia	7,500
National Foundation for Judicial Excellence*, Chicago, Illinois	10,000
National Governors Association Center for Best Practices*, Washington, D.C.	20,000
National Judicial College*, Reno, Nevada	60,000
National Organization of Black Elected Legislative Women, Inc.*, Denver, Colorado	5,000
National Taxpayers Union Foundation*, Alexandria, Virginia	75,000
National Womans Party*, Washington, D.C.	
Sewall-Belmont House & Museum – Alice Awards Luncheon	5,000
Oxford Institute for Energy Studies*, United Kingdom	35,000
Pacific Legal Foundation*, Sacramento, California	10,000

Exxon Mobil Corporation
2012 Worldwide Contributions and Community Investments

Public Information and Policy Research

Pennsylvania State University*, University Park	
Unconventional Hydrocarbon Resources Education and Training Program	$333,334
Peterson Institute for International Economics*, Washington, D.C.	105,000
Public Affairs Research Council of Louisiana, Inc.*, Baton Rouge	25,000
Rand Institute for Civil Justice*, Santa Monica, California	85,000
Regents of the University of California*, Berkeley	
Lawrence Berkley Laboratory	35,000
Regents of the University of California*, Davis	
Institute for Transportation Studies	40,000
Resources for the Future*, Washington, D.C.	
Center for Climate and Electricity Policy	25,000
Seeds of Peace*, New York, New York	
Annual Benefit Dinner	50,000
General Support	50,000
Skinner Leadership Institute, Inc.*, Tracy's Landing, Maryland	
Master Series for Distinguished Leaders Reception	15,000
Southern Governors' Association*, Washington, D.C.	5,000
Southern Methodist University*, Dallas, Texas	
John Goodwin Tower Center for Political Studies	10,000
Stanford University*, California	
Center for International Development	35,000
Institute for Economic Policy Research	35,000
Tax Council Policy Institute*, Washington, D.C.	20,500
Tax Foundation*, Washington, D.C.	
Annual Conference & Dinner	6,000
General Support	25,500
Other Contributions, each under $5,000	1,000
Subtotal	**$ 32,500**
Texas Appleseed*, Austin	
Good Apple Dinner	10,000
Texas Civil Rights Project*, Austin	5,000
Texas Defender Service*, Houston	5,000
Texas Equal Access to Justice Foundation*, Austin	20,000
Texas Judicial Foundation*, Austin, Texas	20,000
Texas Southern University*, Houston	
Texas Legislative Internship Program	10,000
Transparency International USA*, Washington, D.C.	
General Support	50,000
Integrity Award Dinner	5,000
UN Women for Peace Inc.*, New York, New York	50,000
United Nations Foundation*, Washington, D.C.	
United Nations Business Council	25,000
United States Council Foundation, Inc.*, New York, New York	
Creating U.S. Jobs in a World of Global Value Chains	50,000
United States Energy Association*, Washington, D.C.	
U.S.-China Oil & Gas Industry Forum	10,000
United States-Indonesia Society*, Washington, D.C.	100,000

Exxon Mobil Corporation
2012 Worldwide Contributions and Community Investments

Public Information and Policy Research

University of Texas at Austin*	
Center for Energy Economics – Houston, Texas	$ 5,000
Unconventional Hydrocarbon Resources Education and Training Program	333,334
University of Texas at Dallas*, Richardson	
Corporate Governance Conference	7,500
University of Texas Law School Foundation*, Austin	
Center for Women in Law	10,000
General Support	10,000
Law Center for Energy, International Arbitration and Environmental Law	5,000
Subtotal	**$ 25,000**
Washington Legal Foundation*, Washington, D.C.	40,000
Western Governors' Association*, Denver, Colorado	15,000
Women In Government Foundation Inc.*, Washington, D.C.	
2012 Energy Summit	5,000
Business Council	20,000
Woodrow Wilson International Center for Scholars*, Washington, D.C.	
Africa Program	10,000
Annual Award for Public Service Dinner	25,000
Artic Energy Seminar	5,000
Awards Dinner – Dallas, Texas	25,000
Canada Institute	15,000
Kennan Center	5,000
Subtotal	**$ 85,000**
World Affairs Council*	
2012 Academic WorldQuest – Washington, D.C.	35,000
Andrew Card Luncheon – Houston, Texas	5,000
Annual Dinner – Washington, D.C.	5,000
Ambassador Luncheons – Dallas, Texas	10,000
Dillon Anderson Lecture Luncheon – Houston, Texas	5,000
General Support – Houston, Texas	5,000
H. Neil Mallon Award Dinner – Dallas, Texas	25,000
Jones International Citizen Award Luncheon – Houston, Texas	10,000
Subtotal	**$ 100,000**
Exxon Mobil Corporation*	
Other Contributions, each under $5,000	17,300
Total Public Policy Contributions made through the United States	**$8,469,460**
Contributions Benefiting Communities in the United States#	**$8,276,612**
Contributions Benefiting Communities outside the United States#	**$ 311,448**
Total Worldwide Public Policy Contributions#	**$8,588,060**

Exxon Mobil Corporation
2012 Worldwide Contributions and Community Investments

Public Information and Policy Research

Exxon Mobil Corporation*	**$8,588,060**
Total Public Information and Policy Research#	**$8,588,060**

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Acton Institute for the Study of Religion and Liberty, Grand Rapids, Michigan	$ 50,000
Advertising Council, Inc., New York, New York	20,000
AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C.	25,000
Africa Grantmakers Affinity Group*, New York, New York	
Membership	7,500
Africa Society*, Washington, D.C.	25,000
Africare*, Washington, D.C.	10,000
American Conservative Union Foundation, Alexandria, Virginia	50,000
American Council for Capital Formation Center for Policy Research, Washington, D.C.	360,000
American Council on Germany, Inc.*, New York, New York	
John J. McCloy Award Dinner	10,000
American Council on Science and Health, New York, New York	25,000
American Enterprise Institute for Public Policy Research, Washington, D.C.	
Annual Dinner*	5,000
General Operating Support	235,000
American Friends of Lubavitch*, Washington, D.C.	
Annual Benefit Event	5,000
American Legislative Exchange Council, Washington, D.C.	
Annual Conference*	90,000
Energy Sustainability Project	80,000
General Operating Support	71,500
Subtotal	**$ 241,500**
American Spectator Foundation*, Arlington, Virginia	15,000
Americas Society, Inc.*, New York, New York	
Sponsorship Dinner	10,000
Annapolis Center for Science-Based Public Policy Inc., Maryland	30,000
Arab American Institute Foundation*, Washington, D.C.	
Kahlil Gibran Awards	10,000
Asia Society*, Washington, D.C.	
Annual Dinner	25,000
General Operating (including DC Metro and NY)	45,000
Silver Anniversary Tiger Ball 2005 – Houston, Texas	25,000
Subtotal	**$ 95,000**
Asian American Journalists Association*, San Francisco, California	
Annual National Convention	5,000
Aspen Institute, Inc.*, Queenstown, Maryland	10,000
Atlas Economic Research Foundation, Arlington, Virginia	100,000
Baker Institute For Public Policy – Rice University*, Houston, Texas	
Energy Forum Membership	50,000
National Oil Companies Study	10,000
Brookings Institution, Washington, D.C.	
General Operating Support*	95,000
Project Support	75,000
Business Council for International Understanding*, New York, New York	
Commercial Diplomacy Program	50,000
Capital Research Center, Washington, D.C.	50,000
Center for American and International Law, Plano, Texas	
CAIL Rogers Award Dinner (February 2006)'	6,000
Institute for Energy Law	8,000
Institute for Transnational Arbitration	6,500
International and Comparative Law	5,000
Other contributions*, each under $5,000	2,500
Other contributions, each under $5,000	100
Subtotal	**$ 28,100**

Center for Strategic and International Studies Inc., Washington, D.C.	
Conference Support*	25,000
General Operating Support	150,000
Other contributions*, each under $5,000	2,500
Subtotal	$ **177,500**
Center for the Defense of Free Enterprise, Bellevue, Washington	60,000
Center for the Study of Carbon Dioxide and Global Change, Tempe, Arizona	25,000
Central and East European Law Initiative institute, Washington, D.C.	
General Operating Support	50,000
Judge and Lawyer Training Program ($100,000: 2002–2005)	25,000
Centre for New Europe – USA, Washington, D.C.	50,000
City of Irving*, Texas	
8th Annual Texas Transportation Summit	5,000
Committee for a Constructive Tomorrow, Washington, D.C.	90,000
Communications Institute*, Pasadena, California	75,000
Competitive Enterprise Institute, Washington, D.C.	
General Operating Support	90,000
General Operating Support*	180,000
Congress of Racial Equality, New York, New York	75,000
Congressional Black Caucus Foundation, Inc.*, Washington, D.C.	
Annual Legislative Dinner	15,000
Corporate Council on Africa*, Washington, D.C.	
General Operating Support	10,000
US-Africa Business Summit	100,000
Council of State Governments*, Lexington, Kentucky	6,000
Council on Foreign Relations, Inc.*, New York, New York	
Africa Initiative	*50,000*
Annual Corporate Membership	*60,000*
Annual Subscription to Corporate Program	60,000
Roundtable Dinner – Washington, D.C.	*3,000*
Subtotal	$ **173,000**
CPR institute for Dispute Resolution, Inc.*, New York, New York	10,000
East-West Center*, Washington, D.C.	
Membership – US Asia Pacific Council	15,000
Eisenhower Exchange Fellowships Inc., Philadelphia, Pennsylvania	
2005 Arab Middle East Program	40,000
Environmental Law Institute*, Washington, D.C.	
Star Sponsor – October 19,2005 Award Dinner	10,000
Environmental Literacy Council, Washington, D.C.	50,000
Federal Focus*, Washington, D.C.	
Data Quality Rapid Response Fund	125,000
Federalist Society for Law and Public Policy Studies, Washington, D.C.	15,000
Financial Executives Research Foundation, Inc.*, Florham Park, New Jersey	10,000
Florida International University*, Miami	5,000
Foreign Policy Association*, New York, New York	15,000
Foundation for American Communications*, Pasadena, California	50,000
Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment, Bozeman, Montana	*30,000*
Foundation for the Center for Energy, Marine Transportation and Public Policy at Columbia University*, New York, New York	*75,000*
Foundation of the International Association of the Defense Counsel, Chicago, Illinois	10,000
Free Enterprise Education Institute, Inc., Potomac, Maryland	*70,000*
Frontiers of Freedom Institute, Chantilly, Virginia	
Annual Gala and General Operating Support*	*50,000*
General Operating Support	90,000
Fund for Peace*, Washington, D.C.	15,000

George C. Marshall Institute, Washington, D.C.	
Awards Dinner and General Operating Support*	*25,000*
General Operating Support	90,000
George Mason University Foundation, Inc., Fairfax, Virginia	
Law & Economics Center	*30,000*
Georgetown University, Center Contemporary Arabic Studies, Washington, D.C.	*30,000*
Heartland Institute, Chicago, Illinois	
General Operating Support*	90,000
General Operating Support	29,000
Henry L. Stimson Center, Washington, D.C.	10,000
Heritage Foundation, Washington, D.C.	30,000
Hoover Institution, Stanford, California	20.000
Houston Bar Foundation Records Preservation*, Texas	
Historic Court Records Preservation	10,000
Houston Forum*, Texas	6,500
Hudson Institute Inc., Washington, D.C.	10,000
Independent Institute, Inc., Oakland, California	30,000
Independent Women's Forum, Washington, D.C.	15,000
Institute for Energy Research*, Houston, Texas	65,000
Institute for Research on the Economics of Taxation*, Washington, D.C.	5,000
Institute for Senior Studies, Arlington, Virginia	30,000
Institute for the Study of Earth and Man*, Dallas, Texas	
Hollis D. Hedberg Award	10.000
Institute for Trade, Standards, and Sustainable Development, Inc.*, Princeton, New Jersey	15,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	
Research Program	*5,000*
international Foundation for Election Systems, Washington, D.C.	
Democracy Dinner*	10,000
General Operating Support	10,000
International Policy Network – North America*, Washington, D.C.	130,000
International Republican Institute, Washington, D.C.	10,000
Johns Hopkins University, School for Advanced International Studies, Washington, D.C.	*75,000*
Joint Center for Political and Economic Studies*, Washington, D.C.	
2005 Annual Dinner	15,000
Kuwait-America Foundation*, Washington, D.C.	
Benefit Dinner	100,000
Landmark Legal Foundation, Kansas City, Missouri	
Environmental Accountability insurance	10,000
Lindenwood University, St. Charles, Missouri	5,000
Massachusetts Institute of Technology, Cambridge	
Energy Policy Studies	*75,000*
Media Institute, Arlington, Virginia	20,000
Media Research Center, Arlington, Virginia	*50.000*
Mentor Group, Boston, Massachusetts	
Court Forum	30,000
Mexican Cultural Institute*, Washington, D.C.	5,000
Mexico Institute*, Dallas, Texas	5,000
Middle East Institute, Washington, D.C.	
Annual Conference and Banquet*	10,000
General Operating Support	40,000
Middle East Policy Council, Washington, D.C.	20,000
Mosaic Foundation*, McLean, Virginia	
Annual Gala	100,000
National Association of Neighborhoods, Washington, D.C.	25,000
National Association of Women Judges*, Bellaire, Texas	
Annual Conference	10,000

National Black Caucus of State Legislators*, Washington, D.C.	14,000
National Black Chamber of Commerce, Washington, D.C.	60,000
National Bureau of Asian Research*, Seattle, Washington	
NBR Chairman's Council	15,000
Program Support	38,000
National Bureau of Economic Research*, Cambridge, Massachusetts	25,000
National Center for Policy Analysis, Dallas, Texas	75,000
National Center for Public Policy Research Inc., Washington, D.C.	
General Support and Educational Activities	*55,000*
National Center for State Courts, Williamsburg, Virginia	*25,000*
National Conference of State Legislatures Foundation for State Legislatures*, Denver, Colorado	
Foundation for Legislatures	15,000
General Operating Support	5,000
National Council on U.S.-Arab Relations*, Washington, D.C.	
Conference Support	20,000
National Democratic Institute for International Affairs, Washington, D.C.	20,000
National Foreign Trade Council Foundation, Inc.*, Washington, D.C.	
World Trade Dinner	10,000
National Governors Association Center for Best Practices*, Washington, D.C.	15,000
National Judicial College, Reno, Nevada	45,000
National Legal Center for the Public Interest, Washington, D.C.	25,000
National Taxpayers Union Foundation, Alexandria, Virginia.	70,000
Pacific Legal Foundation, Sacramento, California	15,000
Pacific Research Institute for Public Policy, San Francisco, California	95,000
Property and Environment Research Center (PERC), Bozeman, Montana	20,000
Public Affairs Research Council of Louisiana, Inc.*, Baton Rouge	30,000
Rand Institute for Civil Justice*, Santa Monica, California	
Distinguished Scholar Program	15,000
General Operating Support	85,000
Reason Foundation, Los Angeles, California	20,000
Regents of the University of California, Berkeley	
Lawrence Berkeley Laboratory	25,000
Regulatory Checkbook*, Mt. Vernon, Virginia	45,000
Smithsonian Astrophysical Observatory*, Cambridge, Massachusetts	105,000
Southern Legislative Conference*, Montgomery, Alabama	
Conference	10,000
Southern Methodist University Law School Foundation, Dallas, Texas	10,000
Stanford University, California	
Center for International Development*	*25,000*
Stanford Institute for Economic Policy Research	*80,000*
Tax Council Policy Institute, Washington, D.C.	*20,000*
Tax Foundation*, Washington, D.C.	
Annual Conference and Dinner	*5,500*
Annual Sponsorship	25,500
Texas A&M University*, College Station	
U.S.-China Relations Conference	100,000
Texas Civil Rights Project*, Austin	
14th Annual Bill of Rights Dinner	6,500
Texas Cultural Trust Councils*, Austin	
Texas Medal of Arts Award Leadership Dinner	20,000
Texas Women's Alliance*, Austin	
Fall Encampment	5,000
Transparency International USA, Washington, D.C.	*50,000*
University of Houston Law Foundation, Texas	
Annual Gala*	15,000
General Operating Support	*25,000*
Institute for Energy, Law, and Enterprise	*5,000*

Subtotal	**$ 45,000**
University of North Carolina at Chapel Hill	
Air Quality Research Support	80,000
University of Texas at Austin*	*50,000*
University of Texas Law School Foundation*, Austin	10,000
Washington Legal Foundation, D.C.	30,000
Western Governors' Association*, Denver, Colorado	15,000
Women in Government*, Washington, D.C.	
Women in Government Business Council	20,000
Woodrow Wilson International Center for Scholars*, Washington, D.C.	
Annual Dinner – Dallas, Texas	25,000
Awards Dinner – Houston, Texas	25.000
General Operating Support	25.000
Subtotal	$ 75,000
World Affairs Council*	
Conversations with History – Houston, Texas	15,000
General Operating Support – Dallas, Texas	20,000
General Operating Support – Washington, D.C.	10,000
Global Education Dinner – Washington, D.C.	5,000
Subtotal	$ **50,000**
World Press institute, St. Paul, Minnesota	20,000
Wyoming Heritage Foundation*, Casper	
Leadership Development	10,000
Exxon Mobil Corporation*	
Other contributions, each under $5,000	9,500
ExxonMobil Foundation	
Other contributions, each under $5,000	14.000
Total Public Policy Contributions Made Through the United States	$6,682,100
Contributions Benefiting Communities in the United States	$6,592,100
Contributions Benefiting Countries Outside the United States'	$ 185,900
Total Worldwide Public Policy Contributions'	$6,778,000
Exxon Mobil Corporation*	$3,088,900
ExxonMobil Foundation	$3,689,100
Total Public Information and Policy Research'	$6,778,000

Grants made by ExxonMobil Foundation except where indicated by:
* Exxon Mobil Corporation

May include contributions to nonprofit and NGO organizations; direct spending on community-serving projects; social bonus projects required under agreements with host governments by Exxon Mobit Corporation, its divisions and affiliates' and, ExxonMobil's share of community expenditures paid by joint ventures operated by other companies.

Exxon Mobil Corporation"'
2006 Contributions and Community Investments"!
($ Millions)

2006

	United States	*Canada*	*Africa & Middle East*	*Asia Pacific*	*Europe, Russia, & Caspian*	*Latin America*	*Totals*
Arts and Culture	3.3	.9	.1	.4	.5	–	5.2
Civic and Community	16.6	1.9	6.2	3.6	11.7	.9	40.9
Environment	1.9	.5	.6	1.6	1.6	.3	6.5
Health	3.9	.7	11.0	.4	2.7	.3	19.0
Education:							
Higher Education	32.0	.8	.5	.6	.9	.3	35.1
Pre-College[3]	10.1	1.2	2.9	.5	3.6	.6	18.9
Total Education	42.1	2.0	3.4	1.1	4.5	.9	54.0
Policy Research	6.1	–	.2	.1	.1	–	6.5
United Appeals	5.4	1.0	–	–	.1	–	6.5
Total	79.3	7.0	21.5	7.2	21.2	2.4	138.6

(1) Includes donations from Exxon Mobil Corporation its divisions and affiliates and ExxonMobil Foundation

(23 Includes contributions to nonprofit and NGO urganizabons. direct spending on community serving projects. social bonus projects required under agreements with host governments by Exxon Mobil Corporation, its divisions and affiliates. and ExxonMobil s share of community expenditures paid by joint venture: operated by other companies

(3j Includes in-kind donation in the United States of $225,000

Acton Institute for the Study of Religion and Liberty*, Grand Rapids, Michigan	$ 50,000
AEI-Brookings Joint Center for Regulatory Studies*, Washington, D.C.	25,000
Africa Society*, Washington, D.C.	10,000
American Council for Capital Formation Center for Policy Research*, Washington, D.C.	15,000
American Enterprise Institute for Public Policy Research*, Washington, D.C.	
Annual Dinner	5,000
General Operating Support	235,000
American Friends of **Lubavitch***, Washington, D.C.	
Annual Benefit Event	5,000
American Legislative Exchange Council*, Washington, D.C.	
Annual Meeting Host Committee Sponsorship	15,000
Annual Meetings Sponsorship	31,000
General Support	10,000
Subtotal	$ **56,000**
American Legislative Exchange Council, Washington, D.C.	30,000
American Spectator Foundation*, Arlington, Virginia	25,000
Americas Society, **Inc.***, New York, New York	
Annual Spring Party	10,000
Annapolis Center for **Science-Based** Public Policy Inc., Maryland	
General Operating Support"	30,000
General Operating Support	75,000
Arab American Institute Foundation*, Washington, D.C.	
Kahlil Gibran Awards	10,000
Asia Society"'	
Annual Conference – Washington, D.C.	20,000
Annual Dinner – Washington, D.C.	25,000
Tiger Ball 2006 – Houston. Texas	25,000
Washington, D.C. Metro and New York, New York	20,000
Other contributions, each under $5,000	2,000
Subtotal	**$ 92,000**
Aspen Institute, **Inc.***, Queenstown, Maryland	10,000
Atlas Economic Research Foundation, Arlington, Virginia	00,000
Baker Institute For Public Policy – Rice **University***, Houston, Texas	
Energy Forum Membership	50,000
Brookings Institution, Washington, D.C.	
AEI-Brookings Judicial Education Program*	30,000
Corporate Council	75,000
General Operating Support	30,000
Subtotal	**$135,000**
Bush House*, Bakersfield, **California**	
Bill Thomas Event	10,000
Business Council for International Understanding*, New York, New York	
Commercial Diplomacy Program	25,000
Capital Research **Center***, Washington, D.C.	25,000
Camegie Endowment for International Peace, Washington, D.C.	
Russian and Eurasian Program Support	25,000
Cato Institute*, Washington, D.C.	20,000

Public Information and Policy Research

Center for American and International Law, Plano, Texas	
CAIL Rogers Award Dinner 2007*	$ 6,000
Institute for Energy Law	8,000
Institute for Transnational Arbitration	6,500
International and Comparative Law	5,000
Other contributions', each under $5,000	5.500
Subtotal	**$ 31,000**
Centerfor Strategic and International Studies Inc., Washington, D.C.	
General Operating Support	225,000
Support of the Middle East & Energy Programs'	17.000
US-Saudi Energy Dialogue'	40,000
Subtotal	**$282,000**
Center for the Study of Carbon Dioxide and Global Change*, Tempe, Arizona	10,000
Central and East European Law Initiative Institute*, Washington, D.C.	25,000
Chemical Educational Foundation*, Arlington, Virginia	
Product Stewardship Bulletins	25,000
Committee for a Constructive Tomorrow, Washington, D.C.	70,000
Committee for Economic Development*, Washington, D.C.	10,000
Committee to Encourage Corporate Philanthropy*, New York, New York	
Membership	10,000
Common Good Institute, Inc., New York, New York	25,000
Communications Institute*, Pasadena, California	75,000
Congress of Racial Equality*, New York, New York	25,000
Congressional Black Caucus Foundation, Inc.*, Washington, D.C.	
Annual Legislative Dinner	7,500
Corporate Council on Africa*, Washington, D.C.	
Africa Chiefs of Mission Gathering 2006	5,000
General Operating Support	10,000
Membership	10,000
Subtotal	**$ 25,000**
Council of State Governments*, Lexington, Kentucky	5,000
Council on Foreign Relations, Inc.*, New York, New York	
Africa Initiative	50,000
Annual Corporate Membership	60,000
Eisenhower Exchange Fellowships, Inc., Philadelphia, Pennsylvania	
Northeast Asia Program	40,000
Environmental Law Institute*, Washington, D.C.	
Award Dinner	10,000
Corporate Program Membership	10,000
Federalist Society for Law and Public Policy Studies, Washington, D.C.	15.000
Financial Executives Research Foundation, Inc.*, Florham Park, New Jersey	
Research Program	15,000
Foundation for American Communications*, Pasadena, California	50,000
Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment, Bozeman, Montana	30,000
Foundation for the Center for Energy, Marine Transportation and Public Policy at Columbia University*, New York, New York	100,000
Foundation of the International Association of the Defense Counsel, Chicago, Illinois	10,000
Frontiers of Freedom Institute, Oakton, Virginia	
General Operating Support"	90,000
Science & Policy Center	90,000

Fundfor Peace*, Washington, D.C.	
Human Rights & Business Roundtable	$ 15,000
George C. Marshall Institute*, Washington, D.C.	
General Support and Annual Dinner	85,000
George Mason University Foundation, Inc., Fairfax, Virginia	
Law & Economics Center	30,000
George Washington University, D.C.	
Research & Education	25,000
Georgetown University, Center Contemporary Arabic Studies, Washington, D.C.	30,000
Heartland Institute, Chicago, Illinois	
Anniversary Benefit Dinner*	10,000
General Operating Support*	15,000
General Operating Support	90,000
Subtotal	**$115,000**
Henry L Stimson Center, Washington, D.C.	20,000
Heritage Foundation*, Washington, D.C.	30,000
Independent Women's Forum*, Washington, D.C.	
Annual Dinner Sponsorship	15,000
Institutefor Energy Research*, Houston, Texas	65,000
Institutefor International Economics, Washington, D.C.	
US-Indonesia FTA Project	15,000
Institutefor Research on the Economics of Taxation*, Washington, D.C.	
Membership	10,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	
Research Program	5,000
International Conservation Caucus Foundation*, Alexandria, Virginia	
Inaugural Gala	25,000
International Foundation for Election Systems, Washington, D.C.	10,000
International Institute for Conflict Prevention & Resolution*, New York, New York	
Membership Support	10.000
International Policy Network - North America*, Washington, D.C.	95,000
International QSAR Foundation To Reduce Animal Testing*,	
Two Harbors, Minnesota	
McKim Conference	5,000
Johns Hopkins University, School for Advanced International Studies,	
Washington, D.C.	
20th Anniversary Celebration*	15,000
Energy Club Trip	13,000
SAIS - International Programs	90,000
Subtotal	**$118,000**
Joint Center for Political and Economic Studies*, Washington, D.C.	
2006 Annual Dinner	15,000
Landmark Legal Foundation, Kansas City, Missouri	
Environmental Accountability Insurance	10,000
Leadership America Inc*, Dallas, Texas	
Sponsorship of Leadership America Reception	5,000
Lindenwood University, St. Charles, Missouri	10,000
Manhattan Institute for Policy Research*, New York, New York	30,000
Media Research Center, Arlington, Virginia	52.500
Mentor Group, Boston, Massachusetts	
Court Forum	30,000
Mercatus Center*, Arlington, Virginia	40,000

Public Information and Policy Research

Middle East Institute, Washington, D.C.	
General Operating Support'	$ 10,000
General Operating Support	40,000
Middle East Policy Council, Washington, D.C.	20,000
Mosaic Foundation*, McLean, Virginia	
Annual Gala	100,000
National Association of Neighborhoods, Washington, D.C.	25,000
National Black Caucus of State Legislators*, Washington, D.C.	15,000
National Black Chamber of Commerce, Washington, D.C.	50,000
National Bureau of Asian Research*, Seattle, Washington	
2005 China Energy Conference	10,000
NBR Chairman's Council	15,000
Program Support	50,000
Subtotal	**$ 75,000**
National Bureau of Economic Research*, Cambridge, Massachusetts	25,000
National Center for Policy Analysis*, Dallas, Texas	75,000
National Center for Public Policy Research Inc.*, Washington, D.C.	55,000
National Center for State Courts, Williamsburg, Virginia	25,000
National Conference of State Legislatures Foundation for State Legislatures*, Denver, Colorado	
Foundation for Legislatures	5,000
National Council on US-Arab Relations*, Washington, D.C.	
Conference Support	20,000
National Foreign Trade Council Foundation, Inc.*, Washington, D.C.	
World Trade Dinner	10,000
National Governors Association Center for Best Practices*, Washington, D.C.	15,000
National Judicial College, Reno, Nevada	45,000
National Legal Center for the Public Interest, Washington, D.C.	25,000
National Taxpayers Union Foundation*, Alexandria, Virginia	70,000
Nixon Center*, Washington, D.C.	
Service Award Dinner	10,000
Pacific Legal Foundation, Sacramento, California	15,000
Pacific Research Institute for Public Policy*, San Francisco, California	75,000
Property and Environment Research Center (PERC)*, Bozeman, Montana	20,000
Public Affairs Research Council of Louisiana, Inc.*, Baton Rouge	
Membership	30,000
Rand Institute for Civil Justice*, Santa Monica, California	85,000
Regents of the University of California*, Berkeley	
Lawrence Berkley Laboratory	25,000
Regulatory Checkbook*, Mt. Vernon, Virginia	50,000
Seeds of Peace, Washington, D.C.	
Conflict Management Program	100,000
Smithsonian Astrophysical Observatory*, Cambridge, Massachusetts	
Project Support	105,000
General Operating Support	50,000
Social Investment Forum Foundation*, Washington, D.C.	
Global Leadership Forum Honorarium	10,000
Southern Methodist University Law School Foundation, Dallas, Texas	10,000
Stanford University/Center for International Development*, California	25,000
State Legislative Leaders Foundation*, Centerville, Massachusetts	
Annual National Speaker's Conference	15,000
Tax Council Policy Institute, Washington, D.C.	20,000

Tax Foundation*, Washington, D.C.	
Annual Conference & Dinner	$ 5,000
Annual Sponsorship	25,500
Project Support	50,000
Subtotal	$ **80,500**
Temple University, Philadelphia, Pennsylvania	
Judical Training Program (China)	75,000
Texas Appleseed*, Austin	
Good Apple Dinner	25,000
Texas Conference for Women*, Austin	
Conference	15,000
Texas Public Policy Foundation*, Austin	
2006 Policy Orientation	10,000
General Operating Support	5,000
Tides Center/Africa Grantmakers' Affinity Group*, New York, New York	
Membership	7,500
Transparency International USA, Washington, D.C.	50,000
University of Houston Law Foundation, Texas	
Annual Gala*	20,000
General Operating Support	25,000
University of North Carolina at Chapel Hill	
Air Quality Research Support	50,000
University of Texas at Austin, Sugar Land	
institute for Energy, Law and Enterprise	5,000
University of Texas Law School Foundation*, Austin	10,000
Washington, D.C. Martin Luther King, Jr., National Memorial Project Foundation, Inc.	1,000,000
Washington Legal Foundation, D.C.	30,000
Western Governors' Association*, Denver, Colorado	15,000
Women In Government*, Washington, D.C.	20,000
Woodrow Wilson International Center for Scholars*	
Annual Awards – New York, New York	10,000
Kennan Institute Dinner – Washington, D.C.	10,000
World Affairs Council*	
2006 Global Education Dinner – Washington, D.C.	$ 15,000
Ambassador Luncheons – Dallas, Texas	10,750
"Bono Speaks Live" Event – Dallas, Texas	50,000
Conversations with History – Houston, Texas	15,000
General Operating Support – Dallas, Texas	20,000
General Operating Support – Washington, D.C.	10,000
Subtotal	$ **120,750**
World Press Institute, St. Paul, Minnesota	20,000
Wyoming Heritage Foundation*, Casper	5,000
Exxon Mobil Corporation*	
Other contributions, each under $5,000	12,750
ExxonMobil Foundation	
Other contributions, each under $5,000	10,500
Total Public Policy Contributions made through the United States	**$6,171,000**

Public Information and Policy Research

Contributions Benefiting Communities in the United States	**$6,026,000**
Contributions Benefiting Countries Outside the United States'	**$ 478,900**
Total Worldwide Public Policy Contributions'	**$6,504,900**
Exxon Mobil Corporation*	**$3,579,400**
ExxonMobil Foundation	**$2,925,500**
Total Public Information and Policy Research'	**$6,504,900**

Grants made by ExxonMobil Foundation except where indicated by
Exxon Mobil Corporation. its divisions and affiliates

\# May include contributions to nonprofit and NGO organizations direct spending on community serving projects social bonus projects required under agreeinents with host governments by Exxon Mobil Corporation its divisions and affiliates and ExxonMobil s share of community expenditures paid by joint ventures nperated by other companies

Documenting Exxon-Mobil's funding of climate change skeptics.

List Organizations

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A GREENPEACE project.

FACTSHEET: INSTITUTE FOR ENERGY RESEARCH, IER

DETAILS

6524 San Felipe, PMB 287 Houston, Texas 77057-2611
Phone: (713) 974-1918
IER analyzes public policy related to oil, gas, coal, and electricity. According to IER's mission statement, it "articulates free-market positions that respect private property rights and promote efficient outcomes for energy consumers and producers."

IER President Robert Bradley is a Cato Institute scholar and received the 2002 Julian Simon Award from CEI. One of Bradley's areas of concentration is "global warming alarmism." IER does not publish reports, but sells publications Bradley has written for other organizations, such as the Cato Institute. These publications include "Climate Alarmism Reconsidered" (Institute of Economic Affairs, 2003) and "Renewable Energy: Not Cheap, Not 'Green'" (Cato, 1997).

FUNDING

Institute for Energy Research has received $307,000 from ExxonMobil since 1998.

2003
$37,000 ExxonMobil Foundation
Source: Institute for Energy Research website 5/04

2004
$45,000 ExxonMobil Corporate Giving
Climate Change and Energy Policy Issues
Source: ExxonMobil 2004 Worldwide Giving Report

2005
$65,000 ExxonMobil Corporate Giving
Source: ExxonMobil 2005 Worldwide Giving Report

2006
$65,000 ExxonMobil Corporate Giving
Source: ExxonMobil 2006 Worldwide Giving Report

2007
$95,000 ExxonMobil Foundation
Source: ExxonMobil 2007 Worldwide Giving Report

KEY PEOPLE

Robert L. Bradley Jr.
President
Source: Institute for Energy Research website 5/04

PEOPLE

Sen. George Allen

Source: P.R. Watch's Disinfopedia

Wayne Gable
Director
Source: P.R. Watch's Disinfopedia

Robert Bryce

Source: checks and balances project

SOURCES

P.R. Watch's Disinfopedia
"a collaborative project to produce a directory of public relations firms, think tanks, industry-funded organizations and industry-friendly experts that work to influence public opinion and public policy on behalf of corporations, governments and special interests." Run by P.R. Watch (John Stauber and Sheldon Rampton).
http://www.disinfopedia.org/wiki.phtml?title=Disinfopedia

Institute for Energy Research website 5/04
http://instituteforenergyresearch.org/index.html

ExxonMobil 2004 Worldwide Giving Report
2004 Worldwide Contributions and Community Investments Public Information and Policy Research
http://research.greenpeaceusa.org/?a=view&d=4380

ExxonMobil 2005 Worldwide Giving Report
Public Information and Policy Research
http://research.greenpeaceusa.org/?a=view&d=4387

ExxonMobil 2006 Worldwide Giving Report
Public Information and Policy Research downloaded from Exxon website
http://research.greenpeaceusa.org/?a=view&d=4381

ExxonMobil 2007 Worldwide Giving Report
http://research.greenpeaceusa.org/?a=download&d=4586

checks and balances project
http://checksandbalancesproject.org/category/profiles/

Senator SANDERS. Now, in terms of temperature, Senator Sessions, among others, was raising this issue about temperature. Let me ask, Dr. Cullen, my understanding is that according to NASA, the nine warmest years on record have all occurred since 1998. Is that correct?

Ms. CULLEN. That is correct.

Senator SANDERS. Is it also correct that currently the warmest year on record is 2010? Including 2012, all 12 years to date in the 21st Century, that is 2001 through 2012, rank among the 14 warmest in the 133 year period of record. Is that true?

Ms. CULLEN. That is true. And I should say that we also set a global CO2 emissions record in 2012 of 35.6 billion tons. So globally we are setting records for carbon dioxide emissions.

Senator SANDERS. OK, what I want to do is go to Mr. Nutter and Mr. Golden and ask them this. There has been a lot of discussion, including from our economist friends here and my Republican friends, Senator Wicker and others, about the costs, the costs of addressing global warming. And no one denies that it is, of course, expensive. To save the planet will be expensive.

But I want to talk about the cost of inaction, inaction, if we do nothing. I am reading from an article appearing in a publication called The Examiner, I think in 2011, this is what they say. I think it is a Louisiana publication. Does a publication in New Orleans, The Examiner, ring a bell?

Mr. NUTTER. No, it does not.

Senator SANDERS. OK. All right. This is what it says. It says rising seas are expected to wipe out a significant portion of Louisiana's wetlands and the Mississippi River Delta Plain. Our wetland loss is already among the highest in the world. The city of New Orleans has historically depended on these wetlands for protection. Loss of Louisiana's coastal wetlands will also hurt economic sectors such as fishing, timber, agriculture, tourism and recreation along with devastating the Port of New Orleans.

Now, it is not just clearly New Orleans. What do rising sea levels mean economically to Louisiana, to New York, to Florida, to major great American cities in low coastal areas? Who wants to answer that? Mr. Nutter?

Mr. NUTTER. I would certainly offer a comment that Superstorm Sandy is a good example of the impact of rising seas because storm surge was, in fact, probably the major cause of the damages associated with all of that. And certainly that is the kind of pattern one would see going forward in areas of, low lying areas, whether it is the State of Florida or the Gulf Coast, particularly without the natural habitat that has historically been an inhibitor——

Senator SANDERS. Everything being equal, is it possible we will see billions of dollars of damage?

Senator BOXER. Sorry to cut you off. I really am. I have to do that. I have to be fair.

So, we want to thank this panel. You have been, every one of you, terrific. And we are going to leave the record open until 10 a.m. because people may have more questions. I am going to send one to the two economists on the panel, the Republican witnesses, about the tremendous job growth we have seen in California related to our alternative energy. So, I want to see you talk about why you think it is, in fact, a growth industry or not.

We thank you. As you, you should know how appreciative we are, all of you.

We are going to ask the new panel to come up. I am going to hand the gavel over to a real leader on the oceans issues and someone who really asked us to do a panel on oceans, Senator Whitehouse. And he is going to start right now.

Senator WHITEHOUSE.

[Presiding.] Thank you, Chairman. Let me ask the next panel to come forward. What is our vote schedule at this point?

Senator BOXER. The vote begins at 12:15 but we do not have to leave here until 12:30.

Senator WHITEHOUSE. And then just the one?

Senator BOXER. Just the one.

Senator WHITEHOUSE. All right. Let me thank the various witnesses who are here, with a particular welcome to Dean Leinen who, before she went to Florida Atlantic University, was the Dean of the Graduate School of Oceanography at the University of Rhode Island. Welcome here.

Let me just say a moment about where we are from a parliamentary point of view. There is a vote that will begin on the Senate floor at 12:15. So, there may be a certain amount of swirling about as we allow everybody to go and take that vote. I may choose, depending on who is here, to recess the Committee briefly so that we can get that vote done and then return. But, in the meantime, why don't we proceed with the testimony of Dr. Francis. We welcome you here.

STATEMENT OF JENNIFER FRANCIS, RESEARCH PROFESSOR, INSTITUTE OF MARINE AND COASTAL SCIENCES, RUTGERS UNIVERSITY

Ms. FRANCIS. Thank you very much and good afternoon. Thank you for inviting me to participate in this hearing here today.

I am an atmospheric scientist and over my about 25 year career my research has focused primarily on the changing Arctic system and how it connects with the global system. And as a scientist and a mother of two teenagers, I would like to tell you about the top five things that keep me awake at night.

The first, and we have heard some of this already today, is, in the past year we, as a global humanity, have broken two momentous records. First, we have, by burning fossil fuels at a very fast rate, we have emitted the most carbon dioxide into the atmosphere we have ever seen before. This has led to our carbon dioxide levels in the atmosphere being the highest they have been in at least 800,000 years, probably more like 2.5 million years. And we know that the last time carbon dioxide levels were this high in the atmosphere, global temperatures were several degrees warmer and sea levels were tens of feet higher.

So, why has this started to happen already? Well, we know why. It is because it takes a long time for that heat to be conveyed into the ocean. The ocean has a very high heat capacity. It takes a long time to warm it up. The ocean is the flywheel in the climate system.

And we have added this carbon dioxide so fast that it just has not had time to catch up yet. But it is starting to. According to a new U.N. report that was released last month, this past decade of the 2000's was the warmest on record, not only in the record of digital temperatures or thermometers, but also going back probably 2,000 years of proxy records.

We have heard many times already this morning that the air temperature, the surface air temperature, has slowed down in its increase over the last 15 years. But we know why. Here is the real data and the real facts. There are natural fluctuations in the oceans circulation that modulate this increase in temperature over time. Things like El Nino, for example, we know, tends to increase the global average temperature whereas La Nina has the opposite effect.

Over the last 15 years, we have a great number of La Ninas. This has tended to cause the surface temperatures globally averaged to decrease somewhat. But we know this is going to rebound because there will be El Ninos again and we will see that heat that Dr. Cullen talked about returning to the atmosphere from the ocean. The heat is there and the warming has not slowed down.

The second thing is that all this extra heat that was trapped is causing all of the forms of permanent ice in the Arctic to disintegrate. For example, let me just talk about sea ice. The other things would be permafrost and ice sheets and so forth. The sea ice, as of last summer, was three-quarters gone. Three-quarters of it is gone in just 30 years and the only explanation is the increase in greenhouse gases in the atmosphere.

The third thing is that the pace of sea level rise is accelerating. We know this is due to the warming oceans and when the oceans warm they expand. We also know that it is because of these disintegrating permanent forms in the Arctic adding mass to the oceans.

As the oceans warm, they also allow more evaporation into the atmosphere, about 7 percent over the last 30 years. This provides more fuel for storms because when it condenses it releases heat and also for the heavier precipitation events that have been observed over the Northeast.

The fourth thing is that the Arctic has warmed two to three times faster than the rest of the Northern Hemisphere. This is due to sea ice loss and also this water vapor increase. That temperature difference between the Arctic and areas farther south drives what we call the Jet Stream. This is the high level river of air over our heads that creates weather, steers weather and, as the Arctic warms faster, it is decreasing this temperature difference and it is causing the West-East winds of the Jet Stream to slow down. This has been measured.

As that Jet Stream slows down, it takes on a wavier path as it travels around the Northern Hemisphere. We can measure this as well. Those waves cause the weather than we experience here on the surface. And if those waves get bigger, which we see that they are, they tend to move more slowly from West to East, along with the weather than they create. So, this is increasing the likelihood of extremes that are caused by slow-moving weather patterns.

And finally, No. 5 is what I call climate misleaders. These are people who are deliberately ignoring and misconstruing the science in an attempt to convince you all and the public that even human-caused climate change is not happening or that there is nothing to worry about.

And my time is almost up. But what I want to say is that we know they rely on models and they are picking specific variables from models and illustrating that they are not working right. We know that the models are not perfect. And we know also that they are mostly right. The sign that they are telling us is correct and we can depend on that being crystal clear.

And I would agree that we have no more time to wait. We have to start to act.

Thank you.

[The prepared statement of Ms. Francis follows:]

Testimony for a Hearing of the Senate Environment and Public Works Committee

by **Dr. Jennifer Francis**, Research Professor, Institute of Marine and Coastal Sciences, Rutgers University, *francis@imcs.rutgers.edu*

The Warming Oceans: Present and Future Impacts

It seems as though the weather gods have gone berserk in recent years, as nearly every day the headlines report unusual droughts, floods, prolonged cold and snow, heat waves, or unusual weather events happening somewhere around the globe. Sea level is rising ever faster, and its contribution to damage from coastal storms is already being felt. Nearly three-quarters of the sea ice floating on the Arctic Ocean has disintegrated...in only 30 years. How and why are these changes happening, and what can we expect in decades to come?

Atmospheric changes drive ocean changes

In the past year, the human/Earth system reached three important milestones.

- In 2012 more carbon dioxide was emitted into the atmosphere than ever before.
- The amount of carbon dioxide in the atmosphere reached 400 parts per million, a 40% increase since the beginning of the industrial revolution. The last time the atmosphere contained this much carbon dioxide (about 2 million years ago), the Earth was several degrees warmer and the seas were tens of feet higher.
- Arctic sea ice melted to its lowest summer extent in at least 5000 years.

Greenhouse gases, of which carbon dioxide is one, trap heat emitted by the Earth's surface. This fact has been known for over a century. As human activities augment CO_2 concentrations in the atmosphere through fossil fuel burning, we are effectively putting a thicker blanket on the planet. The oceans absorb the vast majority of this excess energy, and because of water's huge heat capacity, the warming process takes a long time. This is why the Earth's temperature is not as warm as it was 2 million years ago: we've added the CO_2 so fast that the warming hasn't been able to catch

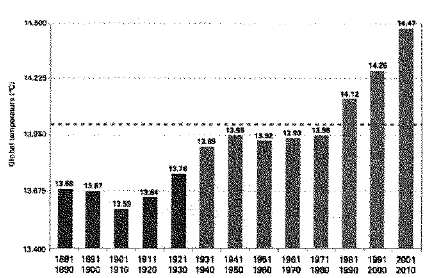

Figure 1: Global average temperature by decade. From http://library.wmo.int/pmb_ged/wmo_1119_en.pdf

up. But it's starting to.

This month the U.N. released a report stating that the past decade was the warmest in at least 160 years (**Figure 1**). Counter to claims by those who choose to ignore peer-reviewed scientific research, the heating of the Earth is not slowing down. Because of surface cooling over much of the Pacific Ocean in recent years owing to natural fluctuations in ocean circulation patterns, global-average *air* temperatures have not risen as fast as during the previous decade. Instead, the additional heat trapped by greenhouse gases has warmed deeper layers of the ocean, as evident in **Figure 2**.

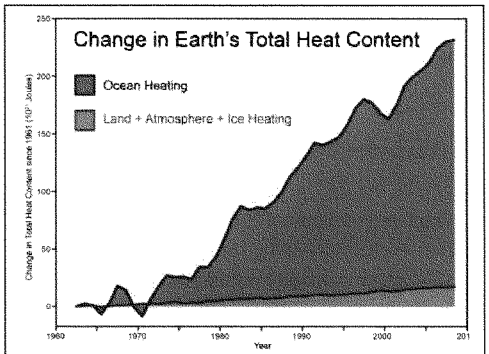

Figure 2: Changes in Earth's heat content, from Church et al (2011).

The Earth's Surface is Not Warming Uniformly

Owing to the effects of ocean currents, weather patterns, and variations in surface characteristics, temperature changes around the globe are far from uniform. This is abundantly clear in **Figure 3**, which illustrates the temperature differences from normal during the past decade. While nearly everywhere warmed, the changes were larger over land than over the oceans, and warming was especially pronounced over the Arctic. Differences in temperature are the drivers of weather patterns, so these spatial differences in warming must disrupt what we consider to be normal weather conditions.

Surface temperature changes are also affected by natural fluctuations in ocean conditions, such as El Niño/La Niña, the Pacific Decadal Oscillation, and the Atlantic Multi-decadal Oscillation, but as shown in **Figure 2**, the overall trend is for global ocean heating.

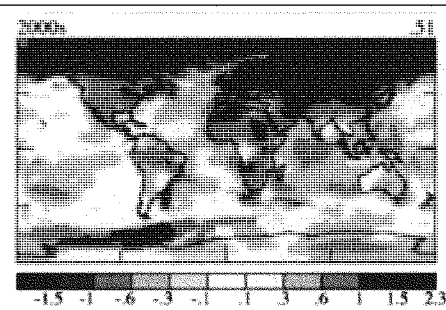

Figure 3: Annual surface temperature differences from normal during 2000-2010. From NASA/GISS.

Warming Oceans Contribute Directly to Sea Level Rise

A basic fact of physics is that when a gas or liquid warms, it expands. Warmer oceans have contributed about half of the observed global-average sea level rise (~1 foot since 1900). The pace of warming has increased, and so has the rate of sea level rise. By the end of the 21st century, sea levels are expected to be about 3 feet higher, which will have devastating impacts on low-lying coastal cities and communities around the world. Approximately 600 million people will be affected. Even if storms do not increase in frequency or intensity (which is *not* the expectation), they will ride on a higher ocean, increasing the destruction by storm surges and wind-driven waves.

Just as temperatures are not changing uniformly, neither will sea-level rise. Some land areas have been sinking and others rising since the last ice age, which either exacerbates or lessens the impact of rising seas. Changes in ocean currents also redistribute heat, and thus affect the amount of water expansion in a particular area. The loss of Greenland's ice sheet and other large masses of land ice also influence sea levels by imposing gravitational changes. The sum of these influences result in the low-lying and densely populated mid-Atlantic coast of the U.S. experiencing some of the largest increases in sea level (http:// tidesandcurrents.noaa.gov/sltrends/index.shtml).

Warming Oceans Cause Increased Evaporation of Moisture into the Atmosphere

As the oceans and atmosphere warm, evaporation from the ocean surface increases, which adds water vapor to the air. This extra water vapor plays several important roles in exacerbating climate change. First, water vapor is a potent greenhouse gas, and as its concentration increases, additional heat is trapped, amplifying the original surface warming – a classic example of a positive feedback in the system. The second effect is to provide additional fuel for storms, because when water vapor condenses into cloud droplets, heat is released into the atmosphere. This energy is the primary power source for hurricanes in particular, as well as for other types of storms. Third, the additional water vapor enables storms to produce more rain and snow, increasing

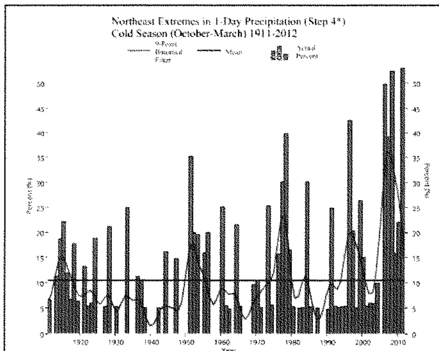

Figure 4: Heavy precipitation events are increasing in the northeastern U.S. From NOAA Climate Extreme Index.

the likelihood of severe rain events, flooding, and heavy snow falls. Heavier precipitation events have already been documented in the northeastern U.S. (**Figure 4**). Fourth, it is one of the main factors contributing to the disproportionate warming occurring in the Arctic, especially in winter and spring. The ramifications of this are discussed later.

Warmer Oceans May Affect Tropical Storms

Very warm ocean temperature is one of the essential ingredients for the development of tropical storms, primarily because it drives large evaporation rates, which supply copious amounts of water vapor that fuel the storms. As the oceans continue to warm, hurricane seasons are expected to lengthen, and the regions where tropical storms can develop and survive will expand. The situation that existed during Superstorm Sandy's lifespan may offer a glimpse of what we can expect to see occur more often in the future.

When Sandy moved out of the Caribbean in late October, it encountered ocean temperatures much above normal for late October all along the east coast of the U.S., which may have allowed the storm to survive intact longer and travel farther north than would be typical for that time of year (**Figure 5**). Meanwhile, the ingredients for an autumn nor'easter were gathering along the eastern seaboard. Because Sandy endured so far north, the two systems – that normally occur in distinct seasons – were able to coalesce into the powerful hybrid storm that wreaked havoc from Delaware to Nova Scotia, along with record blizzard conditions in West Virginia.

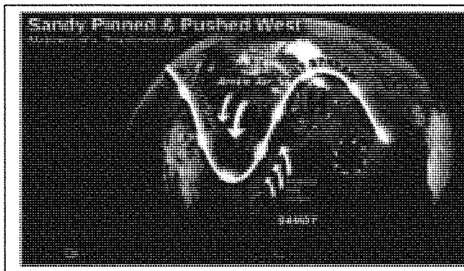

Figure 5: Superstorm Sandy survived farther north than usual for a late-October tropical storm, where it merged with a developing nor'easter. From ClimateCentral.org.

Warming Oceans Contribute to Sea Ice Loss in Both Hemispheres

A number of factors contribute to the recent and ongoing rapid decline of the Arctic sea ice cover (**Figure 6**). These include rising air temperatures, increasing water vapor and clouds, changing wind patterns, and warming oceans. As sea ice retreats, less of the sun's energy is reflected back to space by the diminished ice surface and more of it is absorbed into the ocean. In 2012 alone, the extra energy absorbed into the Arctic Ocean where there used to be ice is roughly the amount used to power the entire United States for 25 years! As this energy warms the ice-free areas, more melting ensues, establishing another powerful positive feedback in the system. Additional ocean heat is also entering the Arctic from lower latitudes via currents flowing in from the North Atlantic and North Pacific Oceans. This source of heat has been shown to be particularly important for reducing the ice extent in the Arctic north of Norway during winter and north of Alaska during summer. Rising ocean temperatures have also been implicated in thinning ice shelves along the Antarctic Peninsula and in warming the air in that region.

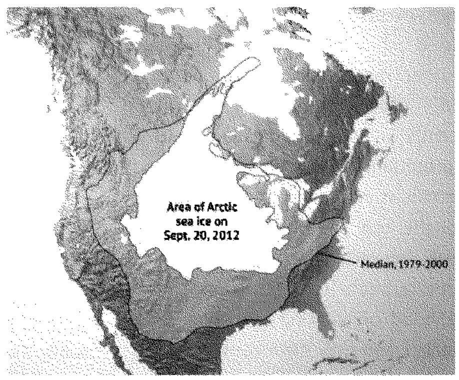

Figure 6: Summer Arctic sea ice has declined in extent by HALF and in volume by THREE-QUARTERS in only 30 years. Image from LiveScience.org.

A Rapidly Warming Arctic Disrupts Weather Patterns in the Northern Hemisphere

Recent research has revealed some less intuitive links between climate change and the escalation of extreme weather. The Arctic is warming two to three times faster than the rest of the northern hemisphere owing primarily to sea-ice loss, earlier snow melt on Arctic land in spring, and increasing water vapor. This so-called "Arctic amplification" means that the temperature difference between the Arctic and mid-latitudes is lessening. This is important because the west-to-east winds of the jet stream are driven by that temperature difference. The jet stream is a fast river of wind high in the atmosphere that takes on a wavy path as it encircles the northern hemisphere, forming the boundary between warm air to the south and cold air to the north. As its westerly flow weakens owing to the reduced Arctic/mid-latitude temperature difference, the waves in its trajectory tend to take larger north-south swings (**Figure 7**). These waves control weather systems on the surface: conditions tend to be clear and dry in the part of the wave where winds blow from the northwest, and it's generally stormy where winds come from the southwest. As the waves increase in size owing to Arctic amplification, they are expected to progress eastward more slowly, which means that the weather associated with those waves lasts longer in any particular location (Francis and Vavrus, 2012). Larger waves are also more likely to form "blocks," which are like back-eddies in a stream that tend to prevent the jet-stream waves on either side—and the weather associated with them—from moving at all.

Large excursions of the jet stream caused many of the recent extreme weather events, such as the unusually cold, snowy winters experienced recently in Alaska and Europe, the unprecedented flooding in Alberta and the Mississippi Valley, and the ongoing drought and heat waves in western North America. The rapidly warming Arctic appears to be increasing the likelihood of blocking over the North Atlantic, and may have contributed to the unusual wind conditions that steered Sandy on its unprecedented westward path toward New Jersey.

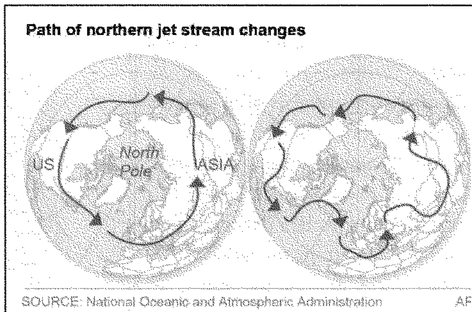

Figure 7: The jet stream, 3 miles above the surface, usually moves fast and relatively straight. Lately it has meandered north and south, causing unusual weather around the northern hemisphere. From NOAA/AP.

The Bottom Line

As the oceans continue to absorb additional heat trapped by ever-accumulating greenhouse gases, as sea ice continues to disappear, and as the Arctic continues to warm faster than the rest of the globe, we can only expect to see more weather-related adverse impacts. The details of those impacts are still emerging from ongoing research, but the overall picture of the future is clear.

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Follow-up Questions from July 18th, 2013, Hearing of Committee for Environment and Public Works

Answers by Dr. Jennifer Francis

From Senator Boxer

1. In addition to Hurricane Sandy, what other recent extreme weather events could be related to the kind of changes in our weather patterns your research describes? Based upon your climate change research and other available scientific evidence, do you expect that more extreme weather events like Hurricane Sandy will occur in the future?

Our research is aimed at the mechanisms that connect the rapidly warming Arctic (2-3 times faster than the rest of the northern hemisphere) to the types of extreme weather that result from persistent weather conditions. These types of events include droughts, heat waves, persistent rain that can lead to flooding, snowy winters, and even long cold spells. The rapidly warming Arctic causes the jet stream to take larger north-south swings as it flows around the northern hemisphere. These waves in the jet stream are what create the high and low pressure areas that dictate our weather. As the waves increase in size, they tend to move more slowly from west to east, as do the weather patterns they create, which causes the conditions to become more persistent and increase the likelihood of the types of extreme events listed above.

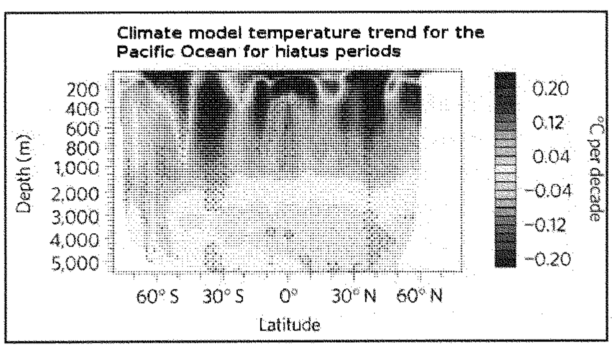
The condition that existed when Sandy came along was one of these large northward swings in the jet stream (called a ridge) over the North Atlantic. This ridge created the strong winds from the east that helped steer Sandy on its unusual westward track into New Jersey. The Arctic was extremely warm in October 2012 following the record loss of sea ice that summer, and our analysis suggests that this was likely a factor in causing that strong ridge. Our analysis of the past few decades also shows that the frequency of ridges in this region during late summer and fall has increased. Recent research also suggests that late-season hurricanes (like Sandy in late October) have increased in frequency owing to warming oceans (Kossin, 2008), so it is logical to assume that the unusual combination of events that led to Sandy may occur more often in the future as global warming continues unabated.

A recent paper (Barnes et al, PNAS, 2013) looked at this question with climate-model projections of the future and came to a different conclusion. The evidence presented in this paper, however, actually supports my expectation. They showed that east winds would decrease in the future just south of Greenland, but this area is well north of the area where the strong east winds occurred during Sandy. In fact, the high-pressure system that was in place when Sandy came along would cause stronger west winds (same as weaker east winds) in that area south of Greenland, which is exactly what is shown in this paper. This indicates that the conditions during Sandy would be more common in the future.

From Senator Whitehouse

1. To your knowledge, what work exists that assimilates ocean observations and models, with specific attention to deep storage of heat?

Most ocean models and climate models only assimilate observations from the surface: sea-surface temperatures, winds, and sea-surface heights (which are related to currents and temperatures). The only group I'm aware of that assimilates observations below the ocean surface is the navy, and they are mainly focused on short-term prediction, not long-term climate changes. These sub-surface measurements are difficult to assimilate into models because the observations are sparse, as can be seen by the asterisks in the following figure. Research showing changes in deep-ocean heat content is generally from observations, not models, although the coupled global climate models do calculate these variables. Note that this figure clearly shows the cooling of the surface and warming of deeper layer of the Pacific during the past 15-years, and remember that the ocean absorbs about 90% of the heat trapped by greenhouse gases.



2. What implication might this work have on comparisons of models and observations?

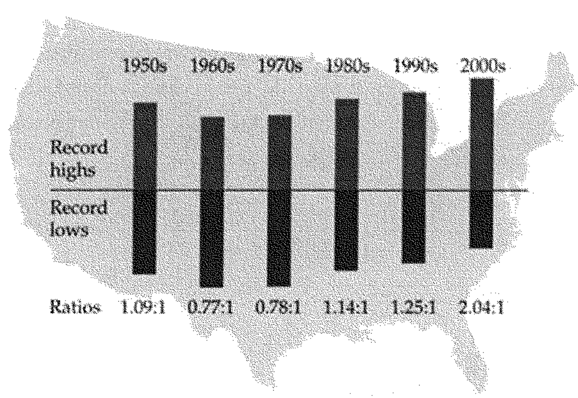
Given the importance of this issue for climate-change understanding, it is very important to compare model simulations of past deep-ocean behavior with observations to assess the realism of the model's ability to represent ocean processes. More observations are needed, however, especially in locations where spatial variations are large and where changes in surface conditions have a direct link to deeper ocean layers. These regions tend to be in high latitudes where deep-ocean water masses are formed. Research is also needed to better understand the atmosphere/ocean conditions that trigger shifts in ocean oscillations.

3. Is the frequency of record-breaking temperatures at individual weather stations the best way to indicate whether or not the atmosphere is warming?

There are many ways to measure how temperatures might break a record, and each is important. For example, breaking a high temperature record over some time period is one way, but the changing number of days per month above some threshold is another very telling type of record. I believe that this second measure is a more meaningful way to measure warming, as instantaneous records may be caused by a number of short-term, very local conditions or single anomalous weather conditions (rather than a system-wide change), and they are rare events. But the larger question of how to measure global warming, not just atmospheric warming, is better answered by observations of variables that represent an integration or accumulation of change over time and space. These indicators include loss of sea-ice volume, sea-level rise, glacier retreat, permafrost thaw, atmospheric increase in water vapor, large-scale vegetation changes, etc.

4. Is there any evidence that increases in average temperatures have caused a shift in either the magnitude or frequency of extremely cold or warm temperatures?

Yes, the following figure from Meehl et al (2009) clearly shows that the ratio of the number of record high temperatures to low temperatures has changed from about equal likelihood before the 1960s to record highs occurring twice as likely in the 2000s. Other evidence shows that night-time low temperatures are increasing most rapidly, which occurs because of both warming temperatures and also because of increased moisture in the atmosphere. The moisture augments the greenhouse effect, trapping heat near the surface. In a report from NOAA last week that investigated climate links to recent extreme weather events, the authors found that heat waves are now four times more likely because of climate change.



<u>From Senator Udall</u>

In New Mexico, we live a long way from the ocean. But my understanding of the science is that our climate is inextricably linked to what happens with the oceans. Our rain and snowfall are dependent on the jet stream and our weather patterns are directly correlated to the Arctic sea ice and ocean. Scientists say that unprecedented loss of Arctic snow and sea ice cover has changed the way hemispheric weather systems operate, increasing the odds of droughts manifesting across our country.

1. Why should we, as New Mexicans, be concerned with what is happening with our oceans?

As you state above, Senator, the oceans exert a strong influence on weather patterns in New Mexico and across the globe. Natural fluctuations in temperature patterns that occur in the ocean – events such as El Niño/La Niña – cause major fluctuations also in weather patterns, particularly in the western U.S. These occur because of changes in the distribution of heating and moistening of the atmosphere in response to ocean temperature patterns, which ultimately also affect the path of the jet stream. While there are several of these large-scale oscillations occurring naturally in the ocean, the changes that are happening in the Arctic are new and they're occurring at an unprecedented pace, mainly caused by increased greenhouse gases. Like the patterns in the Pacific, the Arctic changes also affect the distribution of heat and moisture in the atmosphere that ultimately affect the jet stream. All the details of the mechanisms are still being worked out, including how this "new" Arctic amplification (rapid Arctic warming) will interact with the natural fluctuations. As the jet stream responds to these changes, weather patterns across the northern hemisphere will be affected, including in New Mexico. We believe the overall influence will be to increase the likelihood of extremes related to persistent weather patterns, such as wet and dry spells as well as cold and hot spells. Exactly when and where the various types of extremes occur in any given year is an active area of research. The different "flavors" of these extremes will affect New Mexico's water supply through changes in rainfall and the snow pack as well as its energy needs through persistent temperature patterns.

Beyond the ocean's influence on your weather patterns, marine plants supply most of the oxygen to the atmosphere and form the bottom of the food chain that supplies the seafood we all rely on. If changing ocean temperatures and acidification alter marine ecosystems substantially, we can expect the fisheries to be affected, as well.

2. What is the direct relationship to our climate and how is it related to the drought we are currently experiencing?

In addition to the explanation above, there is recent evidence that the loss of Arctic sea ice during summer and the loss of snow cover during spring on high-latitude land areas are both contributing to heat waves and droughts in North America. While this new research is still in review at a prominent journal, others have linked the loss of snow cover in Eurasia to heat waves and droughts in Europe and Russia. As global warming continues unabated, these connections will become clearer, the events more frequent, and the mechanisms behind them better understood.

Senator WHITEHOUSE. Thank you very much, Dr. Francis.

Dr. Doney, welcome. You are from a neighboring State and a competing ocean science facility, but we are delighted to have Woods Hole represented here. Proceed.

STATEMENT OF SCOTT C. DONEY, PH.D, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Mr. DONEY. Thank you Senator Whitehouse, Ranking Member Vitter and other members of the Committee.

My name is Scott Doney. I am a Senior Scientist at the Woods Hole Oceanographic Institution. Thank you for giving me the opportunity to speak with you today on climate change, the ocean-carbon cycle and ocean acidification.

Over the past two centuries, human activities have resulted in a traumatic and well-documented increase in atmospheric carbon dioxide to more than 40 percent above pre-industrial levels. Atmospheric levels would be even higher today if it were not for the ocean which provides a critical service by removing from the air roughly one-quarter of the carbon emissions from fossil fuel burning and deforestation.

The extra carbon dioxide in the ocean causes well-understood changes in sea water chemistry in a process termed ocean acidification. Today's surface ocean is almost 30 percent more acidic than it was in pre-industrial times. Over the next few decades, the level of acidity of the surface ocean will continue to rise without deliberate action to reduce carbon dioxide emissions and stabilize atmospheric carbon dioxide levels.

Increasingly, ocean acidification will cause major problems for many marine organisms like shellfish and corals that build shells and skeletons from calcium carbonate. Other marine life will be impacted indirectly by losses in their food supply and habitat. Together with climate change, acidification will put further pressure on critical living marine resources such as fisheries and coral reefs that we depend upon for food, tourism and other economic, cultural and aesthetic benefits.

Scientific observations show that ocean acidification is already occurring around the globe and is amplified in some coastal regions by changing ocean circulation, pollution and land management practices. Many coastal waters are experiencing a combination of stresses, acidic conditions, low oxygen and excess nutrients.

Recent near-collapses of the oyster fishery in the Pacific Northwest, directly attributed to changing sea water chemistry, had substantial negative impacts on local jobs and local economies. In Washington State, shellfish farming has an estimated total annual economic impact of $270 million. And shellfish growers directly and indirectly employ more than 3,200 people. Across the Nation, shellfish account for about 20 percent of the value of domestic fishery landings. Recreational shell fishing is also important to many coastal communities.

Ocean warming and acidification could also threaten the estimated $385 million that Hawaiian coral reefs provide annually in goods and services as well as put at risk subsisted fisheries in the Pacific Island communities. Over the past decade, Northwestern Hawaiian Islands experienced several mass coral bleaching events, the result of higher sea surface temperatures. Acidification may make corals more susceptible to this thermal bleaching.

Acidification is independent of climate warming but the two are connected through the underlying cause of elevated atmospheric carbon dioxide. Ocean warming is causing substantial changes in marine ecosystems. For example, commercial fish stocks are already moving and diseases that attack corals, abalones, oysters, fish and marine mammals are becoming more intense and happening in more places.

We have an opportunity now to limit the negative impact of ocean acidification in the future. Key elements include curbing human carbon dioxide emissions to the atmosphere, improving control of local pollution sources, reducing coastal habitat destruction and better preparing coastal human communities to withstand the amount of ocean acidification and climate change that is unavoidable because of past human emissions. Adaptation administration and mitigation strategies are being developed for ocean acidification at the State and local level already.

Thank you for giving me this opportunity to address the Committee and I look forward to answering your questions.

[The prepared statement of Mr. Doney follows:]

WRITTEN TESTIMONY OF
SCOTT C. DONEY, Ph.D.
WOODS HOLE OCEANOGRAPHIC INSTITUTION[1]

HEARING ON
Climate Change: It's Happening Now

BEFORE THE
COMMITTEE ON ENVIRONMENT & PUBLIC WORKS
UNITED STATES SENATE

JULY 18, 2013

Introduction

Good morning Chairman Boxer, Ranking Member Vitter and members of the Committee. Thank you for giving me the opportunity to speak with you today on climate change, the ocean carbon cycle and ocean acidification.

My name is Scott Doney, and I am a Senior Scientist at the Woods Hole Oceanographic Institution in Woods Hole MA. My research focuses on interactions among climate, the ocean and global carbon cycles, and marine ecosystems, and I have published more than 200 peer-reviewed scientific journal articles and book chapters on these and related subjects. I have served on the U.S. Carbon Cycle Science Program Scientific Steering Group and the U.S. Community Climate System Model Scientific Steering Committee. I was the inaugural chair of the U.S. Ocean Carbon and Biogeochemistry (OCB) Program and am currently on the steering committees for the Ocean Carbon and Biogeochemistry Program and the U.S. CLIVAR/CO2 Repeat Hydrography Program. I am also a convening lead author for the Oceans and Marine Resources chapter of the U.S. 2013 National Climate Assessment.

For today's hearing, you asked me to discuss how rising atmospheric carbon dioxide levels alter seawater chemistry, put at risk a wide range of marine life, and affect coastal communities and economies. My comments are based on my own extensive research and on a broad scientific consensus as represented in the current scientific literature and scientific assessments such as the 2013 National Climate Assessment, which was released this past winter in draft form for public comment (Doney et al., 2013; Walsh et al., 2013).

Over the past two centuries, human activities have resulted in dramatic and well-documented increases in atmospheric carbon dioxide and acidification of the upper ocean. Today the surface ocean is almost 30% more acidic than it was in pre-industrial times, and over the next few decades, the level of acidity of the surface ocean will continue to rise without deliberate action to reduce carbon dioxide emissions and stabilize

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[1] The views expressed here do not necessarily represent those of the Woods Hole Oceanographic Institution

atmospheric carbon dioxide levels. Increasingly this will cause major problems for many marine organisms like shellfish and corals.

The ocean takes up roughly one quarter of human emissions to the atmosphere of carbon dioxide from fossil fuel burning and deforestation. Additional carbon dioxide uptake causes direct changes in seawater acid-base and inorganic carbon chemistry in a process termed ocean acidification. Acidification is independent of warming of the atmosphere but the two are linked through the underlying cause of elevated atmospheric carbon dioxide. Growing evidence suggests that ocean acidification will strongly impact many types of marine organisms, from microscopic plankton to shellfish and corals. Acidification and climate change will put further pressure on living marine resources, such as fisheries and coral reefs that we depend upon for food, tourism and other economic and aesthetic benefits.

Scientific observations show that ocean acidification is already occurring around the globe and is amplified in some coastal regions by changing ocean circulation, pollution, and land management practices. Recent near collapses of the oyster fishery in the Pacific Northwest, directly attributed to changing seawater chemistry, had substantial negative impacts on local jobs and economies.

In addition to ocean acidification, marine ecosystems are also already experiencing other large-scale trends linked to global change. Documented trends relevant to marine biota include increasing sea surface temperature, upper-ocean warming, rising sea-level, retreating Arctic sea-ice, and declining subsurface oxygen. Ocean warming is linked to poleward migration of commercial fish stocks and higher intensity and increased spatial ranges of marine diseases that attack corals, abalones, oysters, fishes, and marine mammals.

We have an opportunity now to limit the negative impact of ocean acidification in the future. Key elements include curbing human carbon dioxide emissions to the atmosphere, improved control of local pollution sources, reducing coastal habitat destruction, and better preparing coastal human communities to withstand the amount of ocean acidification and climate change that is unavoidable. At the State and local level, adaptation and mitigation strategies are being developed for ocean acidification. This topic is discussed more in the Adaptation and Mitigation section of the written testimony.

Social and Economic Impacts of Ocean Acidification

Acidification and climate change will likely affect many of the benefits people derive from the ocean–supply of seafood, recreation and tourism, protection from coastal flooding–as well as the jobs and livelihoods that depend on healthy marine ecosystems (Cooley et al., 2009; Halpern et al., 2012; Ruckleshaus et al., 2013).

Many economically and culturally important mollusk species are harvested in the United States, and a number of these species have been show to respond poorly to ocean acidification (Table 1). These include, for example, larval hard clams, oysters, and bay scallops (Talmage and Gobler, 2011), softshell clams (Green et al., 2009), and blue mussels (Gazeau et al., 2010). Declines in these populations or delays in time to maturity could cost fishers, and dependent industries, millions of dollars (Cooley and Doney, 2009). Moreover, some additional impacts may still be identified; studies have not examined yet whether ocean acidification affects economically relevant harvest qualities of mollusks such as meat weight, appearance, and flavor. The commercial revenue numbers in Table 1 reflect what fishermen are paid at the dock for their catch and does not reflect the larger regional total economic impact of fishing, which can be several times larger.

Table 1: Commercial U.S. harvests in 2011 of mollusks with demonstrated negative responses to ocean acidification (Data: NOAA National Marine Fisheries Service, 2012).

Common name	**Scientific Name**	**Commercial revenue, dockside (millions)**
Hard clam, (Northern) quahog	*Mercenaria mercenaria*	$32
Eastern oyster	*Crassostrea virginica*	$91
Bay scallop	*Argopecten irradians*	$2
Softshell clam	*Mya arenaria*	$21
Blue mussel	*Mytilus edulis*	$7
Pacific oyster	*Crassostrea gigas*	$45
Olympia oyster	*Ostrea lurida*	$12
Sea urchins	several	$14

As atmospheric carbon dioxide levels continue to grow, ocean acidification may negatively impact the revenue derived from the commercial harvest of clams, scallops, oysters, mussels, and other calcifiers (like urchins). In 2011, harvests of calcifiers accounted for 19% of the $5.3 billion U.S. ex-vessel commercial fishery revenue. The biological responses to ocean acidification have not yet been determined for particularly valuable mollusk species such as sea scallop (*Placopecten magellanicus*), with national ex-vessel revenues for 2011 of $585 million, and Pacific geoduck (*Panopea generosa*), with revenues of $72 million. Similarly, early results suggesting red king (*Paralithodes camtschaticus*) and Tanner crab juveniles (*Chionoecetes bairdi and C. opilio*) fare poorly under ocean acidification are worrisome, given that the ex-vessel revenues from king crab (including red, blue, brown king crab) in 2011 were $111 million, and for Tanner crabs they were $15 million. "Snow crab," referring to anything in the *Chionoecetes* genus, had revenues of $116 million in 2011.

Elevated seawater carbon dioxide levels appear to be the cause of repeated failures at Pacific Northwest oyster hatcheries from 2005-2009 (Barton et al., 2012). The source of the acidified, low pH water varies regionally; along the coast resulting from enhanced upwelling of carbon dioxide rich ocean waters (Feely et al., 2008) with additional contributions from local pollution sources (nutrients, soil erosion) in estuaries and Puget Sound (Feely et al., 2010). The oyster hatchery failures are especially of concern given that:

> "Washington is the country's top provider of farmed oysters, clams, and mussels. Annual sales of farmed shellfish from Washington account for [more

> than $107 million, which is] almost 85 percent of U.S. West Coast sales (including Alaska) [2]. The estimated total annual economic impact of shellfish aquaculture is $270 million, with shellfish growers directly and indirectly employing more than 3,200 people [3]. Shellfish are also an integral part of Washington's commercial wild fisheries, generating over two-thirds of the harvest value of these fisheries [4]. Licensing for recreational shellfish harvesting generates $3 million annually in state revenue and recreational oyster and clam harvesters contribute more than $27 million annually to coastal economies [5]. Overall, Washington's seafood industry generates over 42,000 jobs in Washington and contributes at least $1.7 billion to gross state product through profits and employment at neighborhood seafood restaurants, distributors, and retailers [6]."

(Quotation from Washington State Blue Ribbon Panel on Ocean Acidification, 2012 and citations therein)

Washington State's story is the best-known story of economic losses due to ocean acidification so far. However, low pH levels in Maine sediments are increasing clam mortality and decreasing harvests, and harvest areas, to levels that are alarming Maine shellfish managers. The Maine shellfish industry is estimated to be worth $60 million a year (Koenig, 2011), and is particularly important in areas of the state where there may be fewer alternative economic opportunities. Potential economic and social impacts extend beyond domestic commercial fishing. Recreational shellfishing, which is typically managed at the local or state levels, supports important sources of seafood, recreational opportunities, and a substantial number of local jobs and coastal economies. Much of the seafood consumed in the United States is imported from abroad, and ocean acidification and climate change put at risk some aspects of global wild-harvest fisheries and aquaculture. Domestic processing, wholesaling and retailing of both domestic and imported seafood supports an important economic sector.

Coral reefs are important for human societies, often supporting locally essential artisanal reef fisheries, and reefs are some of the most valuable marine ecosystems because of tourism and recreation income and coastal protection (Cooley et al., 2009). Ocean warming, coral bleaching, and ocean acidification are highlighted as major risks for the Hawai'i and U.S. Affiliated Pacific Islands region in the draft 2013 National Climate Assessment (Leong et al., 2013). Ocean warming and acidification could threaten the estimated $385 million Hawaiian coral reefs provide in goods and services annually (Cesar and van Beukering 2004) as well as put at risk subsistence fisheries in Pacific island communities (Maclellan 2009). Over the past decade, the Northwestern Hawai'ian Islands experienced several mass coral bleaching events, the result of higher sea surface temperatures (Jokiel and Brown 2004; Kenyon and Brainard 2006), and acidification may make corals more susceptible to bleaching. Under business as usual scenarios, the continued loss of coral reefs will likely result in extensive losses in both numbers and species of reef fish; even with a substantial reduction in emissions, reefs could be expected to lose as much as 40% of their reef-associated fish by the end of this century (Pratchett et al. 2011).

Ocean and Global Carbon Cycle

Over the last two centuries, global average atmospheric carbon dioxide has increased by more than 40% from preindustrial levels, from 280 to 395 ppm (parts per million) by mid-2013 (www.esrl.noaa.gov/gmd/ccgg/trends/ Ed Dlugokencky & Pieter Tans, NOAA/ESRL). Temporary excursions to 400 ppm have already been recorded at the Mauna Loa Observatory in Hawai'i. The excess carbon dioxide can be definitively attributed to human activities using carbon isotopes and ice-core carbon dioxide measurements. Many economic and "business as usual" scenarios project atmospheric carbon dioxide values as high as 700 to 1000 ppm by the end of the twenty-first century, levels not experienced on Earth for the past several million years. Excess carbon dioxide persists in the atmosphere for decades to centuries, and the impact of carbon dioxide emissions are global in extent.

Detailed assessments are now available for the global carbon budget (Le Quéré et al., 2013; Global Carbon Project, www.globalcarbonproject.org/). The main source of excess atmospheric carbon dioxide is fossil fuel combustion with contributions from cement production, agriculture and deforestation. For the last decade for which data are available (2002–2011), fossil fuel emissions averaged 8.3 ± 0.4 billion metric tons of carbon per year and grew with time at a rate of 3.1% per year since the year 2000. Deforestation and land-use change accounted for an additional source of 1.0 ± 0.5 billion metric tons of carbon per year.

The ocean plays a critical service by removing excess carbon dioxide emitted to the atmosphere (Sabine & Tanhua, 2010). The global inventory and distribution of excess carbon dioxide in the ocean was first mapped using measurements from an intensive, international survey in the late-1980s and early 1990s. Ongoing observational programs and numerical models continue to document further ocean uptake of carbon dioxide over time. Over the same time period cited above (2002–2011) ocean carbon uptake is estimated at 2.5 ± 0.5 billion metric tons of carbon per year, 27% of global emissions (Le Quéré et al., 2013). Cumulatively since the beginning of the industrial age the ocean is estimated to have removed about 25-30% of total human carbon dioxide emissions. The physical mechanism for the dissolution of excess carbon dioxide into the ocean is well understood. The global ocean uptake rate is governed primarily by the atmospheric carbon dioxide excess and trend, and by the rate of ocean circulation that exchanges surface waters equilibrated with elevated atmospheric carbon dioxide levels with subsurface waters that have not yet been exposed to atmosphere since preindustrial times.

Climate warming is projected to reduce ocean uptake of excess carbon dioxide due to decreased solubility, increased vertical stratification, and slowing of cold deep-water formation (Arora et al., 2013). There is some evidence that climate change is already slowing ocean carbon dioxide uptake (Le Quéré et al., 2010).

Several other factors, including ocean acidification, may either increase or decrease the ocean uptake of carbon dioxide as the ocean warms and acidifies (Denman et al., 2007). The net effect of these other processes is not well known at this time but is thought to be relatively small compared to overall ocean carbon dioxide uptake over this century (Gehlen et al., 2011). The concern is that the ocean's capacity to absorb excess carbon dioxide may decrease, resulting in an increased growth rates in the atmosphere.

Ocean Acidification and Changing Seawater Chemistry

The ocean uptake of excess atmospheric carbon dioxide, the excess above preindustrial levels driven by human emissions, causes well-understood and substantial changes in seawater chemistry that can affect marine organisms and ecosystems (Doney et al., 2009; Gattuso & Hansson, 2011). Carbon dioxide (CO_2) acts as a weak acid when added to seawater leading to the release of hydrogen ions (H^+) and bicarbonate (HCO_3^-) ions:

$$CO_2 + H_2O \Rightarrow H^+ + HCO_3^-$$

The reaction increases seawater acidity and increases the hydrogen ion activity, thus lowering seawater pH. pH is defined as the negative logarithm of the hydrogen ion activity, so that a 1-unit change in pH is equivalent to a 10-fold change in H^+. Most of the extra hydrogen ions react with carbonate ions (CO_3^{2-}) and lower their ambient concentrations:

$$H^+ + CO_3^{2-} \Rightarrow HCO_3^-$$

This second reaction is important because reduced seawater carbonate ion concentrations decrease the saturation levels of calcium carbonate ($CaCO_3$), a hard mineral used by many marine microbes, plants and animals to form shells and skeletons. Many organisms require supersaturated conditions to form sufficient calcium carbonate shells or skeletons, and biological calcification rates tend to decrease in response to lower carbonate ion concentrations, even when the ambient seawater is still supersaturated.

Long-term ocean acidification trends are clearly evident over the past several decades in open-ocean time-series and hydrographic survey data, and the trends are consistent with the growth rate of atmospheric carbon dioxide (Dore et al., 2009). From preindustrial levels, contemporary surface ocean pH is estimated to have dropped on average from 8.2 to 8.1, or by about 0.1 pH units (a 26% increase in hydrogen ion concentration), and further decreases of 0.22 to 0.35 pH units are projected over this century unless carbon dioxide emissions are significantly reduced (Orr et al., 2005; Bopp et al., 2013).

Global upper-ocean chemistry trends driven by human carbon dioxide emissions are more rapid than variations in the geological past (Hönisch et al., 2012). For example, atmospheric carbon dioxide grew by approximately 30% during the transition from the most recent cold glacial period, about 20,000 years ago, to the current warm interglacial period; the corresponding rate of decrease in surface ocean pH, driven by geological processes, was approximately 50 times slower than the current rate driven largely by fossil fuel burning. Many marine organisms appear to be physiologically adapted to relatively constant local acid-base conditions and are sensitive to relatively small variations in pH and the saturation state of calcium carbonate.

Present-day ocean surface waters are supersaturated for the major carbonate mineral forms used by marine organisms, including the more soluble form aragonite (corals, many mollusks) and the less soluble form calcite (coccolithophores, foraminifera, and some mollusks). However, calcium carbonate saturation states of both mineral forms are declining everywhere. Polar oceans are of particular concern because cold surface waters naturally hold more carbon dioxide and started off with lower calcium carbonate saturation states. Model simulations indicate that polar surface waters will become undersaturated for aragonite in the near future for the Arctic (atmospheric carbon dioxide of 400-450 ppm) and by mid-century for the southern ocean off the Antarctic (atmospheric carbon dioxide of 550-600 ppm) (Orr et al., 2005; Steinacher et al., 2009). This is expected to result in major changes in polar ecosystems.

Other ocean regions also may be more susceptible to aragonite undersaturation because of elevated background levels of carbon dioxide. These include eastern boundary current upwelling systems such as those off the U.S. west coast along coastal California, Oregon and Washington (Feely et al., 2008; Gruber et al., 2012), deep-sea and subsurface oxygen minimum zones (Brewer & Peltzer, 2009), and coastal waters that are already experiencing excess nutrient levels (eutrophication) and low dissolved oxygen (hypoxia) due to human-driven nutrient pollution from land-based activities (Feely et al., 2010; Cai et al., 2011). Nutrient overloading near shore encourages algal growth that is consumed by microbes, using up dissolved oxygen and releasing even more carbon dioxide locally. Coastal, estuarine, and coral reef systems also experience high levels of temporal variability on diurnal to weekly time-scales (Hofmann et al., 2011), challenging both observational efforts and interpretations of biological experiments.

In addition to ocean acidification, marine ecosystems are also already experiencing large-scale changes in physical climate and reduced subsurface oxygen (Doney, 2010; Gruber, 2011; Doney et al., 2012). Documented physical trends relevant to marine biota include rising sea surface temperature, upper-ocean warming, sea-level rise, altered precipitation patterns and river runoff rates, and sea-ice retreat in the Arctic and west Antarctic Peninsula (Bindoff et al., 2007).

Observations and numerical models show strong links between upper ocean temperature and the distributions of marine organisms. Based on satellite data, warming leads to declining tropical and subtropical productivity of phytoplankton at the base of the marine food web as well as expansion of the area of surface waters with very low plankton biomass (Behrenfeld et al. 2006; Polovina et al. 2008). Warming over the past few decades has resulted in the migration of commercial fish stocks poleward and in to deeper water (Nye et al. 2009), and productivity of fisheries is predicted to decline in the lower 48 states, while increasing in parts of Alaska (Cheung et al. 2009). Climate change also influences the spread and impact of marine diseases and parasites (Harvell et al., 2002). Marine disease appears to be on the rise with time, with warmer sea surface temperatures linked with higher intensity and increased spatial ranges of diseases that attack corals, abalones, oysters, fishes, and marine mammals (Ward & Lafferty, 2004).

Biological Impacts of Ocean Acidification

Ocean acidification and climate change effects arise both directly, via effects of warming, elevated carbon dioxide, and lower pH and carbonate ion concentrations on individual organisms, and indirectly via changes to the ecosystems on which they depend for food and habitat (Doney et al., 2009; Doney et al., 2012). The potential biological consequences due to acidification are slowly becoming clearer at the level of individual species, but substantial uncertainties remain particularly at the ecosystem level (Gattuso et al., 2011). Ocean acidification and climate change acts as a stress on marine ecosystems will likely also exacerbate other human perturbations such as over-fishing, habitat destruction, pollution, excess nutrients, and invasive species.

Ocean acidification studies have been conducted for many economically and ecologically important species from both water-column (Riebesell & Tortell 2011) and seafloor or benthic (Andersson et al., 2011) environments. Most biological impacts are measured from short-term manipulation experiments in the laboratory where organisms are exposed to elevated carbon dioxide. In a recent meta-analysis of available scientific literature studies up until 2012, Kroeker et al. (2010; 2013a) found the following statistically significant effects:

calcifying algae	decreased abundance and photosynthesis
coral	decreased abundance and calcification
coccolithophores	decreased calcification
mollusks	decreased growth, calcification, and survival
echinoderms	decreased growth
fleshy algae	increased growth
diatoms	increased photosynthesis and growth

Recently published laboratory studies indicate additional potential negative ocean acidification effects for juveniles of valuable Alaskan crustacean species (Long et al., 2013a; 2013b).

red king crab	decreased growth and molting success
Tanner crab	decreased survival

Pteropods, a group of small planktonic marine mollusks, appear to be especially sensitive to ocean acidification (Orr et al., 2005). Pteropods are abundant in temperate and some subpolar waters and are important prey for juvenile fish. In shipboard incubations, elevated carbon dioxide levels causes dissolution of the shells of living pteropods, and in the present-day Southern Ocean there is evidence that pteropod dissolution is already occurring in some subsurface locations where seawater is undersaturated with respect to aragonite, the more soluble form of calcium carbonate (Bednaršek et al., 2012). A similar phenomenon may arise in the future in the North Pacific and off the U.S. West Coast as seawater conditions become more acidic.

A number of factors may influence the sensitivity of organisms to ocean acidification. Growing evidence indicates that warming amplifies sensitivity to ocean acidification (Kroeker et al., 2013a). Organism response also may vary with life-history stage; juvenile mollusks, for example, are often more susceptible than adults. Nutritional status may be important, and well-fed organisms may be better able to adjust to ocean acidification (Holcomb et al., 2012; Thomsen et al., 2013). In general, some species may be able to accommodate elevated carbon dioxide but at an additional energetic cost with negative consequences for development, reproduction and fitness. However, a recent study looking across ocean regions with naturally low pH found that several species within a major group of stony coral (genus *Porites*) were not able to acclimate to ocean acidification at least with respect to skeletal growth and development (Crook et al., 2013)

Tropical corals appear to be particularly susceptible to the combination of ocean acidification and ocean warming, which would threaten the rich and biologically diverse coral reef habitats (Hoegh-Guldberg et al. 2007). Coral polyps are small animals that contain symbiotic algae. The coral-algal symbiosis is sensitive to minor increases in maximum seasonal temperature, and warming of as little as 1°C can cause coral bleaching, the expulsion of the colored algae that weakens the coral and can lead to coral death (Hoegh-Guldberg et al. 2007, Donner 2009). Acidification appears to make some corals more sensitive to thermal bleaching (Anthony et al., 2008) as well as making it more difficult for corals to secrete and maintain their skeletons (Salvat & Allemand 2009). Acidification is also a threat to other important reef calcifying organisms, such as crustose coralline algae that help build reef frameworks (Kuffner et al. 2008; Anthony et al., 2008; Johnson & Carpenter 2012).

Stony corals help build and maintain coral reefs, and decreases in growth can leave them less able to rebound from natural breakdown processes. In preindustrial times, nearly all coral reefs in or bordering the open ocean were located in water with sufficient carbonate ion concentrations to building hard skeletons (aragonite saturation state above 3.5) (Ricke et al., 2013). But by mid-century, model projections with even rather modest increases in atmospberic carbon dioxide (by 2050 about 475 ppm carbon dioxide) indicate that 50% or fewer of these coral reefs will still be surrounded by ocean waters with carbonate ion concentrations above this threshold to which they acclimated for thousands of years.

Coral and coralline algae losses decrease the structural complexity of the coral reef seascape and therefore the capacity of reefs to provide shelter and other resources for other reef-dependent species of fish and invertebrates (Alvarez-Filip et al. 2009). Because one-quarter of all marine species associate with coral reefs, the ecological impacts of changing climates and chemistry on overall marine biodiversity are potentially severe and widespread. About 75% of the world's coral reefs are threatened due to the interactive effects of climate change and local sources of stress, such as overfishing, nutrient pollution, and disease (Burke et al. 2011; Dudgeon et al. 2010; Hoegh-Guldberg et al. 2007; Hughes et al. 21 2010). In Florida, all reefs are rated as threatened, with significant impacts on the valuable ecosystem services they provide (Mumby and Steneck 2011). Caribbean coral cover has decreased from 50% to only 10% historic reef areas, an 80% reduction in less than three decades (Gardner et al., 2003).

Effects of ocean acidification on many natural populations and communities have been difficult to detect so far. An exception is studies of natural high-carbon dioxide environments, such as shallow volcanic vents, that generally support the conclusions found in laboratory studies (Hall-Spencer et al., 2008; Fabricius et al., 2011; Inoue et al., 2013). For example, Kroeker et al. (2013b) report on pH effects for benthic ecosystems surrounding seafloor carbon dioxide vents in the Mediterranean Sea. Ambient seawater in the study region had a pH of 8.0 while acidified, low pH waters has a pH of about 7.7, roughly equivalent to surface ocean conditions expected at the end of this century under business as usual emission scenarios. In low pH waters, mollusks and crustaceans were less abundant, invertebrates with little or no calcification in their exoskeletons were more abundant, and the food web became simplified with more generalist species present. Kroeker et al. conclude that ocean acidification reduces the diversity, biomass, and food-web complexity of benthic marine communities. These high-carbon dioxide, low pH environments may be a window on the future under elevated atmospheric carbon dioxide conditions.

Adaptation and Mitigation Strategies

We have an opportunity now to limit negative ocean acidification impacts that are already underway and address future impacts that are expected to grow over the next several decades because of increasing atmospheric carbon dioxide levels. This will require a comprehensive strategy that balances adaptation to the amount of ocean acidification that is unavoidable and mitigation to reduce the further rise in atmospheric carbon dioxide. Decisions should incorporate precautionary considerations to account for the fact that potential carbon dioxide thresholds are presently unknown for many aspects of ocean acidification. Implementing adaptive management is also warranted because it can take advantage of new information as it becomes available. Further, it is important to recognize that many of the geoengineering strategies being proposed to mitigate future climate change, such as stratospheric aerosols to control solar albedo, will not reduce ocean acidification.

The Washington State Blue Ribbon Panel on Ocean Acidification (2012) outlined a series of recommended actions that could form the framework for action at the state, national and international levels. Critical tasks include:

- Reduce emissions of carbon dioxide to the atmosphere through a combination of increased energy efficiency, switching to renewable energy sources, and exploring the potential and challenges of carbon sequestration approaches;
- Reduce local land-based contributions to ocean acidification including excess nutrients from fertilizers and agriculture, organic matter from soil erosion, and local acidifcation from atmospheric deposition of pollutants;
- Increase our ability to adapt to and remediate the impacts of ocean acidification including approaches to sustain wild-harvest fisheries and aquaculture;
- Invest in our ability to monitor and investigate the causes and effects of ocean acidification;
- Inform, educate, and engage stakeholders, the public, and decision makers in responding to ocean acidification;
- Reduce other human disturbance factors such as overfishing and coastal habitat destruction to allow more time for ecosystems and social systems to adjust to ocean acidification and climate change.

Thank you for giving me this opportunity to address the Committee, and I look forward to answering your questions.

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Questions from Senator Barbara Boxer:

1. Dr. Doney, if we continue to emit carbon pollution into our atmosphere in increasing amounts, what are the worse case scenarios for ocean acidification and its impacts on out planet?

Ongoing and future human emissions of carbon dioxide to the atmosphere will lead to growing atmospheric carbon dioxide concentrations and further acidification of ocean surface waters. Many types of ocean life, particular those that make shells from calcium carbonate, appear to be negatively impacted with rising atmospheric carbon dioxide levels. In many laboratory experiments, negative biological impacts appear to grow steadily with increasing carbon dioxide levels. However, as atmospheric carbon dioxide continues to grow is may be possible that we will see more dramatic and sudden declines in organism or ecosystem health. Currently we do not know in detail whether and where these specific thresholds may fall for most organisms or ecosystems (Mumby et al., 2011).

Of particular risk are tropical coral reef ecosystems, which are sensitive to both ocean acidification and surface warming both linked to rising atmospheric carbon dioxide. A number of research papers have suggested that coral reefs will be severely degraded once atmospheric carbon dioxide reaches approximately 500-560 ppm (e.g., Hoegh-Guldberg et al., 2007; Silverman et al., 2009), levels that may be reached before mid-century if we continue on a high-emission trajectory. Some researchers have argued that even lower CO2 levels are required to maintain healthy reefs (>350 ppm equivalent to levels in 1990; for comparison, global average surface CO2 levels are currently above 395 ppm).

Coral reefs are unique and highly diverse marine ecosystems that support a wide range of ocean life and ecosystem services (protein for reef fisheries; economic value and livelihoods from tourism and recreation; shore protection from waves and storm surface for coastal infrastructure and habitation). The severe degradation of coral reefs would potentially have substantial effects both within the United States (e.g., parts of southern Florida, Hawaii, U.S. Pacific and Caribbean Territories) as well as internationally, with some of the hardest hit areas being in developing tropical coastal and island nations (e.g., Cooley et al., 2009; Hilmi et al., 2013). Similarly, loss of commercially valuable shellfish fisheries would have impacts both of food supply and regional economies (Cooley and Doney, 2009; Cooley et al., 2012).

Cooley, S.R. and S.C. Doney, 2009: Anticipating ocean acidification's economic consequences for commercial fisheries, *Environ. Res. Lett.*, **4**, 024007, doi:10.1088/1748-9326/4/2/024007.

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Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, et al. 2007. Coral reefs under rapid climate change and ocean acidification. Science 318:1737–42

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Veron, J.E.N., O. Hoegh-Guldberg, T.M. Lenton et al. 2009. The coral reef crisis: the critical importance of < 350 ppm CO2. Mar Pol Bull, 58: 1428–36

2. Is there a practical and safe way to reduce the ocean acidification that is occurring other than limiting the amount of carbon pollution that we are emitting into the atmosphere?

The most direct and effective way of limiting further acidification of ocean surface waters is to limit further human emissions of carbon dioxide to the atmosphere. At some point in the future, it may also be feasible to actively remove excess carbon dioxide from the atmosphere using some form of capture and sequestration technique.

Proposed methods have been suggested to combat ocean acidification by increasing surface seawater alkalinity, for example by adding ground calcium carbonate to the surface ocean. On a global scale, these methods would require large volumes of material and energy to offset the effects of human carbon dioxide by the ocean, which at present is about 2 billion metric tons of carbon per year. The technical feasibility and potential negative environmental impacts of schemes to increase ocean alkalinity have not been explored except in the form of back of the envelope calculations.

At local and regional scales in the coastal ocean and estuaries, ocean acidification from fossil fuel burning is exacerbated by other pollution sources such as excess nutrients, soil erosion and atmospheric pollutant deposition. These local sources of pollution could be better managed to reduce local ocean acidification levels and improve water quality (Washington State Blue Ribbon Panel on Ocean Acidification, 2012).

Washington State Blue Ribbon Panel on Ocean Acidification, 2012: *Ocean Acidification: From Knowledge to Action, Washington State's Strategic Response.* H. Adelsman and L. Whitely Binder (eds). Washington Department of Ecology, Olympia, Washington. Publication no. 12-01-015.

Questions from Senator Sheldon Whitehouse

1. To your knowledge, what work exists that assimilates ocean observations and models, with specific attention to deep storage of heat?

A number of research groups are producing time-evolving estimates of global ocean circulation and heat content by combining ocean observations and numerical models. These approaches go under various names such as ocean state estimation and data assimilation, and key products include:

- Estimating the Circulation & Climate of the Ocean (ECCO, http://www.ecco-group.org/)
- NOAA/NCEP Global Ocean Data Assimilation System (GODAS, http://www.esrl.noaa.gov/psd/data/gridded/data.godas.html)
- European Centre for Medium-Range Weather Forecasts ocean reanalysis system 4 (ORAS4, http://www.ecmwf.int/products/forecasts/d/charts/oras4/reanalysis/) (Balmaseda et al., 2013a)

These data-model systems typical incorporate all available ocean data including full-depth profiles of ocean temperature (e.g., Balmaseda et al., 2013b).

Balmaseda, M. A., K. Mogensen, and A. T. Weaver (2013a), Evaluation of the ECMWF Ocean Reanalysis ORAS4, Q. J. R. Meteorol. Soc., 139(674), 1132–1161, doi:10.1002/qj.2063.

Balmaseda, M.A., K.E. Trenberth, and E. Källén, 2013: Distinctive climate signals in reanalysis of global ocean heat content, Geophysical Research Letters, 40, 1754–1759, doi:10.1002/grl.50382, 2013

2. What implication might this work have on comparisons of models and observations?

Both observational synthesis studies (e.g., Purkey and Johnson, 2010) and data assimilation modeling studies that incorporate observations (e.g., Kouketsu et al., 2011; Balmaseda et al., 2013) indicate that the deep ocean is warming, acting as an important heat reservoir and leading to sea-level rise. These observationally-based estimates provide important constraints on climate model predictions of recent global temperature trends. Over the last decade, global surface temperatures have increased at a relatively slow rate even though greenhouse gas concentrations, such as carbon dioxide, have continued to increase. This so-called warming hiatus could be caused by several factors: compensation by cooling factors such as atmospheric aerosols; overestimation of climate sensitivity to increasing greenhouse gas levels; and natural climate variability that is temporally masking a longer-term warming trend. Some climate models indicate that periods of weak global warming are associated with natural variability that leads to enhanced warming in the deep ocean relative to the upper ocean (Meehl et al., 2011); these patterns are consistent with recent trends where ocean warming has been most substantial below 300m (Balmaseda et al., 2013). The vertical and geographic patterns of ocean temperature change may also provide important tests for more specific hypothesis on the causes for the recent slowing of global surface temperatures. For example, the modeling study of Kosaka and Xie (2013) suggests that the cool tropical Pacific ocean temperatures observed over the last decade are a major cause of slow global warming. The tropical Pacific ocean cooling may reflect a cold period of the Pacific Decadal Oscillation, a natural model of climate variability, suggesting that global warming may accelerate when the Pacific Decadal Oscillation shifts back to a warm period.

Kosaka, Y., and S.-P. Xie, 2013: Recent global-warming hiatus tied to equatorial Pacific surface cooling, Nature, doi:10.1038/nature12534

Kouketsu, S., et al. (2011), Deep ocean heat content changes estimated from observation and reanalysis product and their influence on sea level change, J. Geophys. Res., 116, C03012, doi:10.1029/2010JC006464.

Meehl, G. A., J. Arblaster, J. Fasullo, A. Hu, and K. Trenberth (2011),Model based evidence of deep ocean heat uptake during surface temperature hiatus periods, Nat. Clim. Change, 1, 360–364, doi:10.1038/NCLIMATE1229.

Purkey, S. G., and G.C. Johnson (2010), Warming of global abyssal and deep southern ocean between the 1990s and 2000s: contributions to global heat and sea level rise budgets, J. Clim., 23, 6336–6351.

3. Is the frequency of record-breaking temperatures at individual weather stations the best way to indicate whether or not the atmosphere is warming?

The frequency of breaking temperature records depends on many factors such as the length of the observational data record. For example, under a stable climate, the frequency of record-breaking events will be high early in the data time-series as one is still observing the full range of natural climate variability. Over time for a stable climate, the frequency of record-breaking events will then decline with time as it is less likely to see unusual extremes that have not already been observed. With a warming trend, one would expect to see an increase in the frequency of record-breaking warm events and a decrease in the number of record-breaking cold events but the specific trends would depend on the natural climate variability and the length of the data record.

A more robust way of looking at long-term trends in temperature statistics is to examine the number of warm days above certain thresholds, particularly if these thresholds can be tied to vulnerabilities in natural ecosystems, agriculture, and human communities. For example, one could look at the maximum temperatures measured at a site over a baseline period (for example the 20th century). Presumably people and ecosystems have adapted to those temperatures. One could then examine the number of events moving forward in time when the temperature exceeds that threshold, giving a metric for potential vulnerabilities to conditions not previously observed.

4. Is there any evidence that increases in average temperatures have caused a shift in either the magnitude or frequency of extremely cold or warm temperatures?

This topic was discussed in some detail in the draft National Climate Assessment chapter on climate change (Walsh et al., 2013) released for public comment earlier this year. Quoting from that document:

> "recent prolonged (multi-month) extreme heat has been unprecedented. The 2011 and 2012 events set records for highest monthly average temperatures, exceeding in some cases records set in the 1930s, including the highest monthly temperature on record (July 2012, breaking the July 1936 record); for the spring and summer months, 2012 had the largest area of record-setting monthly average temperatures, including both hot daytime maximum temperatures and warm nighttime minimum temperatures (Karl et al., 2012). Corresponding with this increase in extreme heat, the number of cold waves has reached the lowest levels on record."

Similarly, a recent IPCC synthesis report on extreme weather events (IPCC, 2012) came to the same broad conclusion:
"It is very likely that there has been an overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights, at the global scale, that is, for most land areas with sufficient data. It is likely that these changes have also occurred at the continental scale in North America, Europe, and Australia. ...

Globally, in many (but not all) regions with sufficient data there is medium confidence that the length or number of warm spells or heat waves has increased since the middle of the 20th century." (Seneviratne et al., 2012)

Karl, T.R., B.E. Gleason, M.J. Menne, J.R. McMahon, J. R.R. Heim, M.J. Brewer, K.E. Kunkel, D.S. Arndt, J.L. Privette, J.J. Bates, P.Y. Groisman, and D.R. Easterling, 2012: U.S. temperature and drought: Anomalies of spring and summer 2011-12 and trends. EOS Transactions, AGU, 93, 473

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5. In your testimonies you mention the consequences of ocean acidification on ocean organisms that rely on calcium carbonate for the construction of their shells and skeletons. We know that as the pH of seawater drops, do does the saturation of calcium carbonate and it becomes more difficult for species to make their shells-species like oysters, crabs, lobsters, corals, and plankton that comprise the base of the food web. This includes the tiny pteropod, a type of snail which is about the size of a small pea. Forty-seven percent of the diet of some salmon species in the Pacific is pteropds. The salmon fisheries support coastal jobs and economies.

Can you comment further, or provide additional information, on the potential for ocean acidification to disrupt entire food chains and how ocean monitoring and observing infrastructure plays a role in better understanding possible consequences?

Most of the experimental work on ocean acidification has focused on laboratory experiments. Effects on natural populations and communities so far have been more difficult to detect outside of a limited number of CO2 manipulation experiments conducted on water-column plankton communities (Riebesell et al., 2008) and some studies in isolated high-CO2 environments such as shallow volcanic vents (Hall-Spencer et al., 2008; Fabricius et al., 2011). The high-CO2 volcanic event studies of shallow benthic systems are quite striking in that they show large disruptions of the natural communities in response to CO2, and the changes in the biological communities tend to support laboratory findings with, for example, large reductions in corals, mollusks and other calcifying organisms and more algal growth in response to elevated CO2. Acidification impacts on water-column food-webs are less well understood, but it is likely that decreases in prey abundance (e.g., benthic mollusks, calcifying plankton like pteropods) will have an impact on predators such as fish and marine mammals. To date most of the research on this topic has involved the analysis of simple food-web models, and this is a high priority area for further research particularly for commercially important species.

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Senator WHITEHOUSE. Thank you, Dr. Doney, and Dean Leinen, welcome. Please proceed with your testimony.

I think given the timing, we will take a recess at the conclusion of your testimony then return once the voting is complete. It takes us five or 6 minutes for us to get over there, vote, and get back.

Dean Leinen.

STATEMENT OF MARGARET LEINEN, PH.D, EXECUTIVE DIRECTOR OF HARBOR BRANCH OCEANOGRAPHIC INSTITUTE, VICE PROVOST FOR MARINE AND ENVIRONMENTAL INITIATIVES, FLORIDA ATLANTIC UNIVERSITY

Ms. LEINEN. Chairwoman Boxer, Senator Whitehouse, a great advocate of the oceans, and distinguished members of the Committee, thank you for the opportunity to speak today.

My name is Margaret Leinen and I am the Executive Director of Harbor Branch Oceanographic Institute. I would like to focus on the ecosystems that are affected by climate change.

The East Coast, from North Carolina to Maine, accounts for 30 percent of the $5.3 billion U.S. Fisheries landings. There is a typo in your written testimony that says $5.3 trillion. Fisheries are important, but not quite that important.

[Laughter.]

Ms. LEINEN. A 2009 study of 40 years of fishing research vessel survey data, including some of our most important commercial species, Atlantic cod, haddock, winter and yellowtail flounder, Atlantic herring, showed that about half of the 36 species included have shifted northward over the last four decades as ocean temperatures in the region increased during the same 40 years.

Half of the stocks moved north, some expanded their range, some moved deeper, but the temperature at which each stock was centered did not change with time, suggesting that the fish are moving to remain within their preferred temperature range. Some of the stocks nearly disappeared from U.S. waters as they moved further offshore.

Studies completed last year show that this northward shift has continued. This means that fishers who adapt their vessels and their techniques for one species or group of species may have to travel further to catch those fish, expending more fuel. And when stocks move out of U.S. waters, our fishers must compete with other countries for fish they used to have exclusive access to. Remember that this area from North Carolina to Maine is a $1.7 billion a year landings industry.

Coral reefs comprise some of the most beautiful and diverse ecosystems on earth. They also spur nearly $17 billion in tourism spending and $250 million a year in commercial fishing. They also provide coastal protection from strong ocean currents, waves and hurricanes.

Small algae live inside corals and provide food and energy for the corals through photosynthesis. When these microbes are stressed by heat, they often die and are expelled, leaving corals to starve. For the last 30 years, detailed surveys of this process, called coral bleaching, have been accompanied by surface and satellite temperature data. Using these data, researchers track the conditions that lead to coral bleaching. In Florida and U.S. Caribbean reefs, those closest to my home, heat stress has nearly doubled during the last decade, accompanied by severe coral bleaching events.

Sea surface temperature increases of 2 degrees Fahrenheit per decade have been accompanied by losses of viable coral reef between 5.5 percent and 9.2 percent per year. Western Atlantic reefs have the highest percentage affected by bleaching of any reefs worldwide.

Humans are part of the ecosystem as well. Florida is very flat and low. Our 9 million population is heavily concentrated along our coasts. Miami, the seventh largest city in the Country, the Florida Keys, coastal and inland portions of Broward County, the Florida Everglades and Fort Lauderdale are all less than two feet in elevation.

In the last 50 years, Florida has seen between five and eight inches of sea level rise. Our civic infrastructure, roads, storm sewers, water supplies, power grids, is already seeing the impact of sea level rise. Drainage systems are not working in many areas during lunar high tides and during storms. The streets of Miami Beach are now routinely flooded during peak high tide.

During storm surges, sea water moves into storm sewer systems and pushes water inland, actually causing sea water fountains up to a mile inland. Future sea level rise of only six more inches, forecast as early as 2030, would cripple half of the areas flood control infrastructure. It is a major economic impact.

But the sea level rise problem in Florida is not restricted to inundation. As the sea level rises, it intrudes into our very porous limestone and pushes fresh water up and out. Right now, many wells for South Florida communities are close to the current boundary of salt water intrusion and cities are already spending millions to upgrade their storm water systems and to moving their drinking wells westward. This will only be a temporary solution as sea levels rise.

Members of the Committee, these impacts are already affecting our economy substantially and will continue to do so.

[The prepared statement of Ms. Leinen follows:]

WRITTEN TESTIMONY OF
MARGARET LEINEN, Ph.D.
EXECUTIVE DIRECTOR OF HARBOR BRANCH OCEANOGRAPHIC INSTITUTE
AND VICE PROVOST FOR MARINE AND ENVIRONMENTAL INITIATIVES
FLORIDA ATLANTIC UNIVERSITY

HEARING ON 'CLIMATE CHANGE: IT'S HAPPENING NOW'
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
U.S. SENATE
July 18, 2013

Introduction

Madame Chairwoman and Members of the Committee, thank you for the opportunity to speak with you this afternoon. My name is Margaret Leinen and I am the Executive Director of Harbor Branch Oceanographic Institute and Associate Provost of Florida Atlantic University. In addition I currently serve as the President-Elect of the American Geophysical Union. You have heard much today about the ways in which the climate is changing and physical evidence of those changes. I have been asked to concentrate on changes that we are observing in ecosystems or in systems that affect us directly. I will highlight three systems: US North Atlantic fisheries, Florida-Caribbean coral reefs, and South Florida sea level rise and its impact on shoreline communities.

Changes in the ranges of US East Coast Fisheries

US Fisheries are a major industry responsible for over $5.3T in 2011 (NMFS, Annual Commercial Landings Statistics, 2011). The east coast from North Carolina to Main accounts for $1.7T of that amount. I'm going to mention briefly how this area is being affected by climate change.

A 2009 study of fishing research vessel survey data collected every spring from 1968 through 2007 showed that about half of the 36 different fish species studied, many of them commercially important, have been shifting northward over the last four decades (Nye, et al. 2009). The study, led by Dr. Janet Nye, who is an Assistant Professor at the State University of New York at Stony Brook, focused on some of our most important commercial fish species: Atlantic cod, haddock, yellowtail and winter flounder, Atlantic herring, as well as several less well known species. It covered the entire region from North Carolina to the Canadian border.

Dr. Nye and her colleagues at the Northeast Fisheries Science Center also analyzed historic ocean temperature records and long-term processes like the Atlantic Multi-decadal Oscillation and the North Atlantic Oscillation dating back to 1850 so that they could put recent temperature increases into context. Ocean temperatures in the region increased during the 40 years of survey data.

In fact, a separate study by the Northeast Fisheries Science Center showed that sea surface temperature hit a 150 year high off the US east coast from Maine to North Carolina during 2012. They were high from the sea surface to the bottom, and east to the edge of the Gulf Stream. While sea surface temperatures in this area are generally less than 48°F, they exceeded 51°F during the first half of the year. And bottom temperatures were 1-2C (2 to 4°F) warmer in the Gulf of Maine. While these changes may seem small to us since we see large daily changes in temperature, they are statistically significant for the oceans, where temperatures are much more stable.

The 36 species that were studied were chosen because they were consistently caught in high numbers during the annual spring trawl survey. This is the longest time series of standardized fishery population data.

The researchers looked at where the fish were caught and their total population weight in each year of the survey. For each fish stock, the estimated the center of abundance as well as the average depth of the stock, the area that the stock occupied, and the average temperature at which the stock was found. They took into account natural cycles of ocean temperature and changes in fishing activity.

Nye and her colleagues found that 10 of the 36 stocks had significantly expanded their range while 12 had significantly reduced it. 17 of the stocks moved the increasingly greater depths with time, 3 moved shallower. But the temperature at which each stock was found did not change over time, suggesting that the fish are moving to remain within their preferred temperature range. Some of the stocks nearly disappeared from US waters as they moved further offshore. Studies completed last year (http://www.nefsc.noaa.gov/ecosys/advisory/current/advisory.html), show that the northward shift of the fish stocks has continued.

Changes in ocean temperatures and the timing and strength of spring and fall phytoplankton blooms that provide food for the fish stocks have the potential to affect the spawning success and/or the amount of food available. In fact parts of this regions were declared a fisheries disaster during the first six months of 2012 because stocks of cod, haddock and flounder are not rebuilding in spite of the fact that fishers have been adhering to tough quotas.

These changes have implications for our fisheries, as well as the fish themselves. The changes mean that fishers who have adapted their vessels and gear for one species or group of species, may have to travel further to catch those fish – expending more fuel. Some stocks have moved out of US waters, meaning that our fishers will have to compete with fishers from other countries for the fish that they used to have exclusive access to. Remember that this is a $1.7T industry.

Increasing extent and number of Coral bleaching events on Florida and Caribbean reefs

Coral reefs comprise some of the most beautiful and diverse ecosystems on earth. They are also important economically. US Coral reefs spur near $17B in tourism spending with 45M tourist visits annually to US reefs. They are responsible for $247M in commercial fishing (NMFS, Annual Commercial Landing Statistics, 2011). And coral reefs provide coastal protection from strong ocean currents, waves, and hurricanes. I am going to focus my remarks on Florida and US Caribbean reefs, those closest to my home.

As you may know, small symbiotic algae live inside corals and provide food and energy for the corals through photosynthesis. When these symbiotic organisms are stressed by heat they often die and are expelled leaving the corals to starve. Because these algae are responsible for the color of the corals, the corals look white or 'bleached' and these events are called 'coral bleaching'. Both the intensity and duration of heat waves influence coral stress responses and bleaching. A weeklong spike in temperature at 4°C (7°F) above the average summer maximum temperature can lead to widespread coral bleaching. Likewise just a 1°C (2°F) increase that continues for 4 weeks can result in prolific coral bleaching. Bleaching events that persist for weeks or months usually lead to extensive coral mortality.

For the past 30 years detailed surveys of coral bleaching have been accompanied by discrete sea surface temperature data. Using satellite sea surface temperature data and in situ temperature data, NOAA tracks the sea surface conditions that could lead to coral bleaching. As compared to the previous 15 years, this heat stress in the Caribbean has nearly doubled in the last decade, accompanied by severe coral bleaching events (Eakin, 2007). The Caribbean/Florida region has shown sea surface temperature increases of about 1°C (2°F) per decade (Chollett, et al., 2012) concurrent with losses of viable coral reef area of between 5.5% and 9.2% per year (Cote et al, 2005; Gardner, et al., 2001). Western Atlantic reefs have the highest percentage area affected by bleaching of any reefs worldwide.

Numerous studies have documented increases in coral disease abundance and associated coral mortality during elevated summer temperatures (e.g. Voss and Richardson 2006, Jones et al. 2004). Like coral bleaching, the duration of high temperature anomalies can impact disease abundance and severity (Bruno et al. 2007, Ruiz-Morenol et al. 2012). Thermal stress is known to both compromise coral immunity (Harvell et al. 2009, Mydlarz et al. 2010) and increase the growth rates of certain coral pathogens (Ward et al. 2007).

Superimposed on the increasing temperature of Florida/Caribbean region have been extreme events, like those of 1997-1998 (which was also an El Nino year) and 2005 (which was not an El Nino or La Nina year). 2005 had the warmest regionally averaged Caribbean sea-surface temperatures recorded in the last 150 years. 90% of the reefs in the US Virgin Islands experienced bleaching, and many of these coral experienced secondary disease infections. Overall, coral cover in the USVI was reduced by 60% due to bleaching and disease associated mortality (Miller et al. 2009).

Climate change and associated temperature stress are not the sole drivers of coral reef health. Excess nutrients, increased sedimentation, and other human influenced factors are known to impact coral reefs. Data suggests that the synergistic effects of local stressors can reduce corals thermal tolerance limits (Carilli et al. 2009), exacerbating the potential impacts of climate change on coral health.

Sea level rise

Humans are part of the ecosystem as well and my last example focuses on climate change impacts on coastal communities from sea level rise. Again, I'll focus on the area I know best, South Florida. While this is but one area that will be affected, economic analyses indicate that 40% of the economic impact of the first foot of sea level rise in the US will be in South Florida (Tebaldi, et al., 2012).

As you all know, Florida is very flat and very low. We have a large population, almost 19 million, and it is heavily concentrated with almost 14 million people living along our coast. In South Florida Miami, the 7th largest city in the country, the Florida Keys, coastal and inland portions of Broward Country, the Florida Everglades and Fort Lauderdale are all below 2 feet in elevation.

Florida has seen 5-8 inches of sea level rise in the past 50 years. Our civic infrastructure in South Florida -- roads, storm sewers, water supplies, and power grids – is already seeing the impact of sea level rise. Although sea level has only risen these few inches in 50 years, that rise has been sufficient to prevent drainage systems from working during lunar high tides and during storms. The streets of Miami Beach are now routinely flooded at peak high tide. The addition of storm surges to these higher sea levels means that drainage systems no longer work reliably causing seawater to move into storm sewer systems and force water inland. Several flood gates are unable to discharge storm water at their full capacity during high tides. Future sea level rise of only 6 more inches – forecast as early as 2030 – would cripple half of the areas flood control infrastructure.

But the sea level rise problem in Florida is not restricted to inundation. Very porous limestone underlies most of Florida. As sea level rises, salt water intrudes into the limestone and pushes freshwater up and out of the limestone. The Biscayne limestone aquifer provides much of the freshwater to the coastal region of the southern east coast of Florida. It has been affected by saltwater intrusion and will be subject to further intrusion. Many wells for south Florida communities are close to the current boundary of saltwater intrusion. The City of Hallandale Beach is already spending $16M to upgrade their storm water system and to move the city's entire drinking water supply westward. This will only be a temporary solution as sea level continues to rise.

This south Florida coastal ecosystem, of which people are so much a part, is already seeing the impact of climate change in the rate of sea level rise, as the thermal expansion of ocean waters with their warming is a major component of the sea level rise we are already seeing.

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HARBOR BRANCH

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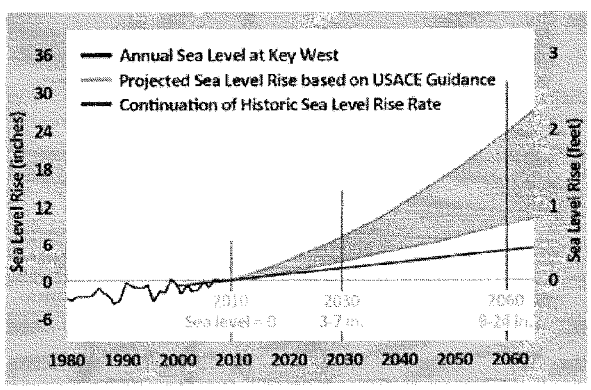
September 20, 2013

Response to question posed by Senator Barbara Boxer from Dr. Margaret Leinen, Executive Director of Harbor Branch Oceanographic Institute and Associate Provost for Marine and Environmental Initiatives, Florida Atlantic University:

Question: Dr. Leinen, your testimony discusses the climate change impacts already occurring in Florida. If we fail to reduce carbon pollution and it continues as projected, what does the scientific evidence indicate Southern Florida will look like in 2050.

Answer:

In 2011, The Southeast Florida Regional Climate Change Compact gathered lead sea level rise experts for a series of meetings to identity a key set of sea level rise projections for the region, through 2060. The following is a graphic that shows the estimates agreed upon which are based on the USACE methodology and NOAA sea level data.



Current measurements of sea level rise in the South Florida region are about 0.38 cm/year. The rate of sea level rise is projected to increase to 0.45-1.25 cm/year between now and 2050. The difference between the current rate and the increased rate would cause between 4 and 18 inches of additional sea level rise by 2050. While the total projected sea level rise seems modest, these projections suggest significant impacts for much of Southeast Florida. In Broward, Miami Dade, and Monroe counties, sea level rise impacts are already being felt today, and the future will bring additional challenges. This region is uniquely vulnerable because the land is at low elevations and composed of porous limestone. As mean sea level increases, the foundation upon which high tide and storm surge build is also increased. Extreme weather and tides will continue to move further inland and lead to temporary flooding as well as permanent inundation.

It is important to recognize that even the current rates of sea level rise will be challenging to South Florida. Miami, the 7th largest city in the country, the Florida Keys, coastal and inland portions of Broward Country, the Florida Everglades and Fort Lauderdale are all below 2 feet in elevation. Thus the current rate of increase will affect a large area, including millions of people along the southeast coast of Florida in Miami, Fort Lauderdale, Boca Raton and Palm Beach and their suburbs.

In the Florida Keys (Monroe County), a two foot (0.6 m) rise in sea level would inundate about 70% of the total land surface, 17% of the population, and 12% of real-estate property (Zhang, 2011). A similar rise in Broward County would cause 33 km^2 of land to dip below sea level, about 30,000 people to be displaced, and $15 billion of potential losses in property value. In Miami Dade County, 11% of the land is already below sea level. Most of this land is located in Everglades National Park (Zhang, 2011). Along with changes in vegetation patterns, SLR threatens 21 rare coastal species in Everglades National Park (Noss, 2011)

Studies of the paths of inundation show that streets in coastal communities will flood first, rendering storm sewers and other flood control infrastructure useless. Already streets in areas of Miami and Fort Lauderdale flood during lunar high tides and storms. These coastal communities are already making plans to modify flood control systems. Only 3-6 inches of sea level rise – which could occur by 2030 – would cripple half of the area's flood control infrastructure. The addition of another 12 inches by 2050 would severely impact more of the region's transportation and flood control infrastructure. Municipalities in South Florida, already having to plan for adaptation to sea level rise, have been told by the US Army Corps of Engineers to plan for 2 feet of sea level rise by the end of the century. That will mean that by 2050, substantial areas of Miami Beach, as well as all of the coastal area of

Fort Lauderdale, Boca Raton and Palm Beach would be under water by 2050.

While the points above relate to average conditions, we all know that South Florida is in the path of tropical storms and hurricanes regularly. The storms, in addition to their wind damage, cause very substantial storm surges. Southeast Florida's beaches experienced a substantial erosion last November during Superstorm Sandy. Part of Route A1A in Fort Lauderdale was washed away and the highway has been reduced from 4 lanes to 2 lanes since.

In addition to this inundation, Southeast Florida will experience major impacts to its fresh water supply. The rock underlying South Florida is porous calcium carbonate formed in the geologic past from coral reef deposits. Seawater infiltrates the porous rock and, as sea level rises, pushes fresh water up and out of the rock. As sea level rises, the subsurfasce boundary between fresh and saltwater is projected to move miles further inland and to move upward. Thus, municipalities will need to move their fresh water wells westward, to avoid contamination of drinking water with salt water. Saltwater intrusion is evident in Hallandale Beach, where 6 out of 8 wells have been closed as a result. As we struggle to maintain a freshwater supply in the dry season, we will face new challenges in the wet season, such as inland flooding. Drainage from gravity-driven flood control structures is compromised by rising seas when the sea level exceeds the canal height.

In summary, with higher rates of sea level rise South Florida will be smaller in area – with some of the most valuable real estate in the US inundated. In addition, the remaining land will experience lunar high tide and storm surge flooding of streets and transportation corridors, substantial further destruction of flood control mechanisms, and higher risk of tropical storm and hurricane inundation and destruction.

There are many adaptation efforts currently under study by the Florida Climate Institute, Southeast Florida Regional Climate Compact, and other groups. As more innovative strategies for planning and development increase our resilience, we can be prepared for the future threats of sea level rise.

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Contributor: Keren Bolter

Response to question posed by Senator Sheldon Whitehouse from Dr. Margaret Leinen, Executive Director of Harbor Branch Oceanographic Institute and Associate Provost for Marine and Environmental Initiatives, Florida Atlantic University:

Question: Dr. Leinen, can you comment further, or provide additional information, on the potential for ocean acidification to disrupt entire food chains and how ocean monitoring and observing infrastructure plays a role in better understanding possible consequences?

Ocean acidification, the increase in the hydrogen ion concentration or pH of the oceans that has been observed over the past approximately 25 years, is of concern for several reasons. First, many marine organisms, like corals, oysters and clams, make skeletal material out of calcium carbonate (CaCO3). As acidity increases, the saturation of calcium carbonate in seawater decreases and it is more difficult for organisms that make skeletal material out of calcium carbonate to form this skeletal material. Second, the ability of organisms to carry out some physiological processes can be dependent on the pH of the water in which they live. The chemistry of the first process is well known and we understand that CaCO3-secreting organisms will all be affected, but we do not know the exact rate or extent to which they will be affected. The second impact – on other physiological processes – is less well known and is being explored through laboratory and field experimental research.

We know that ocean acidification is already affecting the viability of shellfish larvae (e.g., Miller et al 2009) and increases the stress on corals. But further decline of either is not projected to 'disrupt entire food chains'.

HARBOR BRANCH
FLORIDA ATLANTIC UNIVERSITY

It has been suggested, however, that ocean acidification could disrupt food chains if it affected carbonate-secreting organisms lower down in the food chain on which other organisms depend (e.g., Fabry et al, 2008). Researchers have expressed concern about the impact of ocean acidification on pteropods, microscopic marine snails that make their shells from calcium carbonate. We know that these organisms are being affected by ocean acidification. For example, their shells are becoming thinner (ref) and laboratory studies show that the shells dissolve when waters are acidified. These organisms are important food resources organisms higher in the food chain in the North Atlantic (ref.). Pteropods are critical for many ocean ecosystems because they are present in large masses that can easily be found and eaten by fish. Gretchen Hofmann, a University of California (Santa Barbara) biologist and ocean-acidification expert was quoted as saying: "They're small, but carry an enormous amount of nutrition and are eaten even by very big fish. If you're in the Antarctic and see a beautiful emperor penguin, it exists by eating fish under the sea ice. And those fish eat pteropods."

There is no evidence that ocean acidification has affected the food web yet, but if conditions continue to lower pH and if pteropods respond linearly to that acidification, and if they could not survive without their shells, this portion of the food chain could be eliminated. I am not aware of an organism for which pteropods are the only acceptable food and that would be wiped out as a result, but the elimination of this portion of the food chain would force organisms to see alternate food. We do not know how readily organisms further up the chain would switch foods.

Another type of micro-organism that makes skeletal material out of calcium carbonate is foraminiferans. We have evidence that these microscopic organisms have shell weights that are 30-35 % lower than weight of shells of the same species that formed thousands of years ago before waters became more acidic (Moy et al, 2009). Coccolithophorid plankton also make shelly structures out of carbonate.

Because seawater in the Antarctic already has low carbonate concentrations due to its cold temperature, projections suggest that seawater there could be acidic enough to dissolve the shells of calcifying plankton in the wintertime. Since many important species of plankton go through larval development stages in winter, this would be an important impact and could have an impact on the food web.

Other keystone species affected by ocean acidification are those living on the sea floor. These benthic organisms, such as corals and calcified algae that produce the structure, sands and cement for cold and warm-water reefs, are also in danger of dissolving from ocean acidification. These reefs create important habitats for fish and hold within its realm some of the highest biodiversity in the world's oceans.

Initial studies of other physiological reactions to ocean acidification in organisms near the base of the food chain suggest that acidification can affect photosynthetic ability. Some of these effects enhance productivity, others change the rate of uptake of nutrients in ways that could affect the nutritional value of the plankton (e.g., Sterner and Elser, 2002).

If ocean acidification were capable of either removing phytoplankton or zooplankton species or groups of species that form an important food resource, they could disrupt food chains. Likewise, physiological changes in growth rate or changes in community structure of phytoplankton due to physiological changes in important species or groups of species also hold potential to disrupt food chains.

In addition to the direct "acid effects" on organisms with calcified structures under ocean acidification, there are indirect effects of elevated ocean CO_2 on large ocean fish, such as tuna, and other species critical to open-ocean fisheries. These large fish require a high rates of oxygen intake. As they speed through the oceans they take up large amounts of oxygen to support their high metabolic rates. In doing so, they also take up CO_2 gas. If CO_2 is taken up in too high of concentration, however, the fish can suffer from hypercapnia, a condition where there is too much carbon dioxide (CO_2) in the blood.

Ocean monitoring and observing infrastructure plays a critical role in understanding both the acidification process and the impact of the process. Observing systems have already been important to be able to predict upwelling of low pH water onto the coastal zone in the Pacific Northwest so that sensitive larval shellfish can be removed from harms way. But these systems are critical to our understanding of the progress of acidification: where it is happening most quickly or most extensively. They are also key to our ability to determine where low pH water will be transported and how it will affect coral and shellfish systems of immediate economic important, as well as its potential for larger scale impact.

These systems also allow us to study the planktonic ecosystems of the open Pacific at the same time that we measure the pH so that we can begin to determine the degree to which the systems are responding to pH changes and the potential for disruption in the future.

Senator WHITEHOUSE. Thank you very much, Dean Leinen.

The Committee will stand in recess for five, 7 minutes subject to the call of the Chair, shall we say, while we go and do our vote. And then we will reconvene.

[Recess.]

Senator WHITEHOUSE.

[Presiding] The hearing will return to order.

We now have Dr. Roger Pielke. I have pronounced it correctly, I see, by your head nodding.

Mr. PIELKE. You got it. That is correct.

Senator WHITEHOUSE. And then, after that, Dr. Spencer.

Please proceed, Dr. Pielke.

STATEMENT OF ROGER PIELKE, JR., PROFESSOR, CENTER FOR SCIENCE AND TECHNOLOGY POLICY RESEARCH, UNIVERSITY OF COLORADO

Mr. PIELKE. Thank you to the Senators and to the Committee for having me give this testimony today.

I started working on extreme weather and climate in 1993 at the National Center for Atmospheric Research when I started a post-doc position. I am currently Professor of Environmental Studies at the University of Colorado.

Now, I am going to give you seven what I call take home points. And it is important to emphasize that each of these points are consistent with what has been reported by the Intergovernmental Panel on Climate Change, the U.S. Global Change Research Program and the broader peer-reviewed literature. In fact, I find is fascinating that I am the ninth witness out of 10 and I am the first one to invoke the Intergovernmental Panel on Climate Change at a hearing on climate change.

Here are my seven points.

First, it is misleading and just plain incorrect to claim that disasters associated with hurricanes, tornadoes, floods or drought have increased on climate time scales either in the United States or globally. It is further incorrect to associate the increase in costs of disasters with the emission of greenhouse gases.

Second point. Globally, weather-related losses have not increased since 1990 as a proportion of GDP. They have actually decreased by about 25 percent. And insured catastrophe losses have not increased as a proportion of GDP since 1960.

Hurricanes, point three, hurricanes have not increased in the U.S. in frequency, intensity or normalized damage since at least 1900. The same holds for tropical cyclones globally since at least 1970 when we have good data.

Fourth, floods have not increased in the U.S. in frequency or intensity since at least 1950 and, remarkably, flood losses as a percentage of U.S. GDP have dropped by 75 percent since 1940.

Fifth, tornadoes have not increased in frequency, intensity or normalized damage since at least 1950 and there is some evidence to suggest they have actually declined.

Sixth, drought has, and here I quote the IPCC, for the most part become shorter, less frequent and covered a smaller portion of the U.S. over the last century. Globally, and I quote from a recent paper in Nature, there has been little change in drought over the past 60 years.

Seventh, now this, these trends being the case, it is nonetheless a fact that the absolute costs of disasters will increase significantly in coming years no matter what you think about climate change or the human role in it simply due to greater wealth and populations exposed in locations that are prone to extremes. So, disasters will continue to be an important focus of policy irrespective of how climate change evolves.

Now, let me say I have a few statements in addition to these kind of factual scientific ones and, as we have seen this morning, because the issue is so deeply politicized, there are a few points to make so that my testimony is not misconstrued.

First, humans do influence the climate system in profound ways including through the emission of carbon dioxide from the combustion of fossil fuels. And I would point you to the first working group report from the IPCC, Intergovernmental Panel on Climate Change, for discussion of that.

It is true that researchers have detected and in some cases attributed a human influence in measures of climate extremes that go beyond those few that I just mentioned, specifically surface temperatures and precipitation trends.

The inability to detect and attribute changes in hurricanes, floods, tornadoes and drought does not mean that human-caused climate change is not real or of concern. It does mean, however, that some activists, politicians, journalists, corporate and government agency representatives and even scientists who should know better have made claims that are just unsupportable based on evidence in research.

It is my view that such false claims undermine the credibility of arguments for action on climate change and, to the extent that these false claims confuse those who are making decisions related to extreme events, they could, in fact, lead to poor decisionmaking.

Now, a considerable body of research projects that in the future various extremes may, in fact, become more frequent or intense as a direct consequence of the human emissions of carbon dioxide and other greenhouse gases. There are exceptions. The IPCC suggests that winter storms may become less likely.

Our research, and that of others, suggests that assuming that these projections are correct, just taking them as true projections of the future, it would be many decades, perhaps longer, before the signal of human-caused climate change can be detected in the statistics of hurricanes. Now, to the extent that the statistical properties of other phenomena like floods, tornadoes and droughts are the same, that conclusion will hold.

Let me conclude by emphasizing that what I have reported to you today is consistent with what has been reported by the Intergovernmental Panel on Climate Change. And in my written testimony, I have included direct quotes from that. This is mainstream science. It should not be controversial. It is supported by peer-reviewed research and I hope that it is of some use.

Thank you very much.

[The prepared statement of Mr. Pielke follows:]

STATEMENT OF DR. ROGER PIELKE, JR.
to the COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
of the UNITED STATES SENATE

HEARING on CLIMATE CHANGE: IT'S HAPPENING NOW
18 July 2013

Short Biographical Note

My academic degrees are in mathematics, public policy and political science. I began studying extreme weather and climate in 1993 at the National Center for Atmospheric Research in Boulder, CO. Over the past 20 years I have collaborated with researchers around the world to publish dozens of peer-reviewed papers on hurricanes, floods, tornadoes, Australian bushfires, earthquakes and other subjects related to extreme events. Since 2001, I have been a professor of environmental studies at the University of Colorado. A longer bio can be found as an appendix to this testimony. My views on climate policy and politics, not discussed in this testimony, can be found in my recent book, *The Climate Fix* (Basic Books, 2011).

Take-Home Points

- It is misleading, and just plain incorrect, to claim that disasters associated with hurricanes, tornadoes, floods or droughts have increased on climate timescales either in the United States or globally.[1] It is further incorrect to associate the increasing costs of disasters with the emission of greenhouse gases.
- Globally, weather-related losses ($) have not increased since 1990 as a proportion of GDP (they have actually decreased by about 25%) and insured catastrophe losses have not increased as a proportion of GDP since 1960.
- Hurricanes have not increased in the US in frequency, intensity or normalized damage since at least 1900. The same holds for tropical cyclones globally since at least 1970 (when data allows for a global perspective).
- Floods have not increased in the US in frequency or intensity since at least 1950. Flood losses as a percentage of US GDP have dropped by about 75% since 1940.
- Tornadoes have not increased in frequency, intensity or normalized damage since 1950, and there is some evidence to suggest that they have actually declined.
- Drought has "for the most part, become shorter, less frequent, and cover a smaller portion of the U. S. over the last century."[2] Globally, "there has been little change in drought over the past 60 years."[3]
- The absolute costs of disasters will increase significantly in coming years due to greater wealth and populations in locations exposed to extremes. Consequent, disasters will continue to be an important focus of policy, irrespective of the exact future course of climate change.

To avoid any confusion

Because the climate issue is so deeply politicized, it is necessary to include several statements beyond those reported above.

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[1] The IPCC defines climate timescales to be 30-50 years and longer.
[2] This quote comes from the US Climate Change Science Program's 2008 report on extremes in North America.
[3] Sheffield et al. in Nature, http://www.nature.com/nature/journal/v491/n7424/full/nature11575.html

- Humans influence the climate system in profound ways, including through the emission of carbon dioxide via the combustion of fossil fuels.[4]
- Researchers have detected and (in some cases) attributed a human influence in other measures of climate extremes beyond those discussed in this testimony, including surface temperatures and precipitation.
- The inability to detect and attribute changes in hurricanes, floods, tornadoes and drought does not mean that human-caused climate change is not real or of concern.
- It does mean however that some activists, politicians, journalists, corporate and government agency representatives and even scientists who should know better have made claims that are unsupportable based on evidence and research.
- Such false claims could undermine the credibility of arguments for action on climate change, and to the extent that such false claims confuse those who make decisions related to extreme events, they could lead to poor decision making.
- A considerable body of research projects that various extremes may become more frequent and/or intense in the future as a direct consequence of the human emission of carbon dioxide.[5]
- Our research, and that of others, suggests that assuming that these projections are accurate, it will be many decades, perhaps longer, before the signal of human-caused climate change can be detected in the statistics of hurricanes (and to the extent that statistical properties are similar, in floods, tornadoes, drought).[6]

The remainder of this written testimony provides data and references to support the claims made in the "take-home points" above. The "take-home points" are broadly supported by peer-reviewed research, US governmental assessments of climate science and the recent report of the Intergovernmental Panel on Climate Change in its Special Report on Extreme Events (IPCC SREX 2012).[7]

Global Weather-Related Disaster Loss ($) Trends

What the IPCC SREX (2012) says:

- "There is high confidence, based on high agreement and medium evidence, that economic losses from weather- and climate-related disasters have increased"
- "There is medium evidence and high agreement that long-term trends in normalized losses have not been attributed to natural or anthropogenic climate change"

[4] See, e.g., Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[5] There are exceptions, for instance, the IPCC SREX (2012) concludes of winter storms, "There is medium confidence that there will be a reduction in the number of extratropical cyclones averaged over each hemisphere."

[6] Crompton, RP, RA Pielke and KJ McAneney (2011), Emergence timescales for detection of anthropogenic climate change in US tropical cyclone loss data. *Environ. Res. Lett.* **6** (1) doi: 10.1088/1748-9326/6/1/014003

[7] IPCC SREX (2012) refers to IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.) Cambridge University Press.

- "The statement about the absence of trends in impacts attributable to natural or anthropogenic climate change holds for tropical and extratropical [winter] storms and tornadoes"
- "The absence of an attributable climate change signal in losses also holds for flood losses."

What the data says:

1. **Globally, weather-related losses have not increased since 1990 as a proportion of GDP (they have actually decreased by about 25%).**

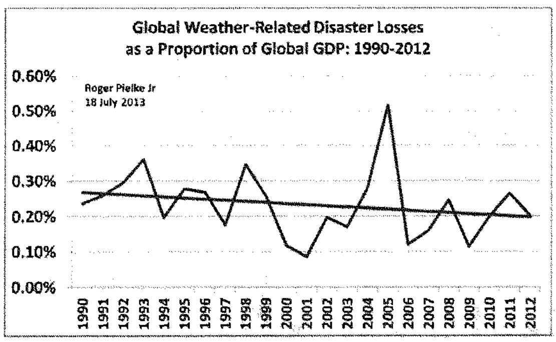

Figure 1. Global weather-related disasters as a proportion of global GDP, 1990-2012. Source of loss data: Munich Re.[8] Source of GDP data: United Nations.[9]

2. **Insured catastrophe losses have not increased as a proportion of GDP since 1960.**

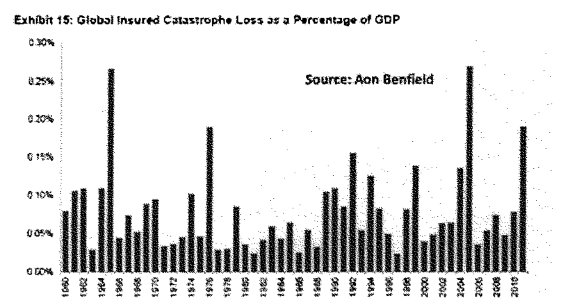

Figure 2. Global insured catastrophe loss as a percentage of global GDP. Source: Aon Benfield.[10]

[8] http://www.munichre.com/en/reinsurance/business/non-life/georisks/natcatservice/great_natural_catastrophes.aspx
[9] http://unstats.un.org/unsd/snaama/dnllist.asp
[10] http://thoughtleadership.aonbenfield.com/Documents/20130103_reinsurance_market_outlook_external.pdf

Note: The peer-reviewed literature on this subject is extensive and robust. Neumayer and Barthel (2011), in a study conducted at the London School of Economics and supported financially by Munich Reinsurance conclude:

> "[B]ased on historical data, there is no evidence so far that climate change has increased the normalized economic loss from natural disasters."[11]

Hurricanes

What the IPCC SREX (2102) says:

- "Low confidence in attribution of any detectable changes in tropical cyclone activity to anthropogenic influences."

What the data says:

3. **Hurricanes have not increased in the US in frequency, intensity or normalized damage since at least 1900.**

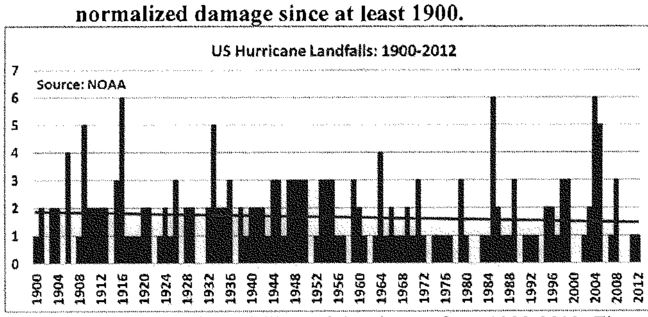

Figure 3a. Number of landfalling US hurricanes from 1900-2012. The red line shows the linear trend, exhibiting a decrease from about 2 to 1.5 landfalls per year since 1900. Source: NOAA.[12]

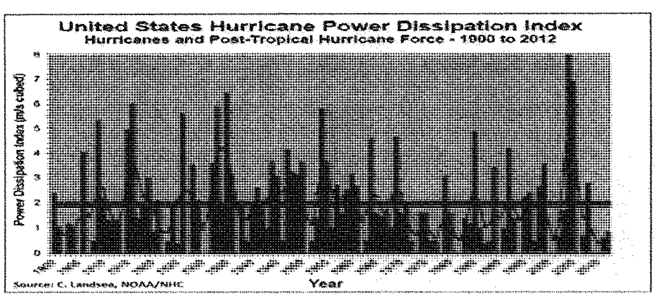

Figure 3b. Intensity of US hurricanes at landfall, 1900-2012 (measured as the summed power dissipation for each year). The heavy black line shows the linear trend. Source NOAA, figure courtesy Chris Landsea, NOAA/NHC.

[11] Neumayer, E. and F. Barthel. 2011. Normalizing Economic Loss from Natural Disasters: A Global Analysis, *Global Environmental Change*, **21**:13-24

[12] http://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html

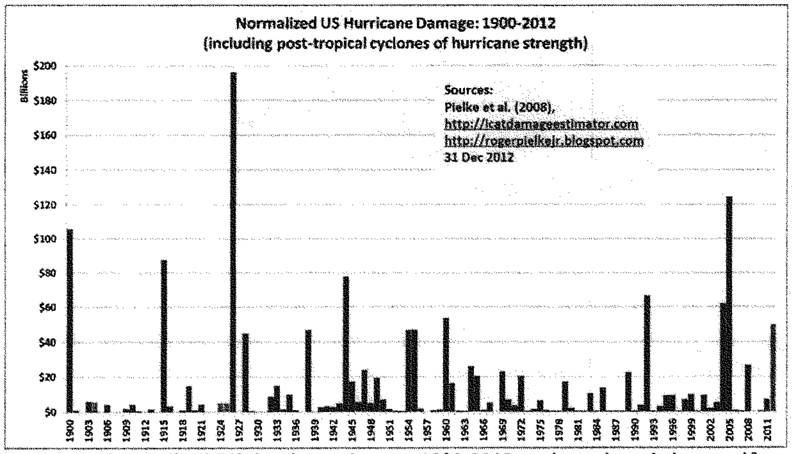

Figure 3c. Normalized US hurricane damage 1900-2012, estimated total damage if each past hurricane season occurred with 2012 levels of development. After Pielke et al. 2008.[13] Note that the figure includes Superstorm Sandy (2012) in gray and placeholders for the three other post-tropical cyclones of hurricanes which made landfall in 1904, 1924 and 1925.

4. **There are no significant trends (up or down) in global tropical cyclone landfalls since 1970 (when data allows for a comprehensive perspective), or in the overall number of tropical cyclones.**

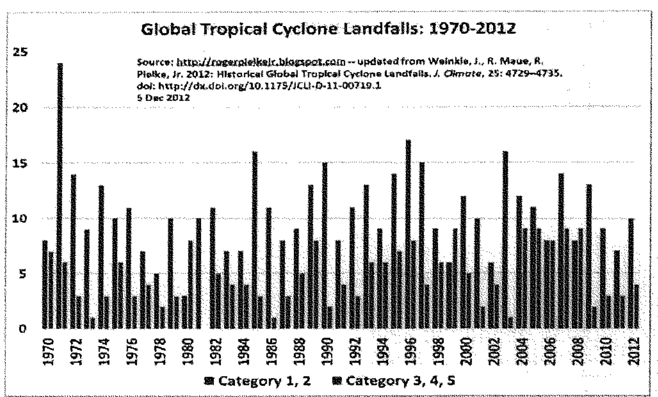

Figure 4a. Global tropical cyclone (called hurricanes in the North Atlantic) landfalls, 1970-2012, after Weinkle et al. 2012.[14]

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[13] Pielke, Jr., R.A., J. Gratz, C.W. Landsea, D. Collins, M. Saunders, and R. Musulin (2008), Normalized Hurricane Damages in the United States: 1900-2005. *Natural Hazards Review* 9:29-42. Data updated to 2012 values using the ICAT Damage Estimator: http://www.icatdamageestimator.com

[14] Weinkle, J, R Maue and R Pielke (2012), Historical Global Tropical Cyclone Landfalls. Journal of Climate, 25:4729-4735

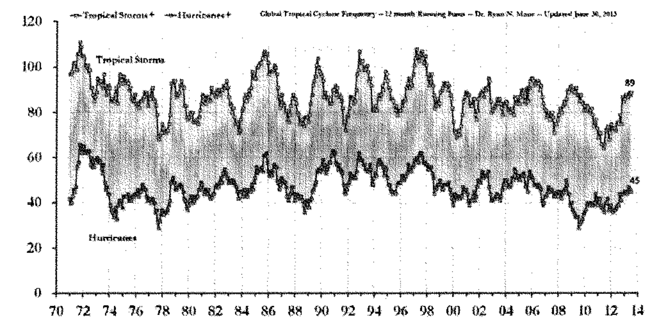

Figure 4b. Total count of tropical cyclones of tropical storm (top curve) and hurricane strength, 12-month running sums 1970 through June 30, 2013. Figure courtesy Ryan Maue.[15]

Floods

What the IPCC SREX (2012) says:

- "There is limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of floods at regional scales"
- "there is low agreement in this evidence, and thus overall low confidence at the global scale regarding even the sign of these changes.."

What the data says:

5. **Floods have not increased in the US in frequency or intensity since at least 1950.**

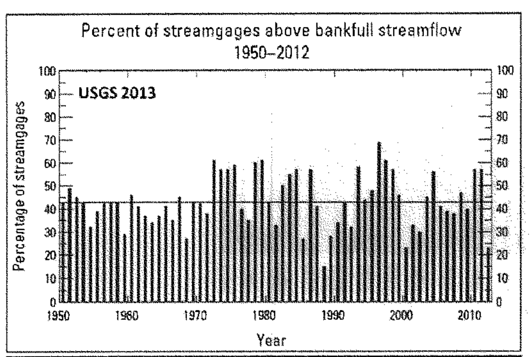

Figure 5. One measure of flood frequency from the USGS, percent of US streamguages above "bankfull streamflow." The USGS explains: "The bankfull streamflow is defined as the highest daily mean streamflow value expected to occur, on average, once in every 2.3 years."[16]

[15] After Maue, R. N. (2011), Recent historically low global tropical cyclone activity. , *Geophys. Res. Letts.* **38**:L14803, doi:10.1029/2011GL047711.

6. **Flood losses as a percentage of US GDP have dropped by about 75% since 1940.**

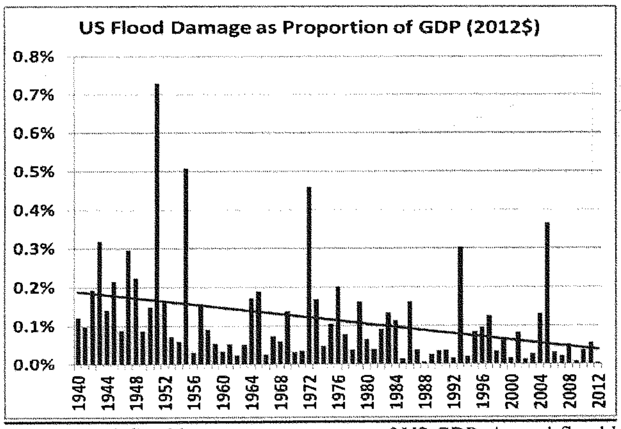

Figure 6. US flood losses as a percentage of US GDP. Annual flood losses have decreased from about 0.2% of US GDP to <0.05% since 1940. Flood loss data from NOAA HIC: http://www.nws.noaa.gov/hic/ GDP data from OMB: http://www.whitehouse.gov/sites/default/files/omb/budget/fy2014/assets/hist10z1.xls[17]

Note: A 2005 peer-reviewed paper examined flood trends around the world and concluded: "observations to date provide no conclusive and general proof as to how climate change affects flood behaviour."[18]

Tornadoes

What the IPCC SREX (2012) says:

- "There is low confidence in observed trends in small spatial-scale phenomena such as tornadoes and hail"

What the data says:

7. **Tornadoes have not increased in frequency, intensity or normalized damage since 1950, and there is some evidence to suggest that they have actually declined.**

[16] Xiaodong Jian, David M. Wolock, Harry F. Lins, and Steve Brady, Streamflow of 2012—Water Year Summary, U.S. Geological Survey, Reston, Virginia, May 2013.
[17] After Downton, M., J.Z.B. Miller, and R. A. Pielke, Jr. (2005), Reanalysis of the U.S. National Flood Loss Database. *Natural Hazards Review* **6**:13-22
[18] Kundzewicz, Z.W., D. Graczyk, T. Maurer, I. Przymusińska, M. Radziejewski, C. Svensson and M. Szwed, 2005(a):Trend detection in river flow time-series: 1. annual maximum flow. *Hydrol. Sci. J.*, **50**:797-810.

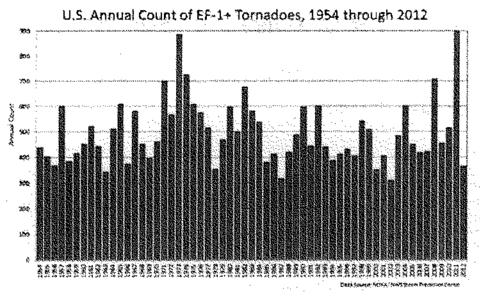

Figure 7a. Count of US tornadoes of at least EF1 strength, 1954-2012.
Source: NOAA, http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadoes.html

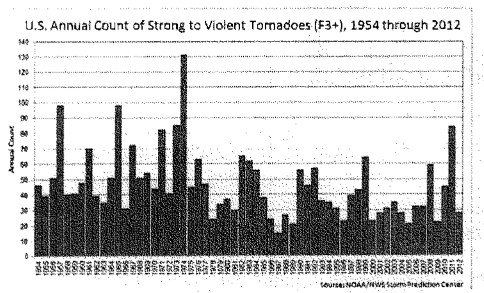

Figure 7b. Count of US tornadoes of at least EF3 strength, 1954-2012.
Source: NOAA, http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadoes.html

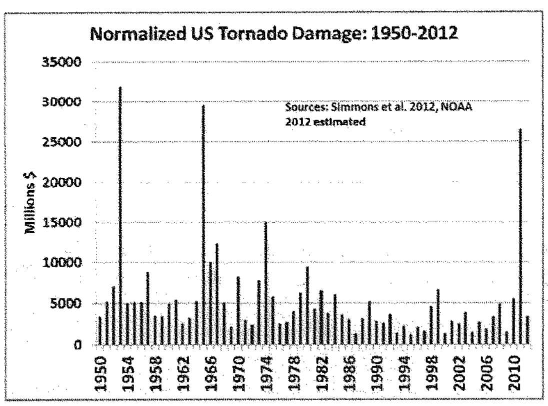

Figure 7c. Normalized US tornado damage, estimated total damage if tornadoes of past years occurred with 2012 levels of development. After Simmons et al. 2012. Note 2012 estimated.[19]

[19] Simmons, KM, D Sutter and R Pielke (2013), Normalized tornado damage in the United States: 1950-2011. *Environ. Hazards* **12**:132-14

Drought

What the IPCC SREX (2012) says:

- "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."
- For the US the CCSP (2008)[20] says: "droughts have, for the most part, become shorter, less frequent, and cover a smaller portion of the U. S. over the last century."[21]

What the data says:

8. Drought has "for the most part, become shorter, less frequent, and cover a smaller portion of the U. S. over the last century."[22]

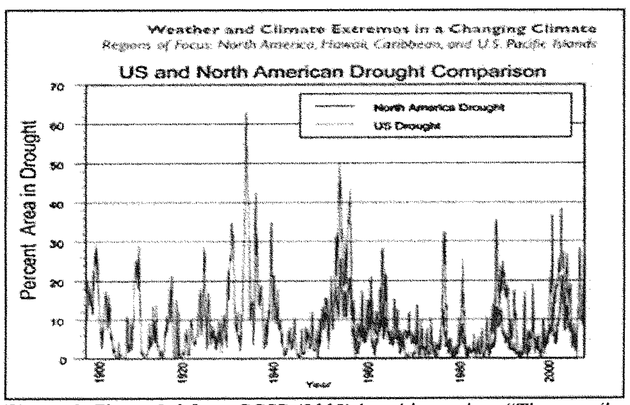

Figure 8. Figure 2.6 from CCSP (2008) has this caption: "The area (in percent) of area in severe to extreme drought as measured by the Palmer Drought Severity Index for the United States (red) from 1900 to present and for North America (blue) from 1950 to present."

Note: Writing in *Nature* Senevirnate (2012) argues with respect to global trends that, "there is no necessary correlation between temperature changes and long-term drought variations, which should warn us against using any simplifications regarding their relationship."[23]

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[20] CCSP, 2008: Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Thomas R. Karl, Gerald A. Meehl, Christopher D. Miller, Susan J. Hassol, Anne M. Waple, and William L. Murray (eds.)]. Department of Commerce, NOAA's National Climatic Data Center, Washington, D.C., USA, 164 pp.

[21] CCSP (2008) notes that "the main exception is the Southwest and parts of the interior of the West, where increased temperature has led to rising drought trends."

[22] This quote comes from the US Climate Change Science Program's 2008 report on extremes in North America.

[23] http://www.nature.com/nature/journal/v491/n7424/full/491338a.html

Biography of Roger Pielke Jr.

Roger Pielke, Jr. has been on the faculty of the University of Colorado since 2001 and is a Professor in the Environmental Studies Program and a Fellow of the Cooperative Institute for Research in Environmental Sciences (CIRES). Roger's research focuses on science, innovation and politics and in 2011 began to write and research on the governance of sports organizations, including FIFA and the NCAA. Roger holds degrees in mathematics, public policy and political science, all from the University of Colorado. In 2012 Roger was awarded an honorary doctorate from Linköping University in Sweden and was also awarded the Public Service Award of the Geological Society of America. Roger also received the Eduard Brückner Prize in Munich, Germany in 2006 for outstanding achievement in interdisciplinary climate research. At CIRES, Roger served as the Director of the Center for Science and Technology Policy Research from 2001-2007. Before joining the faculty of the University of Colorado, from 1993-2001 Roger was a Scientist at the National Center for Atmospheric Research. Roger is a Senior Fellow of the Breakthrough Institute, and holds academic appointments at Macquarie University in Sydney, Australia and the London School of Economics. He is also author, co-author or co-editor of seven books, including **The Honest Broker: Making Sense of Science in Policy and Politics** published by Cambridge University Press (2007). His most recent book is **The Climate Fix: What Scientists and Politicians Won't Tell you About Global Warming** (2011, Basic Books). He is currently working on a book on technology, innovation and economic growth.

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COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES
UNIVERSITY OF COLORADO AT BOULDER

20 August 2013

Senator Barbara Boxer, Chairman
Senator David Vitter, Ranking Member
US Senate
Committee on Environment and Public Works
Washington, DC 20510-6175

Dear Senators Boxer and Vitter:

The accompanying two pages contain my responses to the questions posed by Senators Whitehouse and Vitter. I have reproduced the questions in italics and my replies are offset immediately following each question.

I am grateful for the opportunity to share some of our research before the committee and to provide some replies to questions from members.

Sincerely,

Roger Pielke, Jr.
Professor and Director (as of Sept 1 2013)
Center for Science and Technology Policy Research
University of Colorado/CIRES
Boulder, CO

Replies of Professor Roger Pielke, Jr. to Questions from Senate EPW
21 August 2013

Questions from Senator Sheldon Whitehouse:

1) *In your written testimony, you stated:*

"It is misleading, and just plain incorrect, to claim that disasters associated with hurricanes, tornadoes, floods, or droughts have increased on climate timescales either in the United States or globally. It is further incorrect to associate the increasing costs of disasters with the emission of greenhouse gases."

In your opinion as a science-policy expert, is it also misleading, and just plain incorrect, to claim that man-made global warming is the greatest hoax ever perpetrated on the American people?

PIELKE REPLY: Yes. Both such claims are misleading and incorrect.

2) *Who funds your research currently? Please supply a full list for the record.*

PIELKE REPLY: I currently have one active grant. It is a small grant from the Nathan Cummings Foundation for a project looking at the role of philanthropy in policy and politics (it has nothing to do with climate or extreme events), drawing on an engagement model I proposed in my book, **The Honest Broker** (Cambridge University Press, 2007). Also, at the University of Colorado, I am a Fellow of CIRES (Cooperative Institute for Research in the Environmental Sciences) which is a NOAA Joint Institute.

Questions from Senator David Vitter

1) *Dr. Pielke, as I read Mr. Nutter's testimony, he appeared to be trying to tell us that businesses face a disaster that is happening now. But according to a recent Lloyd's of London survey of almost 600 corporate executives about the risks faced by their business, they ranked climate change #32 behind "piracy" but ahead of "space weather." High taxation was ranked #1. Regulation was ranked #5. Why do you think they placed climate change at #32?*

PIELKE REPLY: Human-caused climate change likely ranks low in the Lloyd's 2013 Risk Index[1] because the vast majority of impacts associated with such changes that would be of direct concern to global businesses in 2013 are presently small or even undetectable at present in the context of historical climate variability, as discussed in my testimony.

2) *Dr. Pielke, do you agree with comments made during the hearing that the weather here in the U.S. has fundamentally changed as is evidenced by an increase in hurricanes,*

[1] http://www.lloyds.com/news-and-insight/risk-insight/lloyds-risk-index

droughts, floods, and tornadoes? Do you agree there is "strong evidence" that extreme weather events in the U.S. have become more frequent and intense?

PIELKE REPLY: A range of evidence summarized in my prepared testimony indicates that, on climate time scales in the US or globally, there has not been an increase in hurricanes, droughts, floods or tornadoes. The evidence for this claim is strong and is well-supported in the peer-reviewed literature, data collected by the U.S. government's research agencies and the recent report on extreme events by Intergovermental Panel on Climate Change.

3) Dr. Pielke, to reiterate your points debunking claims that weather events in the United States are "extreme" in that they are increasing and more intense I would like to ask you a series of questions and provide you the opportunity to answer each.

a) Have United States landfalling hurricanes increased in frequency or intensity since 1900? Have they increased globally? Has damage, adjusted for more people and property, increased in the US or elsewhere?

PIELKE REPLY: As presented in my testimony, the US has not seen an increase in hurricane landfall frequency or intensity since at least 1900, nor in measures of damage, normalized for societal change. In fact, the US is presently in the longest stretch without a Category 3+ hurricane landfall since at least 1900.

b) Has United States flooding increased on climate timescales? Globally? Have United States tornadoes increased? Has United States drought overall increased?

PIELKE REPLY: As presented in my testimony, the US has not seen an overall increase in flooding, nor has such an increase been documented globally. The same holds also for tornadoes and drought.

c) Has the cost of disasters increased globally as a fraction of GDP?

PIELKE REPLY: As presented in my testimony, the cost of disasters as a fraction of global GDP has actually decreased since 1990.

4) Has anyone taken you up on your June 27th twitter invitation to defend President Obama's claim? ("Open invitation: Does anyone wish to defend the Obama claim that worse extreme weather is increasing disaster costs?")

PIELKE REPLY: No one took up the challenge.

Senator WHITEHOUSE. Thank you, Dr. Pielke.

And finally, we will turn to Dr. Spencer. I will say, Dr. Spencer, that I know that Senator Sessions very much wanted to be here and introduce you, U.S. Senator from your home State, and because of the vote and scheduling mishaps, I think it looks like he would not be able to do that.

But I think he would want me to let you know that he was very eager to do that, had asked my permission to do that and was ready, willing and able to do that. So, you will have to go forward without his introduction but I am sure he wishes you his best.

STATEMENT OF ROY W. SPENCER, PH.D, PRINCIPAL RESEARCH SCIENTIST IV, EARTH SYSTEM SCIENCE CENTER, THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Mr. SPENCER. Thank you, Senator, and thank you for the invitation, to you and the Committee and to Chairman Boxer.

First of all, given everything that has been said today, and following on Dr. Pielke's excellent testimony right now, I want to put everything we have been talking about into a little broader climate context. And this is a chart that will be submitted as part of the record tomorrow and at least a few members of the Committee will be able to see it.

The point here, which I will reState orally, is that yes, we are unusually warm right now, just like we were 1,000 years ago during the Medieval Warm Period and 2,000 years ago during the Roman Warm Period. Now, those previous warm periods could not have been our fault. The point is, climate varies naturally.

I know the title of today's hearing something like climate change it is happening today or something like that. Well, yes, and it has always changed. The question is, so what? How much of that change is due to humans? That is a question which I believe I am the only witness today who has actually actively researched and published on.

For instance, we have a new paper that has just been accepted for publication which looks at not only the warming we have seen in the atmosphere over the last let us say 50 years but also the warming we have seen in the oceans. Dr. Cullen mentioned the importance of not just focusing on the atmosphere but also looking at the warming in the oceans. And she is very correct. And we have done so.

And when we take into account how much the deep oceans have warmed since the 1950's, and take into account the effect of El Ninos and La Ninas and increasing carbon dioxide and all of the other forcing mechanisms that the IPCC uses in their climate model runs, we find that the climate system is relatively insensitive, consistent with the big graphic that was shown earlier where it showed that we are not warming nearly as fast as the IPCC climate model suggests we should have been warming.

So, the point is a lot of evidence now is being amassed which suggests that the climate system is simply not as sensitive to our addition of carbon dioxide to the atmosphere as most scientists think it is.

I also want to say since we are talking about most scientists, I have heard 97 percent, 98 percent, there is a recent paper by John

Cook and co-authors who looked at thousands of research papers which have been published in a scientific literature to see what fraction support the scientific consensus on global warming.

Well, it turns out that the 97 percent consensus that they found I am indeed a part of. And Senator Sessions mentioned that he would agree with it to. And my associate, John Christy, he agrees with it. In fact, all skeptics that I know of that work in this business, all are part of that 97 percent because the 97 percent includes people who think humans have some influence on climate.

Well, that is a fairly innocuous statement and that is something that continually annoys me as those of us that are called deniers, it is never actually, I think the d word was actually used by the Chairman today, it has never actually been pointed out. What is that we deny?

Also, this 97 percent, what does the 97 percent consensus mean? What do all of those people agree to? Well, they agree to something fairly innocuous and it is something that most of agree to, that humans must have some influence on climate. The question is, how much? And how much influence makes all of the difference in the world if you are going to be basing policy decisions, carbon taxes, regulations, legislation, whatever on them, it makes all the difference in the world exactly how much warming we can expect due to human activities.

I am going to leave it at that, I think, just to point out that some of the statistics that have been given today, I think, are only giving half the story. For instance, Jennifer Francis has talked about the decrease in the Arctic sea ice. And I know something about that because I am the lead scientist on NASA's best instrument for monitoring that decrease in Arctic sea ice. But what she did not mention is that Antarctic sea ice, over that same 30 year period that we have been monitoring, has been increasing.

So, there are a lot of half truths in this business. You can point to some of areas that are changing, some areas that are changing in one direction, some that are changing in another direction. At some point we have to ask ourselves, is all of this just mostly part of what the climate system does naturally?

With that, I will end my testimony.

[The prepared statement of Mr. Spencer follows:]

STATEMENT TO THE ENVIRONMENT AND PUBLIC WORKS COMMITTEE OF THE UNITED STATES SENATE

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18 July 2013

1. Introduction

I would like to thank the Chairman and the Committee for the opportunity to provide my perspective on the subject of global warming and climate change.

I have been performing U.S. government-sponsored research for the last twenty-eight years, publishing peer reviewed papers on global temperature monitoring with satellites, on the amount of warming we might expect from greenhouse gas emissions, how to monitor hurricane strength from satellites, and quantitatively explaining ocean heat content changes.

Prior to my current position as a principal research scientist at the University of Alabama in Huntsville, I was Senior Scientist for Climate Studies at NASA's Marshall Space Flight Center. I am also the U.S. Science Team Leader for the Advanced Microwave Scanning Radiometer-E flying on NASA's Earth-observation satellite Aqua. I am a recipient of NASA's Medal for Exceptional Scientific Achievement.

In related endeavors I have authored a book on basic economics (*Fundanomics: The Free Market, Simplified*) now used in a college-level economics course; and have co-authored an Energy Law Journal article on the use of climate models under the *Daubert* standard for rules of evidence.

2. The State of Climate Science

My overall view of the influence of humans on climate is that we probably are having some influence, but it is impossible to know with any level of certainty how much influence. The difficulty in determining the human influence on climate arises from several sources: (1) weather and climate vary naturally, and by amounts that are not currently being exceeded; (2) global warming theory is just that – based upon theory; and (3) there is no unique fingerprint of human caused global warming.

My belief that some portion of recent warming is due to humans is based upon my faith in at least some portion of the theory: that the human contribution to atmospheric greenhouse gas concentrations has resulted in an estimated 1% reduction in the Earth's ability to cool to outer space, and so some level of warming can be expected to occur from that change.

Exactly how much warming will occur, however, depends upon something we call "climate sensitivity" (Spencer & Braswell, 2010; 2011), and relatively few researchers in the world – probably not much more than a dozen – have researched how sensitive today's climate system is based upon actual measurements. This is why popular surveys of climate scientists and their beliefs regarding global warming have little meaning: very few of them have actually worked on the details involved in determining exactly how much warming might result from anthropogenic greenhouse gas emissions.

Our most recent peer-reviewed paper on this subject, Spencer & Braswell (2013), has arrived at a climate sensitivity of only 1.3 deg. C for a doubling of atmospheric carbon dioxide, based upon a variety of global measurements, including warming of the global oceans since the 1950s. This level of warming is below the lower limit of 1.5 deg. C minimum predicted in the last (AR4) IPCC report. It is also in line with (an admitted minority of) other estimates of low climate sensitivity published in the peer review literature.

It should also be noted that the fact that I believe at least some of recent warming is human-caused places me in the 97% of researchers recently claimed to support the global warming consensus (actually, it's 97% of the published papers, Cook et al., 2013). The 97% statement is therefore rather innocuous, since it probably includes all of the global warming "skeptics" I know of who are actively working in the field. Skeptics generally are skeptical of the view that recent warming is all human-caused, and/or that it is of a sufficient magnitude to warrant immediate action given the cost of energy policies to the poor. They do not claim humans have no impact on climate whatsoever.

3. Temperature Changes in the Atmosphere and Ocean

While 2012 was a record warm year in the U.S. (at least in the ~100 years for which we have thermometer records) this was not true of the global average, which has not experienced statistically significant warming since about 1998. This is not surprising since the contiguous U.S. covers only about 2% of the Earth, and persistent regional weather patterns – warm or cold – are responsible for most record weather events.

The only truly global temperature measurements, unaffected by artifacts such as urban heat island effects, are for the bulk atmosphere from Earth-orbiting satellites, the methodology for which John Christy and I developed almost 25 years ago; all other measurements are at points and so are geographically incomplete. Our monitoring of the lower troposphere since the satellite record began in 1979 is shown in Fig. 1,

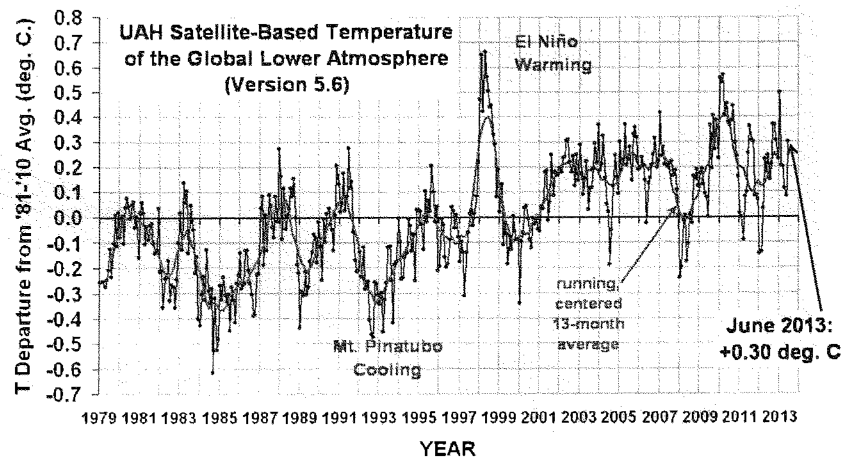

Fig. 1. UAH global lower tropospheric (LT) temperature variations between January 1979 and June 2013.

The satellite measurements reveal several significant features which are pertinent to our concern over human-induced climate change (all of the following points are also supported by the alternative version of the satellite-based temperatures from Remote Sensing Systems [RSS]):

1) The magnitude of global-average atmospheric warming between 1979 and 2012 is only about 50% that predicted by the climate models relied upon by the IPCC in their projections of global warming.
2) The level of warming in the most recent 15 year period is not significantly different from zero, despite this being the period of greatest greenhouse gas concentration. This is in stark contrast to claims that warming is "accelerating".
3) The level of observed tropical atmospheric warming since 1979 is dramatically different from that predicted by climate models; it is below all 73 models we have analyzed the output from (see Fig. 2).

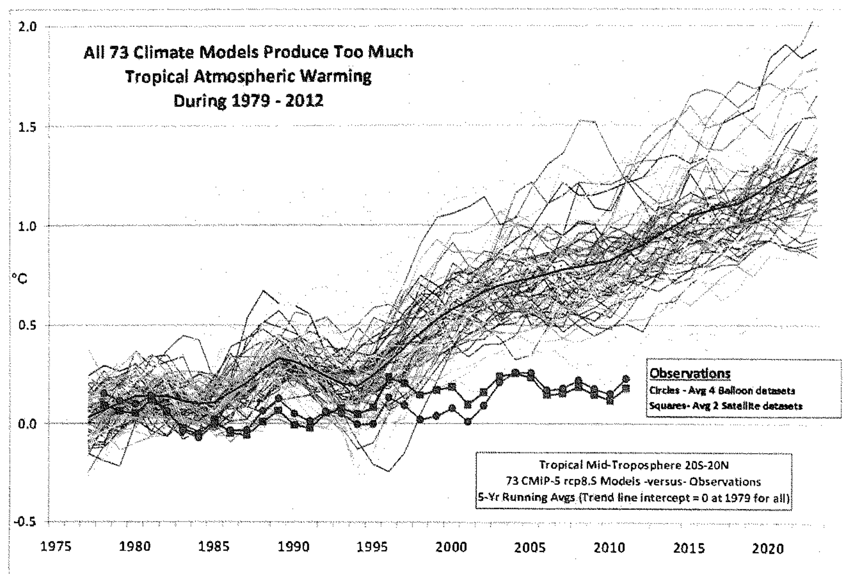

Fig.2. Mid-tropospheric (MT) temperature variations for the tropics (20°N to 20°S) in 73 current (CMIP5) climate models versus measurements from two satellite datasets and four weather balloon datasets.

On this last point, the level of disagreement between models and observations in Fig. 2 is quite striking. While one might argue that it is for a relatively restricted latitude band (20°N to 20°S), this is where almost 50% of the solar energy absorbed by the Earth enters the climate system. The discrepancy between models and observations is related to the lack of a middle- and upper-tropospheric "hotspot" in the observations, which the models produce in response to surface warming combined with positive water vapor feedback. The observations might be telling us that the global warming response to increasing CO2 (and any natural warming influence) is not being amplified by water vapor increases, which have their greatest temperature impact in the middle and upper troposphere (Spencer & Braswell, 1997).

The lack of statistically significant warming in the last 15 years (shown in Fig. 1 above, even more striking in the RSS dataset) is sometimes glossed over with the claim that the global temperature record has a number of examples of no warming (or even cooling) over fifteen year periods. But this claim is disingenuous, because *the IPCC-presumed radiative forcing of the climate system from increasing CO2 has been at its supposed maximum value only in the last 15 years.* In other words, when the climate "stove" has been turned up the most (the last 15 years) is also when you least expect a lack of warming.

It is time for scientists to entertain the possibility that there is something wrong with the assumptions built into their climate models. *The fact that all of the models have been peer reviewed does not mean that any of them have been deemed to have any skill for predicting future temperatures.* In the parlance of the *Daubert* standard for rules of scientific evidence, the models have not been successfully *field tested* for predicting climate change, and so far their *error rate* should preclude their use for predicting future climate change (Harlow & Spencer, 2011).

The claim has been made that the extra energy from global warming has mostly bypassed the atmosphere and has been sequestered in the deep ocean, and there is some observational evidence supporting this view (e.g. Levitus *et al.*, 2012). But when we examine the actual, rather weak level of warming (measured in hundredths of a degree C) at depths of many hundreds of meters, it implies relatively low climate sensitivity (Spencer

& Braswell, 2013). Part of the evidence for this result is satellite radiative budget measurements which suggest that more intense El Nino activity since the 1980s caused an apparent decrease in cloudiness, which allowed more sunlight into the climate system, which caused a natural component to recent global warming. Since the global energy imbalance leading to ocean warming since the 1950s is only about 1 part in 1,000 compared to the average rates of solar heating and infrared cooling of the Earth (Levitus *et al.*, 2012), it should not be surprising that natural climate cycles can cause such small changes in ocean temperature. Even if our ocean temperature measurements of deep warming of hundredths of a degree over the last 50 years are correct, and mostly due to human greenhouse gas emissions, they probably do not support the IPCC's pessimistic view of future warming.

4. Has Severe Weather Increased?

The most indefensible claim regarding climate change from an observational point of view is that severe weather has increased. Meteorologists like me have long known that public perception of weather is skewed by short memories and increasing media sensationalizing of weather disasters.

During globally cool conditions in 1970 a tropical cyclone (hurricane) killed 500,000 people in Bangladesh. Records of such storms killing hundreds of thousands of people extend back to 1582. In contrast, as of this writing, it has been a record 7+ years since a major (Cat 3 or stronger) hurricane has hit the U.S. mainland. New research from northwest Florida, based upon coastal sediments, suggest that the past 600 years has been a period of weaker hurricane activity compared to the 1,000 years before that (Brandon *et al.*, 2013). All of these facts indicate the huge amount of natural variability in tropical cyclones which exists and confounds attempts to determine whether tiny global energy imbalances caused by humans have any noticeable effect.

A Hurricane Sandy class of storm is not that unusual, but it hitting a densely populated area is. Sandy's transition to a strong extratropical cyclone is what happens to virtually all poleward-moving hurricanes. The fact that it happened to merge with a separate developing extratropical cyclone during landfall is somewhat less common, but such events arguably happen every year somewhere in the world – just not where millions of people live.

There is little or no observational evidence that severe weather of any type has worsened over the last 30, 50, or 100 years, irrespective of whether any such changes could be blamed on human activities, anyway. Long-term measurements of droughts, floods, strong tornadoes, hurricanes, severe thunderstorms etc. all show no obvious trends, but do show large variability from one decade to the next, or even one year to the next. While the 2003 heat wave in France and the 2010 heat wave in Russia were exceptional, so were the heat waves of the 1930s in the U.S., which cannot be blamed on our greenhouse gas emissions.

While it is true that storm damage of manmade structures increases over time, this is due to socioeconomic reasons: there are simply more manmade targets for severe storms to hit.

5. Conclusions

The belief that global warming and associated climate change involve more severe weather cannot be supported observationally. And even if we were to observe a trend in severe weather, it would not be possible to determine with any level of confidence the extent to which the change was due to human activities versus natural variability.

While recent global warmth might well be the greatest in the last 150 years for which we have had thermometer records (WMO, 2013), proxy measurements (and even borehole temperatures from the Greenland ice sheet) suggest that global warmth could have been greater 1,000 years ago during the Medieval Warm Period, and 2,000 years ago during the Roman Warm Period (Loehle and McCulloch, 2008; Ljungqvist, 2010). Regarding severe weather, that same WMO report admits, "*the data do not demonstrate that the increase in observed losses is caused by an increase in the frequency and intensity of extreme events. Other factors come into play, notably the increased exposure of people and property to climate extremes and the improved and increased reporting of disasters.*"

Thus, the evidence that humans are mostly responsible for either recent warmth or severe weather changes (if such changes exist at all) is equivocal, at best.

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Principal Investigator, Global Precipitation Studies with the Nimbus-7 SMMR and DMSP SSM/I, 1984-present.

Principal Investigator, Space Shuttle Microwave Precipitation Radiometer, 1985.

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Member, TRMM Space Station Accommodations Analysis Study Team, 1987-1991.
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AWARDS:

1996: AMS Special Award "for developing a global, precise record of earth's temperature from operational polar-orbiting satellites, fundamentally advancing our ability to monitor climate."

1991: NASA Exceptional Scientific Achievement Medal

1990: Alabama House of Representatives Resolution #624

1989: MSFC Center Director's Commendation

FUNDING SOURCES:

- NASA Advanced Microwave Scanning Radiometer-E Science Team Leader	(NNG04HZ31C)
- NASA Discover Program	
- NOAA Microwave Temperature Datasets	(EA133E-04-SE-0371)
- DOE Utilization of Satellite Data for Climate Change Analysis	(DE-FG02-04ER63841)
- DOT Program for Monitoring and Assessing Climate Variability & Change	(DTFH61-99-X-00040)

Roy Spencer's responses (in italics) to EPW hearing questions.

Senator Whitehouse questions:
1. In your written testimony, you present UAH version 5.6 satellite based temperature of the global lower atmosphere. The data you present contains no account of error or measure of uncertainty, which is standard to report. For example, observational and model uncertainty was indicated in the chart of masked HadCRUT4 surface temperatures and model output compiled by Dr. Ed Hawkins of Reading University, and shown by Senator Whitehouse during the Senate EPW Committee hearing.

a. What are the current sources of error in the UAH dataset, and the associated magnitudes?
The current sources of error are related to decay of most of the satellites' orbits over time, which causes three main effects: (1) a cooling bias in the lower tropospheric temperature retrieval ("LT") due to the fall in the satellite altitude (substantial in size, but easily fixed based upon geometry), (2) warming of the MSU sensors themselves (used pre-1998), which causes a spurious warming in the calibrated sensor measurements of the Earth (substantial, and evaluated by comparing simultaneously operating satellites), and (3) drift of the local observation time, which causes a slight spurious cooling of the afternoon satellites' measurements, and warming of the morning satellites' measurements (small, corrected with empirical data analysis). All of these sources of error have corresponding adjustments we perform to correct for them as much as possible, as does Remote Sensing Systems (RSS) in their satellite datasets.

b. What is the current magnitude of uncertainty in the UAH dataset?
The primary evaluation of the uncertainty in the dataset is an error bar on the decadal temperature trend, after adjustments for the 3 error sources above have been accounted for, which is based primarily upon the level of agreement between different satellites observing the Earth at the same time. The 'trend difference' between satellites is always smaller than any comparable metric for the surface thermometer data – if such a metric even exists for the thermometer data. We deal in inter-satellite difference changes of a few hundredths of a degree over years, while surface thermometer data deals with tenths and even whole degree adjustments. The final uncertainty we assign to the global lower tropospheric (LT) trends is currently +/- 0.04 deg. C/decade, compared to our current best estimate of the trend, which is +0.14 deg. C/decade since 1979. Note that when four balloon and two satellite data sets are combined the resulting trend value is +0.14 ± 0.02 °C decade. Thus while our individual error magnitude is estimated at ±0.04 °C/decade, the absolute trend estimate based on many sources is the same as UAH's (+0.14) and the error range is half as much (Willett et al. 2013, "State of the Climate in 2012, Ch. 2, Global Climate", Bull. Amer. Meteor. Soc.)

c. The UAH dataset has been updated frequently over its existence.

i) What were all of the previously reported sources of error, the associated magnitudes, and the uncertainties in the scientific literature published by you and your colleagues regarding the UAH temperature dataset?

Since the dataset has had many revisions over the last 20+ years we have been producing it, I would be glad to do a literature search to answer this question if Congress would like to fund such an effort. As it is, we receive relatively little funding to perform the global temperature monitoring work. A Table 2.3 in the CCSP SAP 1.1(Karl et al. 2006, http://www.climatescience.gov/Library/sap/sap1-1/finalreport/default.htm) gives changes through 2005, with impacts divided between causing either more warming or more cooling. I can say that the answers to such questions will not be very informative because the period of time covered by the dataset has changed with each update, so that an impact of a change made in 1994, for example, will have very little impact if calculated for the current version through 2013. I hope that similar questions are being asked by the Senator of the climate modeling groups.

ii) How did these uncertainties reported in the scientific literature compare to the corrections that were made to UAH as new versions of the dataset were released?

See the answer to (i), above. As an example of the largest impact through 2006, the change from v5.1 to v5.2 was +0.035 °C/ decade while our published error range at the time was ±0.05 °C/decade (Christy et al. 2003, J. Atmos. Oc. Tech). Thus, the correction was within the acknowledged error range.

iii) What effects did corrections of these errors and reduction of uncertainty have on the UAH dataset in terms of temperature trends?

Correction for error source (1) led to warming of global temperature measurements. Correction for error source (2) led to cooling of global temperature measurements. Correction for error source (3) led to slight warming of global temperature measurements. The net result of these corrections are mostly to offset each other, which one would think would reduce the trend error over time. [Note in the referenced CCSP Table 2.3 that when we incorporated the corrections for (1) and (2) into version "D" of the dataset, the two almost balanced each other.] But there is an unknown 'random walk' component common to all long-term datasets which cannot be evaluated without a knowledge of the 'true' temperature trend. We therefore choose to leave the trend error estimate roughly the same, even as advances are made.

iv) For any of these corrections, was surface temperature data, which you have posited is not useful for measuring changes in global atmospheric temperature, useful for identifying errors in UAH global temperature data?

I have never posited that surface temperature measurements are not useful. Surface temperatures are a different metric than deep-layer atmospheric temperatures. They are correlated in many regions (though less correlated over oceans), to be sure, but also give us independent information on how the climate system works. To answer your specific question, we have never used the surface temperature data to identify errors in the satellite data, though we have used them in cross-comparisons (e.g. Christy et al. 2010.)

v) During the Senate EPW Committee hearing, Senator Sessions asked you: "Dr. Spencer, you and Dr. Christy, by utilizing satellite data, hasn't that gained respect worldwide as a more accurate, and a lot of scientists agree that that's the best way to identify global temperature changes?" in your response you said, "we need all of these datasets". Why did your written testimony not include any reference to the NOAA STAR dataset or surface temperature datasets? To your knowledge, has any version of the UAH satellite dataset for temperature been accepted worldwide as the most accurate way to identify global temperature changes?

We did not include STAR because (1) STAR does not produce a lower tropospheric temperature dataset and (2) the STAR dataset has not been corrected for a known shift on 1 Jan 2001 that we (UAH) and Remote Sensing Systems (RSS) have independently determined. I would encourage a careful reading of Christy et al. 2010 Rem. Sens., and Christy et al. 2011, Int. J. Rem. Sens. in which these datasets of a higher atmospheric layer (mid-troposphere) were intercompared and where it was demonstrated that UAH data revealed the lowest error rate of the satellite datasets relative to the highest quality balloon data.

2. In your written testimony, you present the average of UAH and RSS satellite temperature in the mid-troposphere at the tropics. You present the same for the four balloon collected datasets. What are the errors and uncertainties, and the associated magnitudes of each dataset? Why was this not indicated on the graphic displaying this data (Fig. 2 of your testimony)?

I did not think to include such error bars because the level of disagreement between models and observations was so far outside the error bars for the satellite or the balloon datasets. I probably assumed such a question would thus never arise. But, as mentioned above, the error range of the average of all global lower tropospheric datasets was published as ±0.02 °C/decade (Willet et al. 2013). For our individual satellite lower tropospheric trend error we currently use is +/- 0.04 deg. C/decade, and we believe the balloon datasets have somewhat larger individual error bars, but it would be better to as their developers for this information. The key point here is that when all of the datasets are combined, the error ranges will be smaller as the random component is reduced by averaging.

3. Who funds your research currently? Please provide a full list for the record.

My research funding comes from NASA, DOE, NOAA, and a small amount of Alabama state funding. None of it has been provided by private organizations.

4. You have raised the possibility that models are overly sensitive to greenhouse gases like carbon dioxide.

a. Is it possible that more heat is being absorbed by the real oceans, particularly the deep oceans, than modeled oceans?

Yes, this is at least a theoretical possibility. Also, see my response to (b), below.

b. In your oral testimony you referenced a research paper written by you that uses a model to conclude the climate is not sensitive to anthropogenic forcings. Please provide a copy of this manuscript and a discussion of model strengths and weaknesses if that has not been included in the manuscript.

Attached to the e-mail containing my responses is the final version of that paper, which I believe has a fairly thorough discussion of the model strengths and weaknesses.

c. Members of the climate science community have suggested that models may be correctly capturing the effects of increasing greenhouse gases in the atmosphere, but have incorrectly captured the amount of other climate factors, such as small volcanic eruptions, aerosols, changes in ozone, or some other natural or anthropogenic factor. Is there any merit to these suggestions?

Yes, I believe that the models are specifically not capable of capturing multi-decadal time scale natural variability, which (as our new paper describes) might have been a significant component of recent warming of the surface and deep ocean since the 1950s.

Senator Vitter Questions

1. You mention in your testimony that it's time for scientists to entertain the possibility that there is something wrong with the assumptions built into their climate models.

a. Could you explain for us the issues that may be involved with their assumptions?

b. What are they getting wrong?

I believe the most glaring assumption made by the modeling community which has the potential to be seriously in error is that of relatively high climate sensitivity, that is, they produce a relatively large amount of warming in response to an imposed radiative energy imbalance (say, from increasing carbon dioxide). The models have a variety of uncertain tunings, but the modelers tend to retain an overarching belief in high climate sensitivity. The most likely component of spuriously high climate sensitivity is positive cloud feedback, which exists by varying degrees in all climate models I am aware of, but which I believe is actually negative in nature. The arguments for and against positive cloud feedback are complex outside the scope of this forum.

2. How much more progress do scientists need to make to capture the complexity of the climate system in their models?

If the climate system is chaotic (as we know weather is), and if climate sensitivity is low, it might be that we will never be able to obtain useful forecasts from climate models. Even determining the sensitivity of today's climate system based upon 10+ years of global satellite observations has proved to be exceedingly difficult. But the problem is too important to not try, and I am supportive of climate modeling as a research endeavor. But policymakers must be warned that, due to uncertainties regarding the behavior of clouds, etc., models can be tuned to give just about any policy-relevant answer the modeler desires. Yes, the models contain many accurately-known physics, but they also contain many approximations and parameterizations which are poorly known, or not known at all (e.g. potential changes in precipitation efficiency, which in turn would determine free-tropospheric humidity and thus water vapor feedback, which doubles the warming produced by climate models). It is those approximations and parameterizations which lead to large uncertainties in model projections of climate change.

3. Can you explain for us climate feedbacks, climate sensitivity, climate variables? What do these mean in relation to Dr. Cullen's mentioning that global warming happens on top of natural variability?

*'Climate feedback' refers to how a change in temperature will cause other changes in the climate system – say cloud cover – which in turn either amplifies the original temperature change (positive feedback) or reduces it (negative feedback). All of these feedbacks together then determine the sensitivity of the climate system, which is the expected amount of global average surface temperature change resulting from a specific amount of radiative forcing (imposed imbalance between absorbed sunlight and emitted infrared radiation). Feedbacks are difficult to determine from observations because of uncertainty over the direction of causation: a radiative imbalance causing a temperature change will cause the illusion of positive feedback, even when negative feedback exists. 'Climate variables' is a general and non-technical term encompassing any component of the climate system, e.g. temperature, humidity, winds, clouds, storms, etc. Dr. Cullen is correct that *if* anthropogenic global warming is occurring, we expect this long-term signal to be mixed in with (or superimposed "on top of") shorter-term natural climate variability. One oft-missed possibility is that there are additionally long-term natural changes in the climate system, on the time scale of hundreds or thousands of years (e.g. the Medieval Warm Period, the Little Ice Age). Very little is known about the causes of these changes, and their existence seems to be either disputed or ignored by the IPCC.*

4. Dr. Spencer, last month Dr. Judith Curry wrote the following: "Attention in the public debate seems to be moving away from the 15-17 years 'pause' to the cooling since 2002 (note: I am receiving inquiries from journalists). This period since 2002 is scientifically interesting, since it coincides with the "climate shift" circa 2001/2002 posited by Tsonis and others. This shift and the subsequent slight cooling trend provides a rationale for inferring a slight cooling trend over the next decade or so, rather than a flat trend from the 15 yr. 'pause'. Can you offer a comment on that?

I don't believe there is enough evidence to support forecasts of what global temperatures will do in the future, and the distinction between recent temperatures being *flat versus a slight cooling is, in my view, splitting hairs. Regarding what might happen over the next decade, if I had to choose between warming and cooling, I would side with slight to modest warming. But I have very little confidence in any such prediction.*

5. Do carbon emissions have benefits? Are they quantifiable?

One only need look at the technological advances of the last 100+ years made possible by fossil fuels and the resulting increases in prosperity and longevity. Would these advances have ever been made if all we had to rely upon for energy was renewable energy sources? I am quite sure they wouldn't...but then, I'm not a professionally trained economist.

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The Role of ENSO in Global Ocean Temperature Changes During 1955-2011 Simulated with a 1D Climate Model

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(Manuscript received)

Abstract: Global average ocean temperature variations to 2,000 m depth during 1955-2011 are simulated with a 40 layer 1D forcing-feedback-mixing model for three forcing cases. The first case uses standard anthropogenic and volcanic external radiative forcings. The second adds non-radiative internal forcing (ocean mixing changes initiated in the top 200 m) proportional to the Multivariate ENSO Index (MEI) to represent an internal mode of natural variability. The third case further adds ENSO-related radiative forcing proportional to MEI as a possible natural cloud forcing mechanism associated with atmospheric circulation changes. The model adjustable parameters are net radiative feedback, effective diffusivities, and internal radiative (e.g., cloud) and non-radiative (ocean mixing) forcing coefficients at adjustable time lags. Model output is compared to Levitus ocean temperature changes in 50 m layers during 1955-2011 to 700 m depth, and to lag regression coefficients between satellite radiative flux variations and sea surface temperature between 2000 and 2010. A net feedback parameter of 1.7 W m^{-2} K^{-1} with only anthropogenic and volcanic forcings increases to 2.8 W m^{-2} K^{-1} when all ENSO forcings (which are one-third radiative) are included, along with better agreement between model and observations. The results suggest ENSO can influence multi-decadal temperature trends, and that internal radiative forcing of the climate system affects the diagnosis of feedbacks. Also, the relatively small differences in model ocean warming associated with the three cases suggests that the observed levels of ocean warming since the 1950s is not a very strong constraint on our estimates of climate sensitivity.

Key words: Climate sensitivity, climate change, climate modeling, El Nino Southern Oscillation, ocean heat content

1. Background and Justification

Climate modeling in the context of global warming research is usually performed with coupled atmosphere-ocean general circulation models (AOGCMs) which simulate the time evolving nature of the 3D climate system based upon a combination of physical first principles and approximations, e.g., the Coupled Model Intercomparison Project (CMIP3; CMIP5) models (Meehl *et al.*, 2007; Taylor *et al.*, 2012). While 3D modeling may be the ultimate methodology, current models still have limitations.

For example, the 20th Century and SRESa1b simulations from the CMIP3 coupled climate models reveal a wide range of ocean temperature trends during 1955-2010, the period during which ocean temperature profile observations are available for comparison. Of thirteen models we examined (Fig. 1), three models experienced net ocean heat loss, despite imposed positive radiative forcing (Forster and Taylor, 2006) which should have caused a net warming of the model ocean. This suggests the possibility of energy conservation issues in the CMIP3 models (Gupta *et al.*, 2012), although small energy imbalances at model initialization could also result in this behavior. Since anthropogenic global warming is caused by small energy imbalances (changes in the radiative energy balance of the Earth causing changes in total heat content of the ocean), this presents a problem. It should be noted that Lindzen (2002) used a simple model and found that changes in ocean heat content were not a good constraint on climate sensitivity.

Furthermore, the potential role of natural modes of climate variability in multi-decadal temperature change is still not well understood. For example, the El Nino (warm) phase of the El Nino - Southern Oscillation (ENSO, Rasmussen and Carpenter, 1982) was more intense than the La Nina phase for about 30 years starting in the late 1970s (Wolter, 1987; Jin *et al.*, 2003), a behavior which AOGCMs cannot yet explain. This is shown in Fig. 2, a plot of the Multivariate ENSO Index (MEI, Wolter, 1987) which is positive during El Nino conditions, and negative during La Nina conditions. Here we will use MEI rather than the NINO-3 or NINO-3.4 indices due to it representing the larger-scale manifestation of ENSO activity. While one theory claims that anthropogenic global warming has caused El Nino activity to become more frequent or more intense than La Nina activity (Trenberth and Hoar, 1995), it is also possible that there is a natural, low frequency modulation of El Nino and La Nina activity, as evidenced by persistent or unusually strong El Nino conditions experienced approximately during 1920 to 1940 (see Fig. 2), which is arguably before human greenhouse gas emissions could have reasonably been blamed. Such natural variability can complicate our identification and understanding of anthropogenic forcing of the climate system (e.g., Tsonis *et al.*, 2007), a point further evidenced by less than expected surface warming since the late 1990s.

For example, if the atmospheric circulation changes associ-

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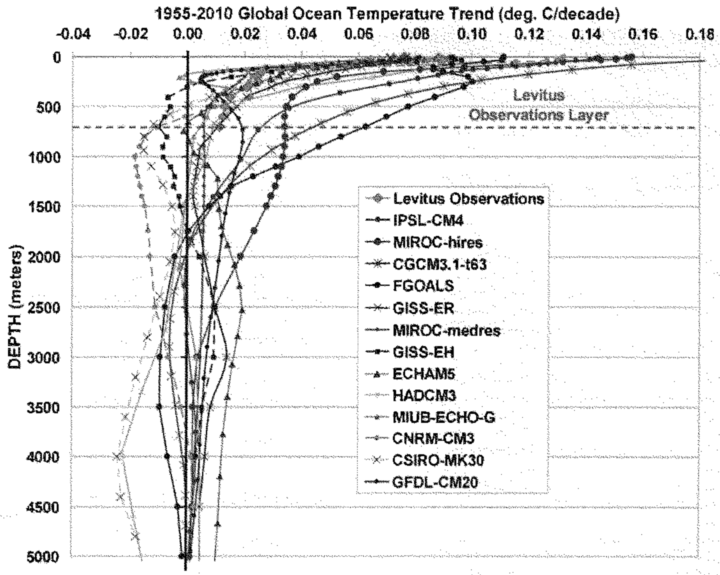

Fig. 1. Ocean temperature trends over the period 1955 through 2010 as a function of depth for the global oceans (+/− 60° latitude) calculated from observations (Levitus) and 13 CMIP3 coupled climate models.

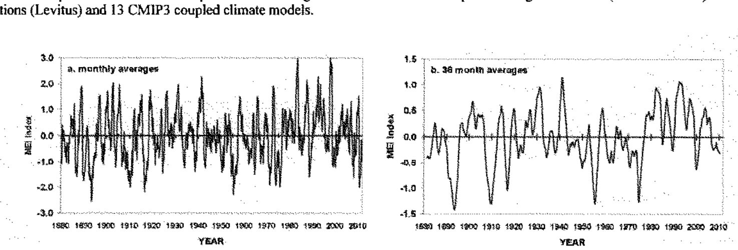

Fig. 2. Multivariate ENSO Index between 1880 and 2011 at (a) monthly and (b) 36 month time resolution. The original MEI data extends from 1950 to the present, while pre-1950 data are reconstructed based upon less extensive data.

ated with more frequent El Nino activity cause a slight change in global average cloud cover - a change which is not merely a feedback upon surface temperature -- the resulting "internal" radiative forcing of the climate system (Spencer and Braswell, 2010) could confound our diagnosis of how sensitive the system is to "external" radiative forcing from anthropogenic greenhouse gases and aerosols. Even if this does not occur, the changes in oceanic overturning during El Nino and La Nina can cause decadal time scale surface warming and cooling which complicate the identification of anthropogenic temperature trends (e.g., Solomon and Newman, 2012).

Since explaining recent increases in the heat content of the ocean represent extremely small energy imbalances on the order of 1 part in 1,000 (e.g., Levitus *et al.*, 2012), it seems reasonable to use a simplified model where energy balance can simply be assumed at the outset. For global averages, transient changes in surface or ocean mixed layer temperature anomalies (departures from the average annual cycle) are dominated by only three processes: (1) radiative forcing, (2) net radiative feedback, and (3) ocean mixing. These three processes can be modeled, albeit simply, in a single (vertical) dimension. While the detailed physics giving rise to complex climate system behaviors such as ENSO would be difficult to create in a 1D model, the vertical redistribution of thermal energy in response to the known history of ENSO events can be used as a pseudo-forcing of the model. If we ignore land-ocean exchanges of energy, the total heat content of the ocean is independent of horizontal transports associated with ENSO; there is only a net change in vertical mixing, and associated changes in feedback losses of energy at the top of the ocean.

We can then use the MEI index to explore the extent to which internal non-radiative forcing (ENSO-related changes in the ocean temperature profile) versus internal radiative forcing (non-feedback changes in ENSO-related radiative balance) contribute to explaining a variety of observations between 1955 and 2011. The novel aspect of the approach is establishing evidence for the postulated existence of ENSO-related atmospheric circulation changes associated with ENSO which change the global ocean radiative budget independent of average surface temperature changes. Importantly, evidence for ENSO-related radiative forcing of temperature would involve the atmospheric radiative changes preceding the ocean temperature changes, after internal ocean mixing changes have already been accounted for. These atmospheric changes could involve some combination of cloud shortwave albedo, cloud longwave, or water vapor changes.

Here we will use a 1D forcing-feedback-mixing model to help explain natural modes of climate variability superimposed upon a general warming trend assumed to be mostly anthropogenic in origin. The model is simpler than previous 1D ocean models (e.g., Harvey & Hwang, 2001, and references therein) because (1) it only addresses departures from the average state, with no annual cycle; and (2) net vertical transports of heat are accomplished only through depth-dependent effective diffusivities (κ_v) operating on vertical gradients of temperature departures from the mean state. Regarding the first simplification, an annual cycle is unnecessary for the task at hand since there is no physical reason to suspect that multi-decadal global warming is caused by the seasons; also, the seasonal phase-locked nature of El Nino and La Nina (which peak during Northern Hemisphere winter) can be imposed upon the model from the observed history of ENSO activity.

Similarly, the second simplification assumes that there is an average oceanic temperature profile, including a thermocline, which the ocean relaxes to when there are temperature perturbations away from that profile. This relaxation is accomplished with an "effective diffusivity" which represents all processes responsible for vertical redistribution of heat anomalies in the ocean, including the thermohaline circulation and turbulent ocean mixing of all types which act to restore the system to its average state. It is recognized that diffusion does not generally act as a restoring mechanism, and ocean transport is not always down-gradient. The primary intent is to include a simple mechanism to allow heating of the surface to mix downward, as expected with anthropogenic global warming. A range of depth-dependent effective diffusivities are swept to find a set which provides a good match between the resulting model simulation and the variety of observations. The effective diffusivities do not vary with time; we believe the inclusion of such variability would be intractable computationally.

The primary question we will address is: What combination of assumed climate sensitivity (net feedback parameter), ocean effective diffusivities, and ENSO-related pseudo-forcings best describe the depth-dependent ocean temperature changes during 1955-2011? An important additional test of model behavior is the lag regression relationship between glohal average sea surface temperature (SST) from HadSST2 (Rayner *et al.*, 2006) and top-of-atmosphere radiative flux variations since 2000 as measured by CERES (Clouds and the Earth's Radiant Energy System, Wielicki *et al.*, 1996). As will be shown, this lag behavior is important from the standpoint of determining the extent to which radiative flux variations are a combination of (1) radiative feedback upon temperature (which would be nearly simultaneous with temperature change) versus (2) radiative forcing of temperature (which would precede temperature change). This issue regarding the direction of causation between variations in temperature and radiative flux was explored in some detail by Spencer and Braswell (2010, 2011), as well as Lindzen and Choi (2011).

2. Observed ocean temperature variations 1955-2011

Global (+/–60° latitude) three-monthly ocean temperature variations from Levitus *et al.* (2009) for the period JFM 1955 through AMJ 2011 were averaged into 50 m layers to a depth of 700 m and interpolated to monthly time resolution. The results in Fig. 3a for the top four layers, the bottom layer, and the 0-700 m average show general warming which decreases with depth.

The strong interannual variability in Fig. 3a is mostly related to ENSO activity. It is well known that ENSO is the dominant mode of interannual variability in the climate system, and we see from Fig. 3b that the warm phase of ENSO (El Nino) leads to a reduction in the rate of vertical overturning of the global average ocean, evidenced by warming in the 0 to 100 m layer, and cooling below. Our intent is not to explain why this occurs, only to exploit the observed relationship for the purposes of the 1D model.

While it is difficult for a simple 1D model to include the physics causing ENSO (even some 3D coupled climate models have difficulty), it is relatively easy to include the ENSO-induced vertical heat redistribution and the resulting changes in radiative feedback at the top of the ocean. For the purpose of forcing ENSO variability upon the model, we use the Multivariate ENSO index from 1950 to 2011, and the extended MEI for the period 1880-1950 (Wolter and Timlin, 2011) during the model spin-up. The MEI is a quantitative empirical measure of the intensity of El Nino (positive MEI) and La Nina

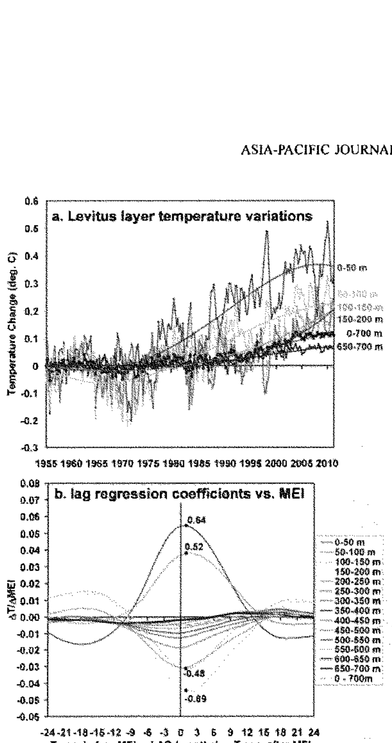

Fig. 3. Three-monthly Levitus global (+/–60° latitude) ocean temperature variations from JFM 1955 through AMJ 2011 averaged into 50 m layers: (a) 0-50 m, 50-100 m, 100-150 m, 150-200 m, 650-700 m, and 0-700 m; and (b) detrended layer temperatures lag regressed against the Multivariate ENSO Index, with lag = +1 correlation coefficients shown for the top four layers. The +/–1σ confidence intervals approximately equals the width of the four data point dots.

(negative MEI) conditions, computed as the first unrotated principal component of six observed variables over the tropical Pacific: sea-level pressure, zonal and meridional components of the surface wind, sea surface temperature, surface air temperature, and total fractional coverage of the sky by clouds. The MEI is normalized to have a standard deviation of 1.

The basis for our simplified partitioning of ocean mixing changes associated with ENSO come from the MEI and ocean temperature data themselves. Lag regression coefficients between the global average ocean layer temperatures and MEI during 1955-2011 (Fig. 3b) reveal warming of the 0-100 m layer, and cooling of the 100-200 m layer, during El Nino conditions (positive MEI), and the opposite behavior during La Nina (negative MEI). This global-average behavior provides the basis for representing the ENSO-induced changes in ocean mixing with exchanges in heat between the 0-100 m layer and the 100-200 m layer in the 1D model.

Initially it will be assumed that ENSO-related temperature changes are only the result of these changes in ocean mixing between the warm near-surface layers above the thermocline (0-100 m) and the colder layers below, as modified by changes in feedback which are (by definition) proportional to surface temperature departures from normal. It will be included in the time-dependent 1D forcing-feedback-mixing model to explore the relative roles of forcing and feedback in explaining the ocean temperature changes during 1955-2011, as well as the satellite-observed variations in top-of-atmosphere (TOA) net radiative flux variations between 2000 and 2010. It will be shown that internal radiative forcing associated with ENSO, possibly the result of changes in cloud cover, is additionally required in order to explain the satellite TOA radiative flux variations, which cannot be explained based upon ocean mixing and feedback alone.

3. The forcing-feedback-mixing model

The simple 1D model used here will include the three primary processes that control global average surface (or ocean mixed layer) temperature departures from equilibrium: forcing, feedback, and ocean vertical mixing. We address monthly and longer time scales so that we can assume the atmosphere is in convective equilibrium with the ocean surface; potential changes in latent and sensible heat transfer from the ocean to the atmosphere are neglected, except to the extent they are implied by the feedback parameter, which implicitly includes all atmospheric changes in response to surface temperature change.

The model is represented in schematic form in Fig. 4, with solid arrows representing radiative energy exchanges, and dashed arrows representing non-radiative energy exchanges. The ocean-only model of temperature departures from equilibrium uses forty 50 m-thick layers extending from the ocean surface to 2,000 m depth. Energy exchanges between land and ocean are neglected. The radiative influence and response of the atmosphere is implicitly included in the model's feedback and radiative forcing parameters. The model equations for the time rate of change of temperature in each of the 40 layers are:

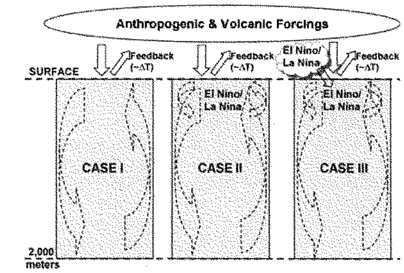

Fig. 4. Schematic representation of the 1D forcing-feedback-mixing model. Solid arrows represent radiative energy exchanges, while dashed arrows represent non-radiative energy exchanges.

$$C_p[d\Delta T_1/dt] = [N(t) - \lambda\Delta T_1] + S_1(t) + C_p\kappa_{v1}d^2\Delta T/dz^2, \quad (1)$$

$$C_p[d\Delta T_2/dt] = S_2(t) + C_p\kappa_{v2}d^2\Delta T/dz^2, \quad (2)$$

$$C_p[d\Delta T_3/dt] = S_3(t) + C_p\kappa_{v3}d^2\Delta T/dz^2, \quad (3)$$

$$C_p[d\Delta T_4/dt] = S_4(t) + C_p\kappa_{v4}d^2\Delta T/dz^2, \quad (4)$$

$$C_p[d\Delta T_i/dt] = C_p\kappa_{vi}d^2\Delta T/dz^2 \ (i = 5,40) \quad (5)$$

where Cp is the bulk heat capacity of a 50 m thick ocean layer, assumed to be a constant with depth; N represents all external and internal radiative forcings; λ is the net feedback parameter (Forster and Taylor, 2006; Forster and Gregory, 2006); S represents non-radiative forcing of temperature change (ocean mixing), with N and S in Watts per sq. meter (W m^{-2}); and the last term represents all processes which mix vertical temperature anomaly structures with depth, with κ_v being the depth-dependent effective diffusivity representing all vertical mixing processes in the global-average ocean. Note the left hand side of Eqs. 1-4 is equivalent to the change in the layer heat content with time. The two terms in brackets together in Eq. 1 represent the total radiative imbalance of the system: the sum of radiative forcing and radiative feedback.

We assume the total radiative forcing N operating on the first model layer is composed of the RCP6 anthropogenic and volcanic external forcings estimated by Meinshausen *et al.* (2011) used in the CMIP5 experiments, with land use and black carbon forcing removed for our ocean-only simulations, and an internal pseudo-forcing proportional to MEI with empirically determined coefficient of proportionality α at adjustable time lag j:

$$N(t) = N_{RCP}(t) + \alpha^*\mathrm{MEI}(t_j) \quad (6)$$

The non-radiative forcing terms of the first four model layers (S) represent inter-layer heat exchange components proportional to MEI with empirically determined coefficient of proportionality β at adjustable time lag k:

$$S_1(t) = 0.5\beta^*\mathrm{MEI}(t_k). \quad (7)$$

$$S_2(t) = 0.5\beta^*\mathrm{MEI}(t_k) \quad (8)$$

$$S_3(t) = -0.5\beta^*\mathrm{MEI}(t_k) \quad (9)$$

$$S_4(t) = -0.5\beta^*\mathrm{MEI}(t_k). \quad (10)$$

The MEI terms in Eqs. 7-10 are meant to approximate the observed relationship between upper ocean temperature variations and MEI shown in Fig. 3b by imposing ENSO vertical heat exchanges associated with El Nino and La Nina activity; for example, warming of the 0-100 m layer and an equal amount of cooling in the 100-200 m layer during El Nino (positive MEI) conditions. While this obviously forces considerable agreement between the model and the observations on interannual time scales, the model ocean must still respond in terms of vertical mixing and radiative feedback, which then alters the total heat content of the model climate system and the deeper ocean temperature profile.

The ten adjustable free parameters of the model are the net feedback parameter; scale factors on the radiative and non-radiative MEI forcings; time lags on the radiative MEI forcing; and six depth dependent effective diffusivities. Ranges of all model adjustable parameters are swept over many thousands of combinations, each resulting in a model simulation which is then compared to the observations.

4. Model simulations with and without ENSO

All experiments are run with the CMIP5 RCP6 radiative forcing histories (Meinshausen *et al.*, 2011), but different assumed combinations of MEI-dependent forcings, net feedback parameter, and ocean effective diffusivities. For simplicity, the ocean diffusivities are assumed to be constant with time, and adjustable for only the top six layers, with the remainder of the layers assumed to have the same diffusivity as the sixth (250-300 m) layer. The ranges of the free parameters tested were 0.5 to 4.0 W m^{-2} K^{-1} for the net feedback parameter; 0 to 4.7×10^{-4} m^2 s^{-1} for the diffusivities; and +/– 12 months lag (relative to the observed time history of MEI) for the ENSO radiative forcings.

The experiments involve initialization of the model in the first month of 1880 with zero temperature anomalies (equilibrium) and are run with a monthly (30.438 day) time step through June 2011. Initialization of the model at the start of the Levitus observational period (1955) rather than in 1880 was found to only reinforce our conclusions. The model output was then compared to the Levitus observations for the period 1955-2011, and to the CERES satellite observations of net radiative flux variations during March 2000 through December 2010.

Various combinations of the model free parameters were tested in a heuristic fashion, by sweeping a range for each adjustable parameter as described above. The model results quickly suggested much narrower ranges of the free parameters over which the model behaved in a manner similar to the observations. The free parameter values that produced good agreement with the observations were chosen in an iterative fashion as the dependence of the model results on the various free parameters was better understood. This tuning of the simple 1D model parameters is little different philosophically from the tuning of various parameterizations performed in 3D models, except in the case of the feedback parameter which we adjust directly whereas it is adjusted indirectly in 3D models as other parameters (such as cloud parameterizations) upon which it depends are adjusted.

Three forcing experiments were run, as shown schematically in Fig. 4. Case I includes only the RCP6 estimates of anthropogenic and volcanic radiative forcings to ensure that the feedback parameter (i.e., climate sensitivity) results were consis-

Table 1. Model free parameter values chosen for optimized fit to observations under different simulation forcing scenarios, and the resulting fraction of 0-2000 m layer heating occurring below 700 m depth.

Parameter	Case I: RCP6 only	Case II: RCP6 + ENSO mixing	Case III: RCP6 + ENSO mixing + ENSO radiative
Feedback parameter (λ, W m^{-2} K^{-1})	1.7	1.9	2.8
MEI non-radiative forcing coeff. (α, W m^{-2})	N.A.	1.2	1.2
α time lag (months)	N.A.	Assumed +1	Assumed +1
MEI radiative forcing coeff. (β, W m^{-2})	N.A.	N.A.	0.6
β time lag (months)	N.A.	N.A.	−9
Layers 1-6 effective diffusivities (κ, 10^{-4} m^2 s^{-1})	0.54, 0.84, 1.1, 1.8, 3.0, 4.7	0.74, 1.3, 2.6, 3.6, 4.2, 4.7	0.72, 1.2, 2.4, 4.2, 4.7, 4.7
Fraction of 0-2000 m heating occurring below 700 m depth	0.40	0.44	0.39

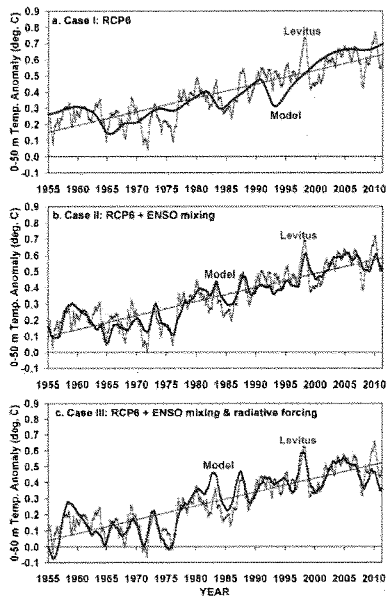

Fig. 5. Model simulations of monthly global average 0-50 m layer ocean temperature variations for three cases: (a) only RCP6 radiative forcings; (b) RCP6 plus ENSO-related non-radiative forcing (ocean mixing); and (c) RCP6 plus ENSO-related radiative and non-radiative forcings.

tent with the CMIP3 models (Forster and Taylor, 2006). Case II adds to the RCP6 forcings ENSO non-radiative forcing (ocean mixing) based upon the time history of the MEI index, with a time lag of 1 month to be consistent with the Levitus observations in Fig. 3b. Case III further adds ENSO-related radiative forcing with adjustable time lag.

Example values of the free parameters which were deemed to provide good overall agreement to the observations for the three cases are given in Table 1, keeping in mind that other slightly different values produced nearly the same results. In all three cases, the model was required to match the 0-50 m observed temperature trend for 1955-2011 to within 0.002 deg. C per decade. None of the time series were detrended for the purpose of the comparisons, since temperature trends are one component of the observations we want to explain.

The 0-50 m model temperature results for the three simulation case scenarios are shown in Fig. 5. All of the model linear trends for the 1955-2011 equal the Levitus trend, while the free parameters were adjusted to optimize the match between the model and the other observations. In Case I, the warming is only the result of the increasing anthropogenic greenhouse gas forcing in RCP6, while the intermittent cooling events are from major volcanic eruptions. The Case I feedback parameter is $\lambda = 1.7$ W m^{-2} K^{-1} (climate sensitivity of 2.2°C, assuming 3.7 W m^{-2} forcing from a doubling of atmospheric carbon dioxide, 2XCO2) which is within the range of diagnosed net feedback parameters from IPCC (2007) AR4 coupled climate models ($\lambda = 0.9$ to 1.9 W m^{-2} K^{-1}, Forster and Taylor, 2006). This suggests the simple model produces a net feedback parameter consistent with CMIP models in response to anthropogenic and volcanic forcings.

In Case II, the impact of the imposed ENSO-related heat exchanges is evident, showing much better agreement with observations (Fig. 5b) for year-to-year variability as would be expected since the model is being nudged in that direction at each time step based upon the time history of ENSO through the MEI index. The feedback parameter in this simulation is $\lambda = 1.9$ W m^{-2} K^{-1}, which corresponds to a slightly lower climate sensitivity of 2.0°C.

Finally, adding the internal radiative forcing from ENSO in Case III (Fig. 5c) leads to only small adjustments to the model 0-50 m layer temperatures, but a rather large increase in the feedback parameter, $\lambda = 2.8$ W m^{-2} K^{-1}, corresponding to a climate sensitivity of 1.3°C. The reason for this change will become apparent shortly.

The temperature trend profiles for the three model cases are shown in Fig. 6. The Levitus trend profile shape is better matched when the effects of ENSO are included, although the

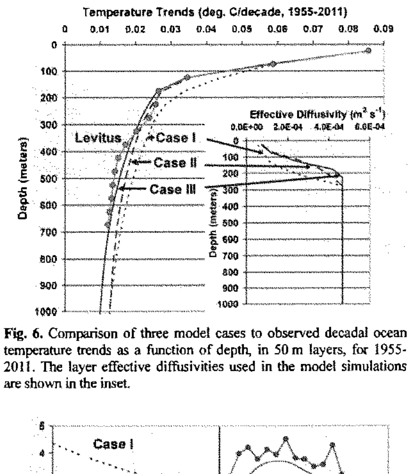

Fig. 6. Comparison of three model cases to observed decadal ocean temperature trends as a function of depth, in 50 m layers, for 1955-2011. The layer effective diffusivities used in the model simulations are shown in the inset.

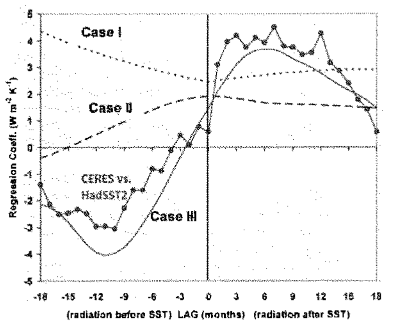

Fig. 7. Lag regression coefficients between monthly CERES radiative fluxes and HadSST2 sea surface temperature variations, and compared to the three model simulations.

differences between the three simulation cases are within the margin of error of the Levitus observations. In all three model cases, the fraction of the 0-2000 m layer warming occurring below 700 m depth (Case I:0.402; Case II:0.440; Case III: 0.389) is consistent with the one-third factor estimate obtained from observations (Levitus *et al.*, 2012), given the margin of observational error.

But the largest differences between the model simulations and observations is found for the relationship between TOA radiative fluxes and SST during the period which the Terra satellite CERES instrument was operating (SST departures in the model are assumed to be the same as the 0-50 m layer temperature departures). The CERES Terra Satellite SSF 2.6 monthly global gridpoint radiative flux anomalies were averaged over the 60°N-60°S oceans for direct comparison to the Levitus and HadSST2 ocean surface temperatures. Significantly, the lag regression relationship between radiative flux and surface temperature (Fig. 7) can reasonably match the CERES vs. SST observations only if ENSO-related radiative forcing is included in the model. In Case II, where the only radiative effect is feedback upon the ENSO mixing-forced ocean temperature variations, the model is unable to capture the radiant energy accumulation (loss) which precedes the highest (lowest) temperature anomaly conditions.

In Case III, the greatest agreement with observations was found when the assumed ENSO radiative forcing (with its assumed proportionality constant, see Eq. 6) preceded the MEI index by around nine months. This is a significant result. It suggests that as part of the changes in the coupled ocean-atmosphere circulation associated with ENSO, there are non-feedback changes in the global radiative balance which occur that contribute to later surface temperature anomalies associated with ENSO, possibly through changes in cloud cover and the resulting global albedo. Feedback upon previous ENSO activity cannot explain the lag, as evidenced by the Case II curve in Fig. 7.

The most obvious (but not necessarily correct) explanation for this behavior is that the Earth's radiative budget is a partial function of circulation regime associated with El Nino and La Nina activity, independent of radiative feedback upon temperature. From Table 1 we see that the estimated magnitude of this internal radiative forcing is 0.6 W m^{-2} per unit MEI index. Compared to the estimate a rate of energy absorption/loss by the climate system of 240 W m^{-2}, this amounts to a 0.25% non-feedback modulation of the average global radiative energy budget by ENSO activity. Thus, the extended period of El Nino activity starting in the late 1970s appears to impact our interpretation of the sensitivity of the climate system to anthropogenic forcing by providing additional radiative heating of the climate system, which then implies a lower climate sensitivity in order to explain the same amount of temperature rise, at both the surface and within the ocean.

The model results also address the issue of the relative size of radiative forcing versus radiative feedback associated with ENSO (Dessler, 2011). Even though the non-radiative (ocean mixing) forcing in Case III was twice the size of the radiative forcing (see Table 1), supporting the Dessler (2011) view that ENSO is a primarily ocean-driven phenomenon, that smaller radiative forcing is still 2.8 times larger than the radiative feedback, with monthly standard deviations of 0.51 W m^{-2} and 0.18 W m^{-2} respectively over the ten-year satellite observation period. This is because radiative feedback is, by definition, proportional to surface temperature changes, which are very small in the global average. This supports the contention of Spencer and Braswell (2010) that short term internal radiative forcing can corrupt our estimates of radiative feedback in the climate system.

Finally, note that the common practice of diagnosing the feedback parameter at zero time lag would lead to a 50%

underestimate of the specified feedback for Case III in Fig. 7 (1.4 diagnosed vs. 2.8 W m^{-2} K^{-1} specified), consistent with the conclusions of Spencer and Braswell (2010, 2011) and Lindzen and Choi (2011) that the presence of time varying radiative forcing tends to lead to an underestimate of the net feedback parameter diagnosed from observations.

5. Conclusions

While it is easy to criticize the simplicity of a 1D model of the climate system, for global averages there are only three main processes which control surface (or ocean mixed layer) temperatures: radiative forcing, radiative feedback, and vertical ocean mixing, all of which can be included in a 1D model. Given the wide variety of ocean responses in the more complex 3D models (see Fig. 1), it is entirely reasonable to use a simple 1D model which can include these three main processes in an attempt to best explain observed rates of ocean warming. Insights gained through such a simple model can then help guide the development and tuning of the much more complex 3D models.

The 1D forcing-feedback-mixing model results presented here suggest that radiative changes generated within the climate system associated with ENSO can have a considerable impact on our interpretation of ocean temperature changes and our inferences regarding feedback. Forcing of the model with only the traditional external forcings (mainly anthropogenic and volcanic) and adjusting the model ocean effective diffusivities to match the observed warming profiles down to 700 m since 1955 yields a climate sensitivity within the range of the CMIP3 climate models.

Adding ENSO non-radiative forcing (imposed exchanges of heat between the 0-100 m and 100-200 m layers proportional to the Multivariate ENSO Index) did not substantially change the optimum net feedback parameter, but the resulting radiative behavior of the model could not capture the satellite-observed time-lag relationship between radiative flux and temperature. Only with the inclusion of ENSO related radiative forcing nine months prior to peak MEI (El Nino or La Nina conditions) could the lag relationship between satellite measured global oceanic radiative flux variations during 2000 through 2010 be reasonably well reproduced, which in turn required a substantially larger net feedback parameter in the model, 50% larger than with anthropogenic and volcanic forcings alone. This is interpreted as evidence that stronger El Nino activity, such as that experienced approximately between 1977 and 2006, causes internal radiative forcing of the climate system, which supplements anthropogenic warming.

Nevertheless, the relatively small differences in the ocean warming profile for the three modeled cases in Fig. 6 - despite a 50% range in assumed climate sensitivity - suggest that the levels of ocean warming observed since the 1950s might not provide a very strong constraint on our estimates of climate sensitivity. The uncertainty in the rates of ocean mixing and the exceedingly small changes in deep ocean temperature contribute to this difficulty in diagnosing the sensitivity of the climate system.

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Senator WHITEHOUSE. Thank you very much, Dr. Spencer.

Let me begin my questioning, I think we have time to either expand the rounds or have two rounds. How do you want to handle this, David?

Senator VITTER. Could I have two rounds? Because I may have to go.

Senator WHITEHOUSE. OK, we will have two rounds so that I may move quickly on.

Let me start with Dr. Pielke. I take from your testimony that we actually have a fair amount in common. As I understand it, we agree that climate change is happening, correct? That is a yes?

Mr. PIELKE. Yes.

Senator WHITEHOUSE. And we agree that we should both mitigate and adapt in response to that change.

Mr. PIELKE. Yes.

Senator WHITEHOUSE. And we both find the IPCC reports credible?

Mr. PIELKE. Yes.

Senator WHITEHOUSE. Yes. Can we also agree that a body of credible research projects that extreme weather events could increase in frequency and intensity due to manmade carbon dioxide emissions?

Mr. PIELKE. Yes. That is certainly the case. And if you look at the literature, you will find many such projections. And I would encourage you take a look at my testimony where we actually took climate model output and we asked the question, let us assume that it is true. When would we be able to detect that signal in, we looked specifically at North Atlantic hurricanes?

And the answer, much to our surprise, and it has been replicated now by Kerry Emanuel at MIT with different assumptions, it said it is many decades to centuries before we can say ah hah, we have seen that signal.

Now, that does not mean that climate change, we can forget about it. What it means is that we have to be very careful making strong statements about attribution today because they just rest on a very weak foundation.

Senator WHITEHOUSE. And if you are being a prudent actor and looking forward to protecting your children, your grandchildren and so forth, it is possible that there could be a point, particularly with this issue where we are already outside of the bounds that have been, our species boundaries for at least 800,000, we have been between 170 and 300 parts per million for at least 8,000 centuries and now, poof, we are suddenly out, we are at 400 parts per million, it is climbing. Is there a point at which it might be wise to anticipate behavior rather than wait for its signal to emerge?

Mr. PIELKE. Absolutely. I have written on adaptation for an awful long time. And there is a lot of talk now about we are entering a new normal. If you take a close look at the statistics that I showed you today, one of the concerning things is that we are not even at the old normal, the tornadoes of the 1950's or the hurricanes of the 1920's or drought of the 1930's and 1950's. We are not prepared for the old normal. So, I think there are a lot of reasons to adapt.

What I would suggest is, I agree entirely with your comments about being prudent and acting on energy policy and de-carbonizing, but there are much, much better justifications for that action than invoking extreme events. For a group of climate, people who want action on climate, to invoke the importance of science and then very quickly leave that behind and say, this latest disaster, that and so on, they undermine their own efforts to advocate for action because it is just not supportable.

Senator WHITEHOUSE. We do know a few things, though, as I understand it. We do know that warmer oceans create stronger storms because of the extra heat that is thrown up into the atmosphere off the warmer oceans. Is that accepted phenomenon?

Mr. PIELKE. Yes. I mean that, independently, is true but at the same time there are countervailing forces like wind sheer.

Senator WHITEHOUSE. I understand. But at least part is true.

Mr. PIELKE. Yes, that is absolutely true.

Senator WHITEHOUSE. And it also true that warmer oceans and warmer air carry more moisture and therefore can lead to more severe precipitation. That is a known scientific proposition. Correct?

Mr. PIELKE. Yes, that is absolutely true.

Senator WHITEHOUSE. So, when you start to put some of those things together, you can start to draw reasonable conclusions that if the Gulf of Mexico is considerably warmer and it is on the hurricane track, you might want to be careful.

Mr. PIELKE. Absolutely correct. But again, we cannot detect that scientifically for decades. My thing is we note that, identify it as a risk, and then we move on to talking about other basis for action.

Senator WHITEHOUSE. And it is interesting that a lot of the focus of the hearing has been on atmospheric models. I had actually hoped to focus on oceans issues and it is not your fault that you guys were selected as the Republican witnesses, but the other panelists bring a lot of oceans experience and so if I am taking you outside of your level of expertise, then just let me know.

But it does strike me that when you compare the atmospheric data, you really do have to get into issues of climate modeling and people can pick apart the modeling issues. When it comes to rising sea levels, when it comes to warmer ocean temperatures and when it comes to ocean acidification, we are not talking about modeling we are talking about measurement. Is that not correct?

Mr. PIELKE. Yes.

Senator WHITEHOUSE. So, I mean we know that Newport, Rhode Island, 10 inches higher in sea level since the 1930's. We know that has consequences. We know that Narragansett Bay is four degrees warmer, mean water temperature, than it was 30 or 40 years ago. We know that has caused a lot of valuable fish to move out and affected our fisherman in a very unfortunate way.

Some of these things, once you look at the oceans, become much clearer and the signal problem begins to dissipate. Do you not agree?

Mr. PIELKE. Yes. I think it is important to separate out looking for a signal of climate change, and I would agree with many of the witnesses today who said it is unequivocal that there is human-caused climate change, from trying to find that signal in extreme events.

Senator WHITEHOUSE. Understood.

Mr. PIELKE. We do not look at extreme events to show climate change.

Senator WHITEHOUSE. I am over my time, so I will come back as we will have another round with the time pressure off but I do want to yield to the Ranking Member and be courteous.

Senator VITTER. Thank you, Senator, and thanks to all of our panelists. And I want to really continue this discussion because I do think it is important that we bring some rigor to the discussion and that we be precise. And that also dovetails with Dr. Spencer's comments.

On the one hand the title of the hearing is Climate Change: It's Happening Now. Well, I mean, if we take a vote in Committee about how many people agree with that, we take a vote among the witnesses how many people agree with that, everyone will raise their hand, myself included.

But the suggestion which was in fact stated several times by the Chair, by some witnesses, one of the big themes, one of the big narratives, is that extreme weather events are dramatically increasing as a direct result of human-related carbon emission. So again, I think it is important to be precise. So, let me focus on that because that is a huge narrative in the last several years.

So Dr. Pielke, since you have focused on that, is there evidence that statement is true, extreme weather events are dramatically increasing recently for any reason and that if they are it is related to carbon and climate change?

Mr. PIELKE. Unfortunately, the phrase extreme weather is slippery and general enough to encompass many things and people can invoke that statement and imply something that maybe is not supported.

The reality is that with respect to heat waves, as we heard earlier, and what has been called extreme precipitation, which is a scientific term and often is not what most people would think of as extreme precipitation, yes, there has been a documented increase in those phenomena and there have been attribution that link it to increasing greenhouse gases.

But when it comes to the most costly visible disasters, hurricanes, floods, drought and tornadoes, as I discussed, there is not presently attribution or even detection of increasing trends with respect to those phenomena. There may be in the future, but there is not presently.

Senator VITTER. OK. And that directly relates to pictures of Superstorm Sandy, discussion of Hurricane Katrina, etcetera.

Let me bring up these charts again because they are yours. The data is not yours, but they are from your testimony. And if you could just briefly walk us through what each chart represents and what do you think it says. So, heat waves.

Mr. PIELKE. That one is not from my testimony.

Senator VITTER. Oh, sorry, I thought it was. This is, let me comment on this. This is EPA data with regard to heat waves over many decades. Let us go to the next one. Drought.

Mr. PIELKE. That one also is not from my testimony. I do refer to drought but since the IPCC in 2007 came out with its report, the community has recognized that the phenomena of drought is more complicated than was originally thought and there are trends in some places of increasing drought and in other places of decreasing drought. But overall, over the planet, the conclusion has been that over 60 years there has been no trend one way or the other.

Senator VITTER. OK. Next chart is wildfires.

Mr. PIELKE. Yes, this one does not appear in my testimony either. It is very plausible that there could be a signal of human-caused climate change in western wildfires in particular. There is a number of causal steps in that chain that need to be connected and it is logical.

But doing convincing attribution is made complicated because humans have been so deeply interfering with the western ecosystems that, according to a recent study and proceedings of the National Academy of Sciences, climate and societal behavior and fire have all been decoupled over about a century.

Senator VITTER. OK. And hurricane landfalls in the U.S.?

Mr. PIELKE. Yes, this does come from my testimony. And remarkably, over a century, there has actually been a slight decrease in the number of hurricane landfalls. Presently, we are in the longest stretch with no Category III or stronger hurricanes making landfall in the U.S. ever recorded. Now, that goes back to 1900 and the data before that is even less. The State of Florida is in the longest stretch without being hit by a hurricane.

So, the idea that we are in some sort of enhanced hurricane regime sets the stage for setting the false expectations. We are not. We have actually been pretty lucky in recent years.

Senator VITTER. And this is the global equivalent, global cyclone landfalls, which is basically hurricanes, typhoons, global landfalls, is it the same story basically?

Mr. PIELKE. Yes. That is a study we did where we added up all of the landfalls globally and the data is good in 1970 and there is no trend globally either.

Senator VITTER. OK. Thank you very much.

Senator WHITEHOUSE. Let me ask if any of the other witnesses would care to respond to those charts and that data? Starting over here at the left. Dr. Francis, do you want to share your views?

Ms. FRANCIS. Sure. There is a lot of information presented there. But I think I wanted to reiterate something that Dr. Cullen said and that is when you are looking at trends like heat waves and droughts and floods, you cannot take an area the size of the United States, average over the entire area, and then present trends based on that because there are huge regional differences. And so, if you average over the East being wetter and the West being drier, you get no signal. So, what I saw there was an average over the United States. Again, that trend does not reflect what is really happening on a regional basis.

In terms of the hurricanes, I am not a hurricane expert. But I think focusing on land falling hurricanes also is a rather not quite realistic way to go about it because, for example, the last 2 years there have been a large, many more hurricanes than in a typical year, over the last two summers in the Atlantic, and for whatever reason, very few of them actually made landfall in the United States. But there were way more hurricanes than normal. So, I think the statistics as presented there present a rather misleading picture.

Senator WHITEHOUSE. Let me turn to Dr. Spencer and let me first ask a kind of unrelated question, Doctor. Do you believe that the theory of creation actually has a much better scientific basis than the theory of evolution?

Mr. SPENCER. And why are we going in this direction?

Senator WHITEHOUSE. Because it is something that you have said and I just wanted to see if you still believe it.

Mr. SPENCER. I believe that evolutionary theory is mostly religion. It is naturalistic. But my faith is not strong enough to believe that everything happened by accident. I mean, there is a lot of work out there that has shown that you cannot statistically combine all of the elements that are contained in a DNA molecule by chance over however many billions of years you want to invoke or over how many, how much known universe there is with all of the matter in it.

So what I am saying is some areas of science deal a lot more with faith than with known science. And so, I am open to alternative explanations.

Senator WHITEHOUSE. And do you still believe that the theory of creation actually has a much better scientific basis than the theory of evolution, to be specific?

Mr. SPENCER. I think, I think I could be put into a debate with someone on the other side and I think I could give more science supporting that life was created than they could support with evidence that life evolved through natural, random processes. So, yes.

Senator WHITEHOUSE. OK. In your testimony, you have a graph that I think we have seen a lot of versions of during the course of the day which shows an average trimmed line, the black line, that is the average of all of the other lines which are various climate models.

Mr. SPENCER. Yes, those are 73 of the latest IPCC climate models.

Senator WHITEHOUSE. And then you have your own balloon and satellite data sets which are indicated by the various marks running below.

Mr. SPENCER. Yes. Those big blobs are the observations. There is a total of six data sets there, one of which is ours. The other five are not ours.

Senator WHITEHOUSE. And they all come from the tropical mid-troposphere?

Mr. SPENCER. Yes, this is all tropical mid-troposphere. That is right.

Senator WHITEHOUSE. So, they are all from the tropics and they are all from above 5,000 roughly?

Mr. SPENCER. Well, it is actually a deep layer of the atmosphere from the surface to, let us say, 10 or 12 kilometers altitude. So, it is a bulk measure of the tropical atmosphere.

Senator WHITEHOUSE. OK. Let me show you a second graph which looks rather similar to it, other side, upside down, and was presented to this Committee by Dr. John Christy who, I believe, is a collaborator and co-author of yours. Do you recognize that?

Mr. SPENCER. Yes.

Senator WHITEHOUSE. And that shows what appears to be the same data set going along the bottom line, the same average, but it also shows an additional data set in the middle which includes surface temperature readings.

Mr. SPENCER. Yes.

Senator WHITEHOUSE. And it would appear to me that the surface temperature readings, when you add them, are far closer to the average than the data set that you selected.

Mr. SPENCER. Yes, the surface temperatures appear to be closer. The reason why we emphasize deep tropospheric temperatures is because they are not subject to certain kinds of errors, for instance urban heat island effects. Also, our satellite measurements are the only truly global measurements. That is for global. Ours are the only truly global measurements because they sample all of the global atmosphere.

Senator WHITEHOUSE. And then let me show a third graph which I think is fairly common in the literature on this that I believe was produced by Ed Hawkins at the University of Reading that is a common display, I gather, in the scientific community. And that shows from an even broader set of data sources the match between observed and modeled projections. Have you seen that before?

Mr. SPENCER. I have not seen this one.

Senator WHITEHOUSE. OK. But it is certainly apparent that, as you go through those sets, the data set that you have selected is the one that is most divergent from the model data and that as you add further observations, the trends close rather than separate. Correct?

Mr. SPENCER. Oh, Senator, I can turn that around and tell you that usually what we see from the IPCC are comparisons which are the closest and it takes someone like me to come along and say all right, you are not showing all of the data. So, we are just trying to give some equal time to the other half of the story that is not being told.

Senator WHITEHOUSE. But you will concede that in this graph there is more data than in the data sets, the six data sets that you incorporated in your testimony? That is just factual. Correct?

Mr. SPENCER. More data? No, I would not concede that.

Senator WHITEHOUSE. All right. Can I ask Dr. Francis to comment on this? Or, I do not know who else would like to.

Ms. FRANCIS. Sure. I will take a stab at it. So, we who have used model output for many years for various things are as aware as anyone that they are not perfect. We know they are not perfect. But they get the general sense of change correct. Some of them do a darned good job and there are variables that, in fact, they project are changing slower than the real world. So, in fact, they are more conservative than the actual change that we observing in the real world.

This sea ice loss is a classic example. Most of the models have, when they are run in hind cast, models looking back at the real world and what has happened are not able to capture the speed of change of the sea ice loss in the Arctic.

So, I think it is very possible to look through the model output and find problems. But overall the models do an amazingly good job of simulating what is an incredibly complex system, this climate system that involves the oceans and the atmosphere and the ice and the biosphere and the soil moisture and coming up with very close representation of what the real world has undergone and, of course, into the future there are so many assumptions about what is going to happen in terms of future emissions of carbon dioxide and future technologies and things like that.

Senator WHITEHOUSE. Now, there has been testimony here that we are, and I have said it, I think it is fairly commonly knowledge, that we are outside boundaries of carbon concentration in our atmosphere that have persisted for somewhere between 800,000 and many millions of years. A minimum of 800,000 years.

So, if carbon pollution has forced us outside of those boundaries and we are now in unknown territory for our planet without going back into geologic times, certainly unknown territory for our planet while it has been inhabited by our species, it is foreseeable that there is going to be some uncertainty about the modeling. We have never been here before, have we?

Ms. FRANCIS. That, it is very possible although the models are based on physics, the laws of physics, and the laws of physics are not changing. We understand what happens to the earth when you increase greenhouse gases. That has been known for a hundred years.

Senator WHITEHOUSE. Generally.

Ms. FRANCIS. Generally.

Senator WHITEHOUSE. But if there was a specific short-term cooling trend that is driven by changes in the ocean and by the changing patterns of the ocean and the current flows and the increasing absorption, that is something that 10 or 15 years ago would have been a pretty tough thing to try to model exactly.

Ms. FRANCIS. You cannot model it exactly. The models have those kinds of variability built into them but to have the changes happen in the ocean exactly the same year in the model as they happen in the real world, you know that to create these model graphs like this they run the same model many times to create what they call ensembles because the models have natural variability in them just like the real world does. So, each of those runs of the model does not necessarily correspond to what the real world has done because we only have one run of the real world to compare to those.

Senator WHITEHOUSE. OK, let me interrupt. I see Senator Sessions here. I went ahead with Dr. Spencer's testimony but I did let him know that you had wanted to be here when his time came to introduce him and I will yield to you the time.

Senator SESSIONS. The 11, or 10 minutes, that you used.

Senator WHITEHOUSE. Well, there was nobody else here so I figured I was not inconveniencing anybody.

Senator SESSIONS. That is all right. But somebody else is here now.

Well, if you just look at that chart it shows that is dropping down below the modeling levels. Dr. Spencer, let us look at this chart and let us get clear about what the chart says.

The red line does not represent one or two models, does it?

Mr. SPENCER. It represents the average of all of the IPCC models included. And I want to emphasize the reason why the average is important. The IPCC based its bottom line conclusions basically on that average.

Senator SESSIONS. OK.

Mr. SPENCER. But the red line represents what the IPCC predicts for the future.

Senator SESSIONS. So, back in 1995 our, well, in recent times the models were predicting a rather continuing increase in temperature because CO2 continues to increase in the world and whatever other factors they use. That made sense to those computer models.

Mr. SPENCER. Well, even Kevin Trenburth who is on the other end of the spectrum from me has admitted that we do not know why it stopped warming and it is a travesty that we do not know.

If I can return to the chart that Senator Whitehouse presented as evidence of supposed agreement between the observations, the one behind you, Senator Whitehouse.

Senator WHITEHOUSE. This one over here? OK.

Mr. SPENCER. Would you admit that chart shows that the observations are now approaching the bottom of the full range of climate model projections?

Senator WHITEHOUSE. I think the chart speaks for itself and, like this chart, it continues to show rising temperatures, maybe not at the level of the average, but that clearly is not a flat line from where they depart upwards. It has, it is well above the 0.2, it is more than halfway to 0.4, that, to me, is an increase, not a decrease.

Mr. SPENCER. And I do not think anyone has claimed that there is a zero change. But there is a big difference between a tiny change and a huge change. And since we have policies that are being discussed that are going to be based on that red line, I think we need to consider the possibility that we need to go back and figure out what is wrong with the models before we start basing policies on models which produce at least two times as much warming as we have observed in nature and possibly three times as much warming.

Senator SESSIONS. Dr. Spencer, you and Dr. Christy, by utilizing satellite data, has that not gained respect worldwide as a more accurate, a lot of scientists agree that is the best way to identify global temperature change?

Mr. SPENCER. Well, we need all of these data sets. We need the satellite data set, partly because it is the only truly global data set. It also measures up where we can see other things happening.

We think what is going on in the upper atmosphere is that is it not warming as fast because something called positive water vapor feedback is not happening. Now, these models amplify warming, at least twice the warming that occurs in all of these climate models is because they increase water vapor throughout the whole atmosphere in response to the warming and it about doubles the warming. And this lack of warming up in the free atmosphere to us suggests that, on these climate timescales, there is not positive water vapor feedback or that it is very weak.

So that is one reason why, another reason why, we use the satellite data. It tells us more about the climate system than just the surface. The surface is just a thin layer six feet above the surface and there are so many things that can affect that, wind and things.

This is a bulk measurement of the heat content of the atmosphere that we think has more physical meaning for understanding the climate system.

Senator SESSIONS. Just to get this straight, the Economist said over the past 15 years air temperatures at the earth's surface have been flat. Is that disputed? Or is that generally accepted today?

Mr. SPENCER. I think it depends on the surface temperature data set that they are talking about. There are different, just like there are different satellite data sets, there are different weather balloon weather sets, there are different surface temperature data sets and I think one or more of the surface temperature data sets show in the last 10 or 15 years a temperature change which is not statistically different from zero.

Maybe there is a light warming, or a slight cooling depending on the data set. I am not an expert on all of those. But we are mincing words when what we should be emphasizing is we are not getting anywhere near the warming that the models have predicted. To me, that is the take-home message.

Senator SESSIONS. Well, thank you for that. I think it should give us cause to analyze and think about that.

It is pretty obvious also that there are long-term variations in temperature that have occurred naturally over the centuries. Is that correct?

Mr. SPENCER. Wait. While you were not here, I asked to enter into the record this plot of temperatures over the last 2,000 years which suggests that previous warm periods that our current warm period may not be exceptional compared to the Medieval Warm Period or the Roman Warm Period. In other words, global warming and global cooling happens almost every century.

Senator SESSIONS. Well, they happen for some reason and we may be finding that CO2 will impact global temperatures. But they have been occurring without huge increases in CO2, it seems to me.

Mr. SPENCER. Well, I just find it very unscientific for scientists to claim that there are these past periods of warming which, well, we really do not know what caused them. They obviously were not due to people, but the current period of warming we know is due to increasing CO2. It just logically does not make sense.

Now theoretically I can admit I do expect some warming from CO2. But as I have mentioned, my primary area of research is trying to determine exactly how much. And right now the State of that science is, I do not think we can say how much of our current warmth is due to human CO2 emissions versus natural processes.

Senator SESSIONS. In one of our last hearings, I do not know if you have these numbers in your mind or at hand, but earlier the question, the statement was made that we have had record high temperatures in the last few years and an unusual number of record high temperatures.

As I understand the data, there are quite many more record temperatures during the Dust Bowl times of the 1930's. Is that correct?

Mr. SPENCER. Yes, that chart was shown, maybe while you were not here, that shows that by far most of the high temperature records that were in the United States were set in the 1930's. And I do not know what we are doing today so far in Washington, DC, but I do not think we are going to hit 103 degrees today, which is the record high for this date in Washington, which was set in 1887.

Senator SESSIONS. Well, one of the things that is confusing us a bit is they use the Heat Index and the Humidity Index and it makes the numbers go up and the Weather Channel's ratings go up. We hear all about storms because we hear about every one of them.

But Dr. Pielke, you have just demolished this idea, it seems to me, from your research that we are having extraordinary increases in storms of all kinds, floods, droughts. I remember that Kingston Trio song, they are rioting in Africa, they are starving in Spain, the whole world is full of strife and Texas needs rain.

So, what is it, would you comment a little further on your finding objectively with regard to storms? I just had the numbers from NOAA that shows there has not been an increase but really a decline in hurricanes and Dr. Cullen's own statement to us that there is no evidence to indicate that EF4, EF5 tornadoes, like the ones that devastated a large swath of Moore, Oklahoma in May, are becoming more frequent or more severe. Do you have any comments on that?

Mr. PIELKE. Yes. I will just say that this is one area of research and science that really should not be controversial because, I mean, hurricanes, you do not miss them. They are big and you count them up. It is just math.

And I said earlier and I will repeat this, if one wants to invoke the importance of science in these debates, you are not allowed to say, well, I like this science but I do not like that science. And the fact of the matter is, the Intergovernmental Panel on Climate Change did a big report, reported out in 2012, it looked globally at extreme events, and summarized these data.

Now, looking forward, there are projections there may be more extreme events. But the good news is, we are monitoring, we are detecting, and simply statistically one of the last places you would want to look to see the signal of climate change is extreme events because they are rare, they do not occur all the time, and so it takes a long time to understand the statistics.

To the extent there is large variability, that makes it even more difficult. So, I would say that images of Katrina and the like, they get a lot of attention and the media focuses on it, but it takes the scientific community down a path where pretty quickly they depart from what you can say based on data and analysis. And that does not help the discussion and it does not help, certainly, claims that are supposed to be grounded in science.

Senator SESSIONS. Thank you, Mr. Chairman. I would just say I appreciate Dr. Spencer coming and to the extent to which he believes this is a created universe, we share that common belief.

Senator WHITEHOUSE. I am delighted that the witnesses were here and I want to thank them for their testimony.

I do believe that NASA stands by its data that shows that the 12 warmest years on record since 1880 all happened in the last 15 years. I was not here for the Dust Bowl but certainly it happened after 1880 and 12 out of 15 is pretty serious information. And I tend to believe that NASA knows what they are talking about, particularly when they are driving a rover around on the surface of Mars. That is not a small achievement.

And I would close by noting one other thing which is that the discussion in this panel from the Republican side has largely been about the atmospheric issues and has largely been about the modeling of atmospheric issues and particularly looking at tropical tropospheric atmospheric data. And the focus of the hearing, I had hoped, was to be on oceans, because once you get into the oceans, a lot of modeling issues go away.

We actually measure ocean acidification. We actually measure ocean temperatures. We actually measure sea level rise. And if all of the focus is on areas of technical dispute and we are blind to what is visibly and measurably happening all around us, I think we are going to miss the most important signal.

So, let me pay a particular thank you to the oceans experts who came in today and if the other side wants to being oceans witnesses at some point, I would be delighted to continue this discussion.

But we really are having two panels. We have got an oceans panel, which seems to be pretty unanimous, and we have atmospherics and economics panel and I think to me, I am from the Ocean State, and it matters a lot to Rhode Island when the sea level is 10 inches higher than it was in our last big, big, big crusher hurricane. When we get our next one, that is going to make a big difference.

It makes a big difference to me when fishermen cannot catch winter flounder any longer in Narragansett Bay because it has moved offshore and our lobstermen have to drive twice as far, as I think Dr. Leinen mentioned. When these fishermen have to drive farther to find their catch, it is not just a fuel burn. It is not just an expense. It is not just time. Fishermen have a dangerous job. They go out into a dangerous place. And the more time they have to spend for their time out on the ocean, the more at risk they are.

So, it is really, really important to Rhode Island that we get this right and that we listen to the signals to the ocean.

Senator SESSIONS. Can I say one thing in regard to Dr. Spencer's background? He was Senior Scientist for Climate Studies at NASA's Marshall Space Flight Center. During his tenure at the center, he and Dr. John Christy received NASA's Exceptional Scientific Achievement Medal for developing innovative methods for precise monitoring of earth temperatures via earth orbiting satellites which is regarded as a major advancement in our ability to monitor climate fluctuations. And he has been engaged in a lot of other important scientific endeavors.

Thank you.

Senator WHITEHOUSE. The Chairman has already announced that the hearing record will close at 10 a.m. tomorrow but further questions can be in for the usual EPW 2 weeks.

So with that, I thank the witnesses, I thank those who attended and adjourn the hearing.

[Whereupon, at 1:25 p.m., the committee was adjourned.]

United States Senate

WASHINGTON, DC 20510

June 24, 2013

The Honorable Gina McCarthy
Assistant Administrator
Office of Air and Radiation
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue NW
Washington DC 20460

Re: Assertions by the Administration about Global Temperature Predictions

Dear Assistant Administrator McCarthy:

We are writing to express continued concern with repeated assertions by the President regarding global temperature predictions and your refusal to provide data and analysis that would support his statements, as requested by Members of this Committee. We are referring, in particular, to two statements by the President. On November 14, 2012, President Obama stated that "the temperature around the globe is increasing faster than was predicted even 10 years ago."[1] He made a similar statement again on May 29, 2013.[2]

These statements contradict the nearly universal view of those who have studied the data, including entities generally supportive of the Administration's climate change policies. For instance, *The Economist* magazine recently explained that "temperatures have not really risen over the past ten years..."[3] and that "[o]ver the past 15 years air temperatures at the Earth's surface have been flat..."[4] For global warming advocates, this lack of warming compared to predictions has been a "surprise" (to use the words of *The Economist*). Last month, BBC News reported: "Since 1998, there has been an unexplained 'standstill' in the heating of the Earth's atmosphere."[5] In light of recent reports that the Administration is preparing to roll-out an aggressive regulatory program aimed at addressing rising global temperatures, your prompt attention to requests for EPA data on these matters is imperative.

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[1] http://www.whitehouse.gov/the-press-office/2012/11/14/remarks-president-news-conference
[2] http://www.whitehouse.gov/the-press-office/2013/05/30/remarks-president-dccc-event
[3] http://www.economist.com/news/leaders/21574490-climate-change-may-be-happening-more-slowly-scientists-thought-world-still-needs
[4] http://www.economist.com/news/science-and-technology/21574461-climate-may-be-heating-up-less-response-greenhouse-gas-emissions/
[5] http://www.bbc.co.uk/news/science-environment-22567023

Importantly, EPA has essentially ignored members of Congress who asked for EPA data due to concerns with the President's claims about global temperature predictions. For example, on December 4, 2012, Senator Sessions wrote former Administrator Jackson:

> The actual temperature data show no significant change in global temperatures over the past decade and certainly less warming than the climate change models predicted. At an August 1, 2012, hearing before the Senate Committee on Environment and Public Works, ... climatologist Dr. John Christy of the University of Alabama-Huntsville offered testimony demonstrating that the IPCC climate models, which have been relied upon by alarmists, vastly over-stated the degree of warming in comparison to actual temperature data observed by advanced satellites. Dr. Christy's chart ... demonstrates that the IPCC models, on average, predicted a significant amount of warming that has not actually occurred. In fact, contrary to the President's assertion, the chart shows that global average temperatures have not increased at all over the past decade, and certainly less than was predicted 10 years ago.
>
> The President's assertion also conflicts with the views of many other scientists and experts. In an editorial published earlier this year in the Wall Street Journal, scientists and engineers from MIT, Princeton, Cambridge, and other leading institutions explained that "perhaps the most inconvenient fact is the lack of global warming for well over 10 years now" and that there has been a "smaller-than-predicted warming over the 22 years since the U.N.'s Intergovernmental Panel on Climate Change (IPCC) began issuing projections." Additionally, the lead author of the 2007 IPCC climate report stated in an email that "we can't account for the lack of warming at the moment..."
>
> As policymakers consider proposals aimed at addressing concerns about rising temperatures predicted by the IPCC climate models, a critical question is whether the planet is warming to the extent predicted by these models. The data suggest to me that the planet is not warming to the extent predicted 10 years ago.[6]

To shed light on this issue, Senator Sessions asked EPA to "provide the best available data that EPA would rely upon to support the President's assertion," along with an EPA-prepared chart comparing "actual global average temperature increases since 1979 (when satellite temperature data became available) versus the latest IPCC predictions..."

On behalf of Administrator Jackson, you responded to Senator Sessions in a letter dated February 14, 2013, by asserting that "there are multiple lines of evidence that clearly demonstrate that average global temperatures are rising...," yet you did not provide any of the requested data relating to average global temperatures. Instead, your letter seems to dodge Senator Sessions' data request by claiming that "only looking at 10 years of a single dataset cannot provide a full picture of climate change trends, and should also not be the sole test by which to judge the usefulness of climate models in either simulating past climates or projecting further climate change." Your letter contained a series of charts (from NOAA's *State of the*

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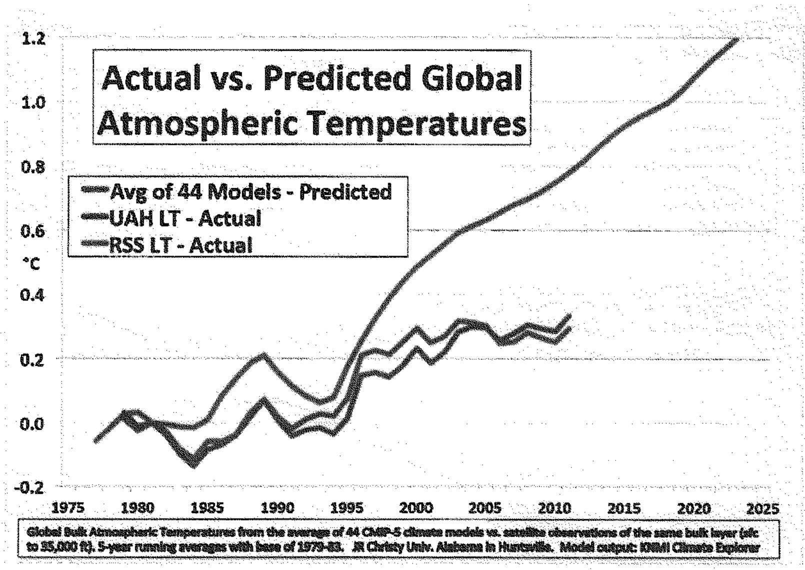
[6] Letter from Sen. Jeff Sessions to EPA Administrator Lisa Jackson dated December 4, 2012.

Climate in 2009 report) related to land surface air temperatures, sea surface temperatures, marine air temperatures, tropospheric temperatures, and stratospheric temperatures. Importantly, while you did not provide the requested chart comparing global temperature averages that correlate to the global temperature averages predicted by the IPCC, the charts you provided are, nonetheless, intriguing because all of these charts show no increases in temperatures for at least the past decade.

Your lack of responsiveness on these points was raised at your April 11, 2013, confirmation hearing when Senator Sessions presented the following chart demonstrating that global temperatures have not increased over the last decade and certainly not to the extent predicted by the climate models:



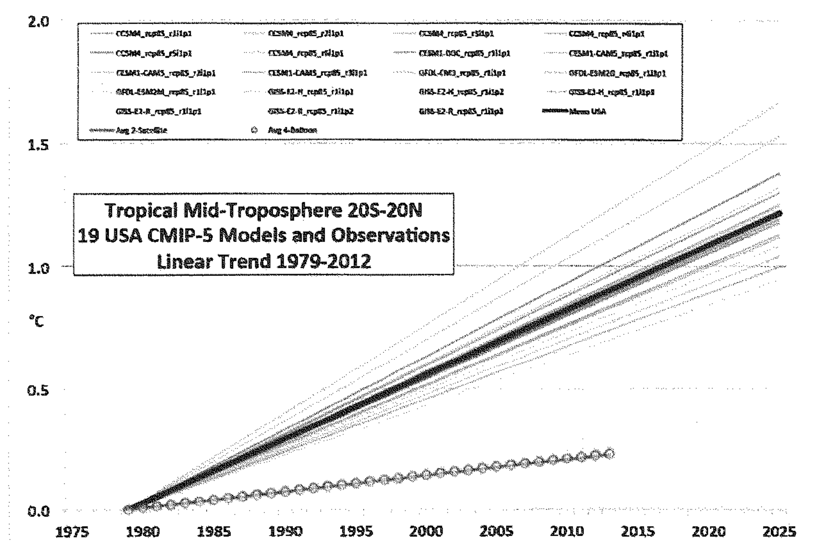
At the hearing, you agreed to look into this issue further.[7] Also, in his questions for the record, Senator Sessions asked you again: "Will you provide me with data showing actual global average temperatures since 1979 versus IPCC predictions, as was requested in my letter?"

On April 30, 2013, you responded to Senator Sessions. Yet, instead of providing the requested analysis including a chart showing official predictions versus actual global temperatures, you simply stated that "EPA has not produced its own analysis, but we expect a definitive comparison in the forthcoming [International Panel on Climate Change] Fifth Assessment Report." This is unacceptable. Unlike EPA, the IPCC is an international body

[7] Confirmation Hearing Transcript at pg. 134.

outside the jurisdiction and control of the United States Congress. Moreover, EPA is the entity of the U.S. government that is seeking to regulate virtually all economic activities on the basis that greenhouse gases are causing temperatures to increase to the extent previously predicted by the IPCC.

It was equally unacceptable for you to answer congressional requests for EPA data by referring members, as you did, to a short paper (Rahmstorf et al. 2012)[8] published in an on-line journal where the editor-in-chief is also the "coordinating lead author"[9] for the IPCC—the same IPCC that published the climate models that vastly over-predicted actual global temperature increases. In light of the actual temperature data, we find it remarkable that EPA would—without conducting its own analysis—endorse that paper's dubious finding that "global temperature continues to increase in good agreement with the best estimates of the IPCC"—a view that appears to be contrary to the actual data and facts. This is shown by a comprehensive comparison of climate models used by the IPCC, which is reflected in the following chart:[10]



[8] http://iopscience.iop.org/1748-9326/7/4/044035/article. It is also noteworthy that this paper was published on November 27, 2012—almost two weeks *after* the President stated that "the temperature around the globe is increasing faster than was predicted even 10 years ago."

[9] http://kammen.berkeley.edu//

[10] Prepared by Dr. John Christy, Distinguished Professor, Atmospheric Science, University of Alabama in Huntsville.

As you recently acknowledged, "sound science and transparency" are among "EPA's core values" that must "guide all EPA action."[11] We agree, and as Members of the Senate Committee with oversight responsibility for these matters, we are perplexed that EPA would refuse to be transparent in this instance and would refuse to follow sound science by not already completing this simple comparative analysis. The American public should be deeply troubled to learn that EPA is actively working to increase energy prices based on predicted global temperature increases without, first, undertaking efforts to determine if temperatures are actually increasing to the extent predicted by the climate models. This refusal to provide reasonable data requested by Members of Congress comes on the heels of a report by your Inspector General highly critical of EPA's review of external data for the endangerment finding.[12]

Astoundingly, the President repeated his incorrect assertion again on May 29, 2013, when he stated, "We also know that the climate is warming faster than anybody anticipated five or 10 years ago."[13] The President's assertions appear to have been made in concert with the efforts of affiliated groups who are supporting the Administration's efforts to impose expensive new mandates on American energy production and use. For instance, *Huffington Post* recently reported:

> Organizing for Action, the advocacy arm pushing the Obama administration's agenda, will begin its next big policy push on Thursday with a focus on climate change. The group, which was formed using the 2012 Obama campaign's machinery, will begin what organizers view as a potential multi-year effort to lay the groundwork for legislative action on climate change.[14]

Last week, it was widely reported that the President is preparing to announce a series of enormously expensive new regulations and executive actions aimed at addressing concerns with rising global temperatures, including greenhouse gas emission limitations for existing power plants. According to the New York Times, "administration officials signaled that Mr. Obama had decided the risks from climate change outweighed the potential economic and political costs from taking steps to address it."[15] We are alarmed that such an effort would be undertaken when the executive branch will not provide relevant information in an open and transparent manner. The Agency's actions must use only the best available science and any efforts must reflect actual, verified data and be based on proven models shown to produce sound predictions.

Accordingly, we would respectfully ask you to provide within 30 days of the date of this letter the supporting data and analysis relied upon by the President showing actual global average temperatures since 1979 versus IPCC predictions, as was requested in Senator Sessions' December 2012 letter and again during your nomination hearing to lead the Agency. This should include an EPA-produced chart comparing actual global average temperature increases since 1979 (when satellite temperature data became available) versus the latest IPCC predictions.

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[11] McCarthy Response to Sessions QFR #7.

[12] EPA Office of Inspector General, *Procedural Review of EPA's Greenhouse Gases Endangerment Finding Data Quality Processes* (Sept. 26, 2011), available at http://www.epa.gov/oig/reports/2011/20110926-11-P-0702.pdf.

[13] http://www.whitehouse.gov/the-press-office/2013/05/30/remarks-president-dccc-event

[14] http://www.huffingtonpost.com/2013/04/25/ofa-climate-change_n_3150383.html?1366884102

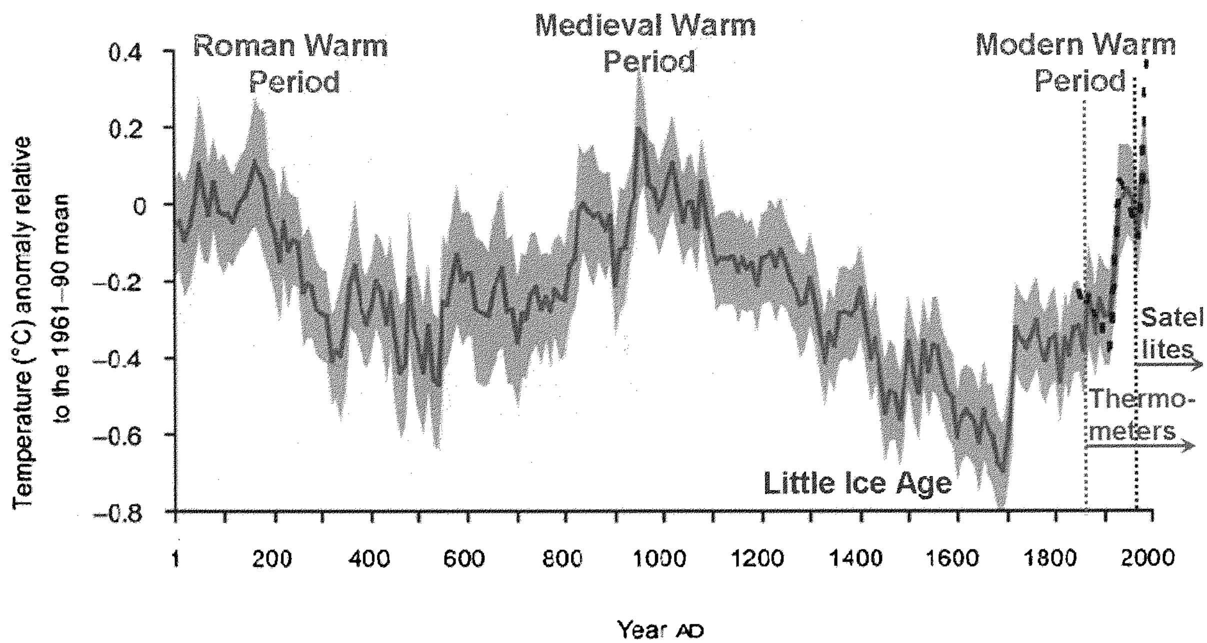
[15] http://www.nytimes.com/2013/06/20/science/earth/obama-preparing-big-effort-to-curb-climate-change.html?hp&_r=0

Your prompt attention to this important matter is greatly appreciated.

Sincerely,

David Vitter U.S. Senator	Jeff Sessions U.S. Senator
James Inhofe U.S. Senator	Roger Wicker U.S. Senator
Deb Fischer U.S. Senator	John Boozman U.S. Senator
John Barrasso U.S. Senator	Mike Crapo U.S. Senator

Temperature Reconstruction* for N. Hemisphere, 1 - 2000 AD
Shows Modern Warm Period Not Exceptional



*Ljungqvist, F.C. 2010. A new reconstruction of temperature variability in the extra-tropical Northern Hemisphere during the last two millennia. Geografiska Annaler: Physical Geography, Vol. 92 A(3), pp. 339-351, September 2010. DOI: 10.1111/j.1468-0459.2010.00399.x

GALLUP

June 28, 2013

Americans Say Economy Is Top Worry for Nation's Future

Federal debt ranks as second-most common worry

by Alyssa Brown

WASHINGTON, D.C. -- Economic issues dominate Americans' concerns about the nation's future. Americans say the economy (17%) is their greatest worry or concern for the future of the United States, followed by the federal debt (11%). Five percent or more also mention jobs and international wars and conflicts.

Looking ahead, what is your greatest worry or concern about the future of the United States? [OPEN-ENDED]

	June 20-24, 2013
	%
The economy	17
Debt/Deficit/Nation's finances	11
Employment/Jobs	6
Wars/Conflicts in other countries	5
Government not working for betterment of the people	4
Healthcare/Cost of healthcare	4
Country is getting worse/Won't get better	4
Losing freedom/Civil liberties	4
National security/Defense	3
Government overreach/power	3
Education/Cost of education	3
Elderly care/Medicare/Social Security	2
Immigration/Border control	2
Decline of religion, morality	2
Becoming a socialist country	2
Poor leadership/President Obama	2
What future will be like for today's children	2
Gap between rich and poor	2

Note: Issues mentioned by 1% or fewer not shown

GALLUP

These findings, collected June 20-24, indicate that Americans think economic issues will be the biggest concern for the future, even as the economy shows some positive signs of recovery.

Americans' concerns for the nation's future are generally similar to their current worries. In a separate Gallup poll conducted June 1-4, Americans said the economy is the most important problem facing the country today, followed by jobs or unemployment.

After economic issues, Americans frequently mention war and conflicts in other countries as their top worry, with 5% saying so. Americans' involvement in the civil war in Syria and recent escalating tension with North Korea are likely driving this concern.

Healthcare or cost of healthcare and losing freedom or civil liberties also rank toward the top of the list of Americans' concerns for the nation's future, likely reflecting Americans' worries about the impact of the Affordable Care Act and disapproval of the federal government's surveillance of Internet and telephone communication. Fewer mention terrorism -- which the federal government cites as the reason for its surveillance of communications -- with 1% saying it is their greatest concern.

More Republicans Than Democrats Mention Federal Debt as Top Worry

Republicans and Republican leaners are as likely as Democrats and Democratic leaners to mention the economy as their biggest worry for the future. However, Republicans are much more likely than Democrats to say the federal debt is their top concern, 15% vs. 6%. Slightly more Democrats than Republicans mention jobs and wars as their greatest worry.

Americans' Top Worry for the Future of the U.S., by Party Identification

	Republican/ Republican leaners	Democrat/Democratic Leaners
	%	%
The economy	18	19
Debt/Deficit/Nation's finances	15	6
Employment/Jobs	5	9
Wars/Conflicts in other countries	3	7

June 20-24, 2013

GALLUP

Americans' Top Worries Consistent Across Age Groups

Americans' top worries for the nation's future remain consistent across age groups, with tbe economy as the most often cited concern, followed by the federal deficit. Employment and jobs ranks third on the list for all age groups, except for those aged 65 or older, who are more likely to cite war as a top concern.

Younger Americans will likely bear the burden of the federal debt in the future, but they are about as likely as those in older age groups to cite the federal debt as a top worry for the nation's future.

Americans' Top Worry for the Future of the U.S., by Age

	18 to 29	30 to 49	50 to 64	65+
	%	%	%	%
The economy	17	23	14	13
Debt/Deficit/Nation's finances	12	9	11	10
Employment/Jobs	7	8	5	4
Wars/Conflicts in other countries	5	3	4	8

June 20-24, 2013

GALLUP

Bottom Line

More Americans say the economy, in general, is their biggest concern for nation's future than any other issue, followed by the federal debt and johs. Americans' top worries for the future are in line with what they mention as the most important problems facing the country today. These concerns are consistent with Americans being slightly more pessimistic than optimistic in their economic outlook, as well as sluggish economic growth and stubborn unemployment rates.

Survey Methods

Results for this Gallup poll are based on telephone interviews conducted June 20-24, 2013, with a random sample of 2,048 adults, aged 18 and older, living in all 50 U.S. states and the District of Columbia.

For results based on the total sample of national adults, one can say with 95% confidence that the margin of sampling error is ±3 percentage points.

Interviews are conducted with respondents on landline telephones and cellular phones, with interviews conducted in Spanish for respondents who are primarily Spanish-speaking. Each sample of national adults includes a minimum quota of 50% cellphone respondents and 50% landline respondents, with additional minimum quotas by region. Landline and cell telephone numbers are selected using random-digit-dial methods. Landline respondents are chosen at random within each household on the basis of which member had the most recent birthday.

Samples are weighted to correct for unequal selection probability, nonresponse, and double coverage of landline and cell users in the two sampling frames. They are also weighted to match the national demographics of gender, age, race, Hispanic ethnicity, education, region, population density, and phone status (cellphone only/landline only/both, and cellphone mostly). Demographic weighting targets are based on the March 2012 Current Population Survey figures for the aged 18 and older U.S. population. Phone status targets are based on the July-December 2011 National Health Interview Survey. Population density targets are based on the 2010 census. All reported margins of sampling error include the computed design effects for weighting.

In addition to sampling error, question wording and practical difficulties in conducting surveys can introduce error or bias into the findings of public opinion polls.

View methodology, full question results, and trend data

For more details on Gallup's polling methodology, visit www.gallup.com.

Back to Top

GALLUP NEWS SERVICE

JUNE WAVE 2

-- FINAL TOPLINE --

Timberline: 937008
H: 639
Princeton Job #: 13-06-009

Jeff Jones, Lydia Saad
June 20-24, 2013

Results are based on telephone interviews conducted June 20-24, 2013 with a random sample of –2,048—adults, aged 18+, living in all 50 U.S. states and the District of Columbia. For results based on these samples of national adults, one can say with 95% confidence that the margin of error is ±3 percentage points.

For results based on the samples of –1,039—national adults in Form A and –1,009—national adults in Form B, the margin of sampling error is ±4 percentage points.

For results based on the sample of –234—adults who do not have health insurance, the margin of sampling error is ±8 percentage points.

Interviews are conducted with respondents on landline telephones and cellular phones, with interviews conducted in Spanish for respondents who are primarily Spanish-speaking. Each sample of national adults includes a minimum quota of 50% cell phone respondents and 50% landline respondents, with additional minimum quotas by region. Landline and cell phone telephone numbers are selected using random digit dial methods. Landline respondents are chosen at random within each household on the basis of which member had the most recent birthday.

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In addition to sampling error, question wording and practical difficulties in conducting surveys can introduce error or bias into the findings of public opinion polls.

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3. Looking ahead, what is your greatest worry or concern about the future of the United States? *[OPEN-ENDED]*

	2013 Jun 20-24
The economy	17
Debt/Deficit/Nation's finances	11
Employment/Jobs	6
Wars/Conflicts in other countries	5
Government not working for betterment of the people	4
Healthcare/Cost of healthcare	4
Country is getting worse/Won't get better	4
Losing freedom/Civil liberties	4
National security/Defense	3
Government overreach/power	3
Education/Cost of education	3
Elderly care/Medicare/Social Security	2
Immigration/Border control	2
Decline of religion, morality	2
Becoming a socialist country	2
Poor leadership/President Obama	2
What future will be like for today's children	2
Gap between rich and poor	2
Global warming/Environmental issues	1
Americans standing together/supporting the country	1
Upcoming election/new leadership	1
Foreign affairs/Foreign policy	1
Gun violence/Gun control	1
China/Debt owed to China	1
Terrorism	1
Poverty/Helping poor, needy	1
Natural resources/Energy/Gas	1
Welfare/Entitlement	1
Cost of living/inflation	1
Crime/Violence	1
Nuclear weapons/war	1
Other	3
Nothing	3
No opinion	3

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BUREAU OF LABOR STATISTICS
U.S. DEPARTMENT OF LABOR

NEWS RELEASE

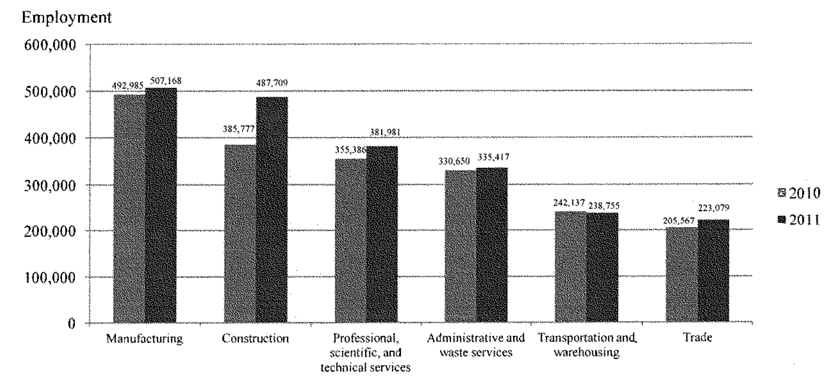
For release 10:00 a.m. (EDT) Tuesday, March 19, 2013 USDL-13-0476

Technical information: (202) 691-5185 • GGSInfo@bls.gov • www.bls.gov/ggs
Media contact: (202) 691-5902 • PressOffice@bls.gov

EMPLOYMENT IN GREEN GOODS AND SERVICES – 2011

In 2011, the percentage of total employment associated with the production of Green Goods and Services (GGS) increased by 0.1 percentage point to 2.6 percent, the U.S. Bureau of Labor Statistics reported today. The number of GGS jobs increased by 157,746 to 3,401,279. GGS employment accounted for 2.3 percent of private sector jobs and 4.2 percent of public sector jobs in 2011. The private sector had 2,515,200 GGS jobs, while the public sector had 886,080 GGS jobs. Among private sector industries, construction had the largest employment rate increase, from 7.0 to 8.9 percentage points, while manufacturing had the most GGS jobs (507,168). (See table 1.) GGS jobs are found in businesses that primarily produce goods and provide services that benefit the environment or conserve natural resources.

Chart 1. Green goods and services private sector employment, 2010–11 annual averages



Green Goods and Services Industry Employment Data are Discontinued

On March 1, 2013, President Obama ordered into effect the across-the-board spending cuts (commonly referred to as sequestration) required by the Balanced Budget and Emergency Deficit Control Act, as amended. Under the order, the Bureau of Labor Statistics (BLS) must cut its current budget by more than $30 million, 5 percent of the current 2013 appropriation, by September 30, 2013. In order to achieve these savings and protect core programs, the BLS will eliminate two programs and all "measuring green jobs" products. These products include: data on employment by industry and occupation for businesses that produce green goods and services; data on the occupations and wages of jobs related to green technologies and practices; and green career information publications. This is the last scheduled release of new data on employment by industry for businesses that produce green goods and services.

Among the states, California had the largest number of GGS jobs (360,245), accounting for 2.5 percent of employment in the state. The District of Columbia had the highest proportion of GGS employment, at 5.1 percent; Oregon had the second highest proportion, at 4.3 percent. (See table 4.)

GGS employment data are compiled through the Green Goods and Services survey under the Quarterly Census of Employment and Wages (QCEW) program. The QCEW includes nearly all businesses with employees covered by state or federal unemployment insurance, which constitute approximately 95.7 percent of civilian wage and salary employment in the U.S. The GGS survey includes approximately 120,000 business and government establishments within 325 industries identified as potentially producing green goods or providing green services. Establishments in the survey report whether they produced green goods and services and the percentage of their revenue or employment associated with that output. Those percentages are multiplied by their employment to derive the number of GGS jobs for the establishment. More information about the survey is provided in the Technical Note.

Private Industry

The private sector had 2,515,200 GGS jobs in 2011, or 2.3 percent of private sector employment. (See tables A and 1.) Manufacturing had the largest number of GGS jobs (507,168) among all private industry sectors. These GGS jobs accounted for 4.3 percent of manufacturing employment. Examples of green goods and services produced by manufacturing industries include iron and steel from recycled inputs, air conditioning and refrigeration equipment meeting selected standards, hybrid cars and parts, and pollution mitigation equipment. (See table 3.)

Table A. GGS employment by private industry sector, 2010–11 annual averages

NAICS	Industry	2010 GGS employment	2011 GGS employment	Change in GGS employment, 2010-11
	Total, all private industries	2,342,562	2,515,200	172,638
11,21	Natural resources and mining	63,344	64,689	1,345
22	Utilities	69,031	71,129	2,098
23	Construction	385,777	487,709	101,932
31-33	Manufacturing	492,985	507,168	14,183
42,44-45	Trade	205,567	223,079	17,512
48-49	Transportation and warehousing	242,137	238,755	-3,382
51	Information	33,321	29,412	-3,909
52,53	Financial activities	462	475	13
54	Professional, scientific, and technical services	355,386	381,981	26,595
55	Management of companies and enterprises	62,630	69,310	6,680
56	Administrative and waste services	330,650	335,417	4,767
61,62	Education and health services	28,789	26,123	-2,666
71,72	Leisure and hospitality	20,642	23,696	3,054
81	Other services, except public administration	51,841	56,257	4,416

NOTE: Data may not add to total due to rounding.

Construction had 487,709 GGS jobs in 2011, comprising 8.9 percent of the sector's employment. The sector had the largest increase in GGS employment from 2010 to 2011, up 101,932, or 26.4 percent. Among the GGS activities performed within the sector are the construction of plants that produce energy from renewable sources and weatherizing and retrofitting projects that reduce household energy consumption.

The trade sector had 223,079 GGS jobs in 2011, accounting for 1.1 percent of the industry's employment. This sector's increase of 17,512 GGS jobs, or 8.5 percent over the year, was the second largest significant change in the private sector. Industries within the trade sector that have GGS output include recyclable material merchant wholesalers and used merchandise stores.

Leisure and hospitality services had 23,696 GGS jobs in 2011. GGS employment in leisure and hospitality grew by 3,054, or 14.8 percent over the year. Nature parks and botanical gardens are examples of GGS services within leisure and hospitality services.

In the transportation and warehousing sector, the number of GGS jobs decreased by 3,382 to 238,755, a decline of about 1.4 percent. Commuter rail systems and charter bus services are examples of GGS services within transportation and warehousing.

Utilities

Utilities had 71,129 GGS jobs in 2011, or 12.9 percent of total private utilities employment. The private utilities sector added 2,098 GGS jobs in 2011, a 3.0 percent increase. Among the industries involved in private sector electric power generation, nuclear electric power generation had the highest GGS employment, with 44,054 jobs in 2011. Hydroelectric power generation had the second largest GGS employment, with 3,780 GGS jobs. Wind electric power generation was third with 2,724 GGS jobs, followed by biomass electric power generation (1,166), geothermal electric power generation (1,017), and solar electric power generation (522). Other electric power generation had 525 GGS jobs in 2011. (See table 2 for public sector utilities data and table 3 for private sector utilities data.)

Government

The public sector had 886,080 GGS jobs in 2011, accounting for 4.2 percent of employment in the sector. Over the year, government GGS employment decreased by 14,890 (-1.7 percent). Local government had 424,201 GGS jobs in 2011, the most in the public sector, representing 3.1 percent of local government employment. The transportation and warehousing sector had the largest GGS employment in local government with 209,063 jobs. (See table 2.)

In 2011, state government had 248,539 GGS jobs, or 5.5 percent of state government employment. Public administration led GGS employment in state government with 164,952 GGS jobs. The enforcement of environmental regulations and the administration of environmental programs are examples of GGS services within public administration.

The federal government had 213,340 GGS jobs representing 7.5 percent of federal government employment in 2011. The public administration sector had 139,884 GGS jobs, the most within federal government. The professional, scientific, and technical services sector followed with 39,714 GGS jobs.

Geographic Detail

Ten states had over 100,000 GGS jobs in 2011: California (360,245), New York (266,308), Texas (227,532), Pennsylvania (167,397), Ohio (137,143), Illinois (136,447), Florida (117,433), North Carolina (108,094), Virginia (107,773), and Washington (101,593). (See table 4.)

The District of Columbia had the highest percentage of GGS total employment of any jurisdiction (5.1 percent) in 2011. Oregon had the next highest proportion of its employment in GGS jobs (4.3 percent). California experienced the largest increase in GGS employment, with an additional 17,366 GGS jobs, or 5.1 percent added, over the year. Maryland had the second largest increase in GGS employment, with 14,143 GGS jobs, or 18.3 percent added between 2010 and 2011.

GGS employment by percentage of revenue or employment from green goods and services

GGS employment is determined based on the percentage of revenue (or percentage of employment, in the absence of revenue) associated with the production of green goods and services. The GGS survey scope is defined as 325 6-digit NAICS industries that potentially produce green goods and services. Any establishment within that scope could fall into one of three categories: no revenue or employment from green goods or services, some revenue or employment from green goods or services, or all revenue or employment from green goods and services.

Table B. GGS employment level by green activity, 2010–11 annual averages

Revenue or employment from GGS	2010			2011		
	GGS in-scope employment[1]	GGS employment	Percent of GGS employment	GGS in-scope employment[1]	GGS employment	Percent of GGS employment
0%	17,696,984	0	0	17,497,369	0	0
0% < GGS < 100%	6,207,622	1,416,620	43.7	6,637,244	1,478,029	43.5
100%	1,826,913	1,826,913	56.3	1,923,251	1,923,251	56.5
Total	25,731,519	3,243,533	100.0	26,057,864	3,401,279	100.0

[1]GGS in-scope employment is the total employment within industries that potentially produce green goods or provide green services, based on the Quarterly Census of Employment and Wages.
NOTE: GGS data for 2010 have been revised to incorporate methodological changes as explained in the Technical Note. Please also note data may not add to total due to rounding.

In 2011, the majority (56.5 percent) of GGS employment was found in establishments that exclusively produced green goods and services; these establishments had 1,923,251 GGS jobs. Establishments that produced a mix of green and non-green goods and services had 1,478,029 GGS jobs in the same time period. Establishments that produced no green goods or services (i.e., no revenue or employment was associated with green goods and services in those establishments) accounted for 67.1 percent of employment within the GGS scope. (See table B.)

For More Information

The tables and charts included in this release contain data for the nation and for the 50 states and the District of Columbia. Data for 2011 green employment levels and percents for all states are provided in tables 4, 5, and 6 of this release. For additional information about the Green Goods and Services data, please read the Technical Note. Further information about the GGS data may be obtained by calling (202) 691-5185 or by accessing the GGS webpage at www.bls.gov/ggs.

Revisions to the Green Goods and Services Data

Effective with this release, the Bureau of Labor Statistics made improvements to the Green Goods and Services (GGS) estimation procedures. The estimates for 2010 have been revised to include these improvements. In addition, the 2010 GGS data have been revised to reflect the 2012 version of the North American Industry Classification System (NAICS). These revisions enable comparisons between GGS series from 2010 to those for 2011. For more information, please see the Technical Note and http://www.bls.gov/ggs/ggsoverview.htm#technote.

Technical Note

This release presents statistics from the Green Goods and Services program (GGS). GGS employment level and rate estimates are published by state, ownership, and industry. Data for GGS are collected and compiled by the Bureau of Labor Statistics from a sample of business and government establishments in selected industries with workers covered by state and federal unemployment insurance (UI) legislation provided by State Workforce Agencies (SWAs).

Collection

In an annual survey of business establishments, data are collected for employment, fiscal year, and the share of revenue or employment associated with production of green goods or services at the establishment level. Data collection methods include mail, computer-assisted telephone interviewing, web, and fax.

Coverage

BLS sampled from 325 North American Industrial Classification System (NAICS) industries identified as potential producers or providers of green goods and services. The GGS survey covers all private establishments in these industries, such as factories, offices, and stores, as well as federal, state, and local government entities in the 50 states and the District of Columbia.

Concepts

Green Goods and Services. Green goods and services are defined as goods and services produced by an establishment that benefit the environment or conserve natural resources. Green goods and services fall into one or more of the following five groups: (1) production of energy from renewable sources; (2) energy efficiency; (3) pollution reduction and removal, greenhouse gas reduction, and recycling and reuse; (4) natural resources conservation; and (5) environmental compliance, education and training, and public awareness.

Industry classification. The industry classifications in this release are in accordance with the 2012 version of the North American Industry Classification System (NAICS). Only the 325 industries identified by BLS as producing green goods and providing green services are included in the scope of the GGS survey. To ensure the highest possible quality of data, the Quarterly Census of Employment and Wages (QCEW) program verifies with employers and updates, if necessary, the NAICS code, location, and ownership classification of all establishments on a 3-year cycle. Changes in establishment characteristics resulting from the verification process are annually introduced into the GGS sampling frame.

Green Goods and Services jobs. GGS jobs are those associated with producing green goods or providing green services. Some businesses produce multiple products and services where one or more may be included in the BLS definition. For these cases, BLS determined from prior research that businesses often have difficulty providing employment associated with the production of green goods and services, while information on the revenue from the sale of the green goods or services is more readily available and less burdensome for the respondent to provide. The percentage of the establishment's revenue related to sale of green goods and services is used to estimate GGS jobs, which are defined as employment related to the production of green goods and services at the establishment level. Sampled establishments that do not generate revenue are asked to report the share of their employment involved with the production of green goods and services. For example, employment related to research and development, non-profit organizations, government agencies, and new businesses may provide green goods and services without generating income.

Employment. Employment includes persons on the payroll who worked or received pay for the pay period that includes the twelfth day of the reference month. Full-time, part-time, permanent, short-term, seasonal, salaried, and hourly employees are included, as are employees on paid vacations or other paid leave. Proprietors or partners of unincorporated businesses, unpaid family workers, or persons on leave without pay or on strike for the entire pay period, are not counted as employed. Employees of temporary help agencies, employee leasing companies, outside contractors, and consultants are counted by their employer of record, not by the establishment where they are working. The monthly employment figure provided by respondents will be compared to employment data BLS has on file as part of the QCEW program, which comprise BLS' business register, in order to verify that data are being collected for the correct establishment.

Estimates. Estimates of GGS employment and GGS percent of total QCEW employment are released with the annual GGS news release.

Sample and estimation methodology

Sample. BLS selects approximately 120,000 GGS establishments per year from the Quarterly Census of Employment and Wages (QCEW) program. This program includes all employers subject to state Unemployment Insurance (UI) laws and federal agencies subject to Unemployment Compensation for Federal Employees (UCFE). Most of these establishments are selected from the second quarter QCEW sample frame, while a small sample of new business establishments is selected from the fourth quarters. The sample is designed to estimate GGS employment at both national industry and state industry sector levels of detail.

The GGS sample is divided into three panels, each containing approximately 40,000 sample units. Two of the three panel samples overlap with the previous year's sample to produce estimates of change in green employment. A new sample is allocated and selected from the panel that does not overlap.

Estimation. A Horvitz-Thompson estimator is used to estimate GGS employment, based on an establishment's 12-month average employment over the reference period, percent of revenue or employment associated with green goods and services, and sampling weight. The 12-month average employment is obtained from corresponding QCEW files and is known for each sampled establishments.

GGS percentage estimates are relative to the QCEW employment of all industries contained within a particular estimation cell's NAICS code, not only the 325 industries included in the GGS scope. For GGS employment percentages, the estimate of GGS employment is divided by the 12-month average of QCEW employment over the reference period.

Reliability. GGS estimates are subject to both sampling and nonsampling error. Sampling error arises from selecting a sample of establishments rather than the entire business population. To measure this error, GGS uses a balanced repeated replication technique to calculate standard errors. Given the standard error for an estimate, an approximate 90 percent confidence interval can be constructed by adding and subtracting 1.645 times the standard error from the estimate.

The standard error of tbe estimated total GGS employment is approximately 34,000. The standard error of over the year change in total GGS employment is about 36,000.

The standard error of the estimated rate of GGS employment is approximately 0.03 percent. The standard error of over the year change in rate of GGS employment is about 0.03 percent.

Nonsampling error arises from various sources, such as establishments failing to respond or misreporting data, coding and data processing errors, and population coverage. Since GGS only samples establishments in 325 industries predetermined to potentially have GGS employment, any green goods and services produced or provided in other industries is not captured. GGS is also subject to errors in the sampling frame, in which some establishments' industry codes may be misclassified.

Specialized Procedures. GGS sampling methodology is coordinated with the Occupational Employment Statistics survey. Sampling overlap between the two surveys is maximized for additional inference to be made about green staffing patterns. Such inferences are not included as part of this GGS release.

Methodological changes

NAICS 2012 Conversion. The original survey estimates for 2010 were based on the 2007 NAICS classification. In that reference period, data were collected for industries defined in the GGS scope according to their NAICS classification at that time. The 2011 survey estimates are based on the 2012 NAICS classification, which impacted the scope of the GGS survey. Some private-ownership manufacturing indnstries that were not included in the 2010 GGS scope combined with in-scope industries. Thus, for 2011 estimates, some establishments that were previously out-of-scope are included in the survey. Revised 2010 estimates are based on the 2012 NAICS classification.

Imputation. Establishments that are sampled in both survey years but only report usable data for one year are imputed. Three methods are used to impute missing green percent values: hot deck imputation; overlays; and mean imputation.

Benchmarking. Benchmarking procedures were revised to incorporate ownership for both survey years.

For more information. For more detailed information on these methodological changes, please visit the Technical Note section of the GGS web page at www.bls.gov\ggs.

Other information

Information in this release will be made available to sensory impaired individuals upon request. Voice phone: (202) 691-5200; Federal Relay Service: (800) 877-8339.

Table 1. Green Goods and Services (GGS) employment by industry sector, annual averages

Industry	NAICS[1]	GGS employment[2]		GGS percent[3]		GGS employment change from: 2010 - 2011
		2010	2011	2010	2011	
Total, all industries		3,243,533	3,401,279	2.5	2.6	157,746
Total private		2,342,562	2,515,200	2.2	2.3	172,638
Natural resources and mining	11,21	63,344	64,689	3.5	3.4	1,345
Utilities	22	69,031	71,129	12.5	12.9	2,098
Construction	23	385,777	487,709	7.0	8.9	101,932
Manufacturing	31-33	492,985	507,168	4.3	4.3	14,183
Trade	42,44-45	205,567	223,079	1.0	1.1	17,512
Transportation and warehousing	48-49	242,137	238,755	6.1	5.9	-3,382
Information	51	33,321	29,412	1.2	1.1	-3,909
Financial activities	52,53	462	475	0.0	0.0	13
Professional, scientific, and technical services	54	355,386	381,981	4.8	5.0	26,595
Management of companies and enterprises	55	62,630	69,310	3.4	3.6	6,680
Administrative and waste services	56	330,650	335,417	4.5	4.3	4,767
Education and health services	61,62	28,789	26,123	0.2	0.1	-2,666
Leisure and hospitality	71,72	20,642	23,696	0.2	0.2	3,054
Other services, except public administration	81	51,841	56,257	1.2	1.3	4,416
Federal government		208,744	213,340	7.0	7.5	4,596
State government		256,224	248,539	5.6	5.5	-7,685
Local government		436,002	424,201	3.1	3.1	-11,801

1 North American Industry Classification System, 2012.

2 GGS employment is the number of jobs related to the production of Green Goods and Services.

3 GGS percent is the percentage of the GGS employment compared to the total employment. This value is derived by dividing the GGS employment by the total employment.

NOTE: GGS data for 2010 have been revised to incorporate methodological changes explained in the Technical Note. Please also note data may not add to total due to rounding.

Table 2. Green Goods and Services (GGS) employment by industry sector in government, annual averages

Industry	NAICS[1]	Federal government				State government				Local government			
		2010		2011		2010		2011		2010		2011	
		GGS employment[2]	GGS percent[3]	GGS employment[2]	GGS percent[3]	GGS employment[2]	GGS percent[3]	GGS employment[2]	GGS percent[3]	GGS employment[2]	GGS percent[3]	GGS employment[2]	GGS percent[3]
Total, all industries		208,744	7.0	213,340	7.5	256,224	5.6	248,539	5.5	436,002	3.1	424,201	3.1
Natural resources and mining	11,21	–[4]	–[4]	–[4]	–[4]	1,642	72.8	1,725	79.2	–[4]	–[4]	–[4]	–[4]
Utilities	22	7,931	58.7	7,218	52.0	–[4]	–[4]	–[4]	–[4]	98,990	40.8	93,644	38.9
Construction	23	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	1,242	1.2
Manufacturing	31-33	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]
Trade	42,44-45	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]
Transportation and warehousing	48-49	–[4]	–[4]	–[4]	–[4]	27,270	51.3	27,583	52.3	210,614	78.3	209,063	77.9
Information	51	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	516	7.4	4,099	3.2	3,644	2.8
Financial activities	52,53	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]
Professional, scientific, and technical services	54	38,445	54.1	39,714	55.1	1,760	9.0	–[4]	–[4]	968	5.2	1,131	6.1
Administrative and waste services	56	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	33,345	46.7	32,577	46.4
Education and health services	61,62	–[4]	–[4]	–[4]	–[4]	43,201	1.7	42,423	1.7	9,463	0.1	10,020	0.1
Leisure and hospitality	71,72	21,848	36.4	21,489	36.5	9,450	38.8	9,024	38.8	21,499	5.5	20,596	5.3
Other services, except public administration	81	–[4]	–[4]	–[4]	–[4]	–[4]	–[4]	228	7.3	3,011	6.6	2,873	6.5
Public administration	92	134,903	8.0	139,884	8.8	171,244	9.2	164,952	9.0	52,886	1.3	49,229	1.3

1 North American Industry Classification System, 2012.
2 GGS employment is the number of jobs related to the production of Green Goods and Services.
3 GGS percent is the percentage of the GGS employment compared to the total employment. This value is derived by dividing the GGS employment by the total employment.
4 Data do not meet BLS disclosure standards.

NOTE: GGS data for 2010 have been revised to incorporate methodological changes explained in the Technical Note. Please also note data may not add to total due to rounding.

Table 3. Green Goods and Services (GGS) private sector employment by detailed industry, annual averages

Industry	NAICS[1]	GGS employment[2] 2010	GGS employment[2] 2011	GGS percent[3] 2010	GGS percent[3] 2011	GGS employment change from: 2010 - 2011
Total private		2,342,562	2,515,200	2.2	2.3	172.638
Natural resources and mining	11,21	63.344	64,689	3.5	3.4	1.345
Crop production	111	36.703	36,796	6.9	6.9	93
Oilseed and grain farming	1111	3.934	4,775	9.3	10.6	841
Vegetable and melon farming	1112	10,045	10,701	10.7	11.3	656
Fruit and tree nut farming	1113	12,954	11,669	7.1	6.3	-1,285
Greenhouse and nursery production	1114	5,627	5,631	3.9	3.9	4
Other crop farming	1119	4,143	4.020	6.5	6.5	-123
Animal production and aquaculture	112	6,626	6,196	2.9	2.7	-430
Cattle ranching and farming	1121	3.800	3,421	2.9	2.5	-379
Hog and pig farming	1122	536	–[4]	1.9	–[4]	–
Poultry and egg production	1123	1.787	1,798	4.6	4.6	11
Sheep and goat farming	1124	–[4]	–[4]	–[4]	–[4]	–
Aquaculture	1125	382	426	6.5	7.5	44
Other animal production	1129	–[4]	–[4]	–[4]	–[4]	–
Forestry and logging	113	9.432	10.564	16.8	19.0	1.132
Timber tract operations	1131	1,061	1,292	29.7	35.6	231
Fnrest nursery and gathering forest products	1132	528	434	17.9	14.1	-94
Logging	1133	7.844	8,837	15.8	18.1	993
Agriculture and forestry support activities	115	10.583	11,133	3.2	3.3	550
Support activities for crop production	1151	5.395	5,761	1.9	2.0	366
Support activities for animal production	1152	–[4]	–[4]	–[4]	–[4]	–
Support activities for forestry	1153	–[4]	–[4]	–[4]	–[4]	–
Utilities	22	69.031	71,129	12.5	12.9	2,098
Utilities	221	69,031	71,129	12.5	12.9	2,098
Power generation and supply	2211	49.973	53.787	12.6	13.6	3,814
Electric power generation	22111	49.973	53.787	29.5	32.4	3.814
Hydroelectric power generation	221111	5.124	3,780	72.7	64.8	-1,344
Nuclear electric power generation	221113	39,818	44,054	75.7	83.6	4.236
Solar electric power generation	221114	–[5]	522	–[5]	97.9	–
Wind electric power generation	221115	–[5]	2,724	–[5]	91.7	–
Geothermal electric power generation	221116	–[5]	1,017	–[5]	96.9	–
Biomass electric power generation	221117	–[5]	1,166	–[5]	92.3	–
Other electric power generation	221118	–[5]	525	–[5]	65.8	–
Water, sewage and other systems	2213	19,058	17,342	40.8	37.0	-1,716
Water supply and irrigation systems	22131	11,995	10,248	32.0	27.2	-1,747
Sewage treatment facilities	22132	6,439	6,448	87.7	88.1	9
Steam and air-conditioning supply	22133	624	646	32.2	34.6	22
Construction	23	385,777	487,709	7.0	8.9	101,932
Construction of buildings	236	78,113	117,263	6.4	9.7	39,150
Residential building construction	2361	31,498	57,016	5.5	10.1	25,518
Nonresidential building construction	2362	46,615	60,247	7.2	9.3	13,632
Heavy and civil engineering construction	237	44,560	49,613	5.5	6.0	5,053
Utility system construction	2371	34,642	39,330	9.1	9.9	4,688
Land subdivision	2372	1,889	1.664	3.7	3.7	-225
Other heavy construction	2379	8,028	8,618	8.5	9.1	590
Specialty trade contractors	238	263.105	320,833	7.6	9.3	57,728
Building foundation and exterior contractors	2381	39,585	51,190	5.9	7.7	11,605
Building equipment contractors	2382	164,809	194,476	10.1	11.9	29,667
Building finishing contractors	2383	38.185	49.119	6.0	7.9	10,934
Other specialty trade contractors	2389	20.526	26,049	4.0	5.0	5.523
Manufacturing	31-33	492,985	507,168	4.3	4.3	14,183
Textile product mills	314	10.484	10,131	8.8	8.6	-353
Textile furnishings mills	3141	9,461[6]	9,271	16.5[6]	17.0	-190[6]
Other textile product mills	3149	1.023	859	1.7	1.4	-164
Wood product mfg	321	33,838	33.052	10.0	9.8	-786
Sawmills and wood preservation	3211	498	323	0.6	0.4	-175
Plywood and engineered wood product mfg	3212	6,545	6,840	10.4	11.2	295
Plywood and engineered wood product mfg	32121	6,545	6,840	10.4	11.2	295
Hardwood veneer and plywood mfg	321211	1,516	1,992	10.3	13.2	476
Softwood veneer and plywood mfg	321212	–[4]	658	–[4]	4.9	–
Engineered wood member mfg	321213	–[4]	345	–[4]	8.6	–
Truss mfg	321214	997	1,158	5.5	6.8	161

See footnotes at end of table.

Table 3. Green Goods and Services (GGS) private sector employment by detailed industry, annual averages — Continued

Industry	NAICS[1]	GGS employment[2] 2010	GGS employment[2] 2011	GGS percent[3] 2010	GGS percent[3] 2011	GGS employment change from: 2010 - 2011
Reconstituted wood product mfg.	321219	2,929	2,687	23.8	22.8	-242
Other wood product mfg.	3219	26,795	25,888	13.8	13.5	-907
Millwork	32191	20,839	21,970	22.7	24.9	1,131
Wood window and door mfg.	321911	18,055	19,041	40.1	44.8	986
Other millwork, including flooring	321918	2,783	2,928	7.9	8.6	145
All other wood product mfg.	32199	5,956	3,919	11.6	7.7	-2,037
Manufactured home, mobile home, mfg.	321991	3,803	2,114	19.9	11.7	-1,689
Prefabricated wood building mfg.	321992	2,154	1,805	10.1	14.2	-349
Paper mfg.	322	33,853	32,032	8.6	8.3	-1,821
Pulp, paper, and paperboard mills	3221	33,853	32,032	30.3	29.3	-1,821
Pulp mills	32211	1,208	1,078	20.3	18.0	-130
Paper mills	32212	19,669	18,167	25.9	24.5	-1,502
Paper, except newsprint, mills	322121	17,052	15,552	25.0	23.3	-1,500
Newsprint mills	322122	2,617	2,615	33.6	34.8	-2
Paperboard mills	32213	12,976	12,787	43.6	43.7	-189
Petroleum and coal products mfg.	324	3,244	3,278	2.9	3.0	34
Petroleum and coal products mfg.	3241	3,244	3,278	2.9	3.0	34
Chemical mfg.	325	23,124	24,733	2.9	3.2	1,609
Basic chemical mfg.	3251	10,600	10,842	7.5	7.6	242
Agricultural chemical mfg.	3253	639	518	1.8	1.4	-121
Paint, coating, and adhesive mfg.	3255	3,674	4,131	6.6	7.2	457
Paint and coating mfg.	32551	2,731	3,078	7.5	8.2	347
Adhesive mfg.	32552	943	1,053	4.9	5.3	110
Soap, cleaning compound, and toiletry mfg.	3256	2,228	2,601	2.2	2.6	373
Soap and cleaning compound mfg.	32561	2,228	2,601	4.3	5.0	373
Soap and other detergent mfg.	325611	674	806	2.8	3.4	132
Polish and other sanitation good mfg.	325612	1,553	1,795	6.8	7.7	242
Other chemical product and preparation mfg.	3259	5,983	6,641	7.1	7.8	658
Printing ink mfg.	32591	1,357	1,400	14.3	14.9	43
All other chemical preparation mfg.	32599	4,626	5,241	6.8	7.7	615
Custom compounding of purchased resins	325991	1,597	1,968	10.5	12.7	371
Other miscellaneous chemical product mfg.	325998	3,029	3,273	8.9	9.3	244
Plastics and rubber products mfg.	326	32,407	33,421	5.2	5.3	1,014
Plastics product mfg.	3261	27,768	28,660	5.5	5.7	892
Other plastics product mfg.	32619	27,768	28,660	10.2	10.5	892
Plastics plumbing fixture mfg.	326191	409	801	3.3	6.7	392
All other plastics product mfg.	326199	27,359[6]	27,860	10.6[6]	10.6	501[6]
Rubber product mfg.	3262	4,639	4,760	3.8	3.8	121
Tire mfg.	32621	3,008	3,221	5.8	6.0	213
Tire retreading	326212	3,008	3,221	45.4	46.4	213
Other rubber product mfg.	32629	1,631	1,539	3.4	3.0	-92
All other rubber product mfg.	326299	1,631	1,539	7.0	6.2	-92
Nonmetallic mineral product mfg.	327	29,710	29,885	8.1	8.2	175
Clay product and refractory mfg.	3271	4,878[6]	4,706	12.1[6]	11.6	-172[6]
Glass and glass product mfg.	3272	7,991	9,079	10.1	11.4	1,088
Cement and concrete product mfg.	3273	9,963	9,495	5.9	5.8	-468
Lime and gypsum product mfg.	3274	2,397	2,433	17.8	18.3	36
Other nonmetallic mineral products	3279	4,481	4,172	6.9	6.3	-309
All other nonmetallic mineral products mfg.	32799	4,481	4,172	8.0	7.4	-309
Mineral wool mfg.	327993	3,597	3,311	22.3	20.8	-286
Miscellaneous nonmetallic mineral products	327999	884	861	8.1	7.8	-23
Primary metal mfg.	331	64,859	63,292	18.0	16.3	-1,567
Iron and steel mills and ferroalloy mfg.	3311	37,831[6]	33,812	44.1[6]	36.9	-4,019[6]
Alumina and aluminum production	3313	8,316[6]	8,200	15.4[6]	14.4	-116[6]
Other nonferrous metal production	3314	9,788[6]	10,493	16.9[6]	17.2	705[6]
Foundries	3315	8,925	10,787	8.0	8.9	1,862
Fabricated metal product mfg.	332	31,476	30,310	2.5	2.3	-1,166
Forging and stamping	3321	1,565	1,527	1.8	1.6	-38
Architectural and structural metals mfg.	3323	21,720	21,792	6.8	6.6	72
Plate work and fabricated structural products	33231	9,508	9,124	6.5	6.0	-384
Fabricated structural metal mfg.	332312	9,508	9,124	12.4	11.5	-384
Ornamental and architectural metal products	33232	12,213	12,668	7.1	7.2	455
Metal window and door mfg.	332321	12,213	12,668	24.1	25.5	455
Other fabricated metal product mfg.	3329	8,190	6,991	3.3	2.8	-1,199

See footnotes at end of table.

Table 3. Green Goods and Services (GGS) private sector employment by detailed industry, annual averages — Continued

Industry	NAICS[1]	GGS employment[2]		GGS percent[3]		GGS employment change from: 2010 - 2011
		2010	2011	2010	2011	
Metal valve mfg.	33291	7,201	6,273	9.0	7.6	-928
Industrial valve mfg.	332911	3,597	3,579	15.5	14.8	-18
Plumbing fixture fitting and trim mfg.	332913	1,716	1,608	17.8	17.2	-108
Other metal valve and pipe fitting mfg.	332919	1,888	1,085	11.6	6.9	-803
All other fabricated metal product mfg.	33299	989	718	0.6	0.4	-271
Fabricated pipe and pipe fitting mfg.	332996	989	718	3.6	2.4	-271
Machinery mfg.	333	67,057	69,097	6.8	6.6	2,040
Ag., construction, and mining machinery mfg.	3331	–[4]	–[4]	–[4]	–[4]	–
Commercial and service industry machinery	3333	10,618[6]	10,577	11.5[6]	11.5	-41[6]
HVAC and commercial refrigeration equipment	3334	41,412	42,242	32.9	32.7	830
HVAC and commercial refrigeration equipment	33341	41,412	42,242	32.9	32.7	830
Fan, blower, air purification equipment mfg.	333413	8,502	9,000	32.5	32.9	498
Heating equipment, except warm air furnaces	333414	5,550	5,736	34.8	33.3	186
AC, refrigeration, and forced air heating	333415	27,360	27,507	32.7	32.5	147
Metalworking machinery mfg.	3335	–[4]	–[4]	–[4]	–[4]	–
Turbine and power transmission equipment mfg.	3336	14,328	15,540	15.7	15.7	1,212
Turbine and power transmission equipment mfg.	33361	14,328	15,540	15.7	15.7	1,212
Turbine and turbine generator set units mfg.	333611	13,400	14,439	50.3	49.7	1,039
Engine and power transmission equipment mfg., excl. turbine mfg.	333612,3	928	1,100	3.8	4.1	172
Computer and electronic product mfg.	334	65,759	74,105	6.0	6.7	8,346
Computer and peripheral equipment mfg.	3341	23,706	24,723	14.9	15.7	1,017
Communications equipment mfg.	3342	2,827	2,688	2.4	2.3	-139
Audio and video equipment mfg.	3343	628	770	3.1	3.9	142
Semiconductor and electronic component mfg.	3344	22,491	27,454	6.1	7.2	4,963
Electronic instrument mfg.	3345	16,107	18,470	4.0	4.6	2,363
Electronic instrument mfg.	33451	16,107	18,470	4.0	4.6	2,363
Automatic environmental control mfg.	334512	2,310	2,515	12.7	14.0	205
Industrial process variable instruments	334513	4,584	5,528	8.2	9.5	944
Totalizing fluid meters and counting devices	334514	2,488	3,302	23.0	30.0	814
Electricity and signal testing instruments	334515	2,736	3,015	6.8	7.2	279
Analytical laboratory instrument mfg.	334516	1,813	1,764	5.9	5.6	-49
Other measuring and controlling device mfg.	334519	2,176[6]	2,346	6.6[6]	7.1	170[6]
Electrical equipment and appliance mfg.	335	41,865	45,998	11.8	12.6	4,133
Electric lighting equipment mfg.	3351	11,214	13,030	24.8	28.9	1,816
Electric lamp bulb and part mfg.	33511	3,844	4,058	42.4	45.5	214
Lighting fixture mfg.	33512	7,371	8,971	20.4	24.7	1,600
Residential electric lighting fixture mfg.	335121	885	956	10.8	11.9	71
Nonresidential electric lighting fixture mfg.	335122	4,618	5,726	24.2	29.7	1,108
Other lighting equipment mfg.	335129	1,868	2,289	21.0	25.8	421
Household appliance mfg.	3352	13,879	14,859	23.7	26.4	980
Small electrical appliance mfg.	33521	–[4]	–[4]	–[4]	–[4]	–
Major appliance mfg.	33522	–[4]	–[4]	–[4]	–[4]	–
Household cooking appliance mfg.	335221	–[4]	–[4]	–[4]	–[4]	–
Household refrigerator and home freezer mfg.	335222	–[4]	3,443	–[4]	25.8	–
Household laundry equipment mfg.	335224	–[4]	–[4]	–[4]	–[4]	–
Other major household appliance mfg.	335228	–[4]	–[4]	–[4]	–[4]	–
Electrical equipment mfg.	3353	8,036	9,222	6.0	6.7	1,186
Electrical equipment mfg.	33531	8,036	9,222	6.0	6.7	1,186
Electric power and specialty transformer mfg.	335311	3,979	4,328	16.6	18.0	349
Motor and generator mfg.	335312	4,057	4,894	10.5	12.3	837
Other electrical equipment and component mfg.	3359	8,736	8,887	7.4	7.1	151
Battery mfg.	33591	4,590	4,642	19.1	17.7	52
Storage battery mfg.	335911	–[4]	–[4]	–[4]	–[4]	–
Primary battery mfg.	335912	–[4]	–[4]	–[4]	–[4]	–
Other electrical equipment and component mfg.	33599	4,147	4,245	12.5	12.0	98
Miscellaneous electrical equipment mfg.	335999	4,147	4,245	15.7	15.2	98
Transportation equipment mfg.	336	43,243	45,367	3.3	3.3	2,124
Motor vehicle mfg.	3361	12,740	11,888	8.3	7.4	-852
Motor vehicle parts mfg.	3363	22,615[6]	25,490	5.4[6]	5.7	2,875[6]
Railroad rolling stock mfg.	3365	–[4]	–[4]	–[4]	–[4]	–
Ship and boat building	3366	–[4]	–[4]	–[4]	–[4]	–
Furniture and related product mfg.	337	12,066	12,469	3.4	3.6	403
Office furniture and fixtures mfg.	3372	9,585	9,779	10.0	10.0	194

See footnotes at end of table.

Table 3. Green Goods and Services (GGS) private sector employment by detailed industry, annual averages — Continued

Industry	NAICS[1]	GGS employment[2]		GGS percent[3]		GGS employment change from:
		2010	2011	2010	2011	2010 - 2011
Other furniture related product mfg	3379	2,481	2,690	6.8	7.6	209
Trade	42,44-45	205,567	223,079	1.0	1.1	17,512
Merchant wholesalers, durable goods	423	94,916	104,913	3.5	3.8	9,997
Misc. durable goods merchant wholesalers	4239	94,916	104,913	34.4	36.1	9,997
Miscellaneous store retailers	453	110,651	118,166	14.3	15.2	7,515
Used merchandise stores	4533	110,651	118,166	88.2	88.7	7,515
Transportation and warehousing	48-49	242,137	238,755	6.1	5.9	-3,382
Water transportation	483	2,393	2,180	3.8	3.4	-213
Sea, coastal, and Great Lakes transportation	4831	1,751	1,586	4.7	4.1	-165
Inland water transportation	4832	642	595	2.6	2.4	-47
Transit and ground passenger transportation	485	239,744	236,574	57.2	55.0	-3,170
Urban transit systems	4851	34,935	34,956	84.7	84.5	21
Interurban and rural bus transportation	4852	11,528	11,494	62.7	62.5	-34
School and employee bus transportation	4854	167,924	166,916	91.9	90.9	-1,008
Charter bus industry	4855	17,326	15,194	58.4	50.2	-2,132
Other ground passenger transportation	4859	8,030	8,014	10.1	9.5	-16
Information	51	33,321	29,412	1.2	1.1	-3,909
Publishing industries, except Internet	511	22,355	21,160	3.0	2.8	-1,195
Newspaper, book, and directory publishers	5111	12,118	11,025	2.4	2.3	-1,093
Software publishers	5112	10,237	10,135	4.0	3.8	-102
Motion picture and sound recording industries	512	–[4]	–[4]	–[4]	–[4]	–
Motion picture and video industries	5121	–[4]	–[4]	–[4]	–[4]	–
Broadcasting, except Internet	515	7,525	5,352	2.6	1.9	-2,173
Radio and television broadcasting	5151	–[4]	–[4]	–[4]	–[4]	–
Cable and other subscription programming	5152	–[4]	–[4]	–[4]	–[4]	–
Other information services	519	–[4]	–[4]	–[4]	–[4]	–
Other information services	5191	–[4]	–[4]	–[4]	–[4]	–
Financial activities	52,53	462	475	0.0	0.0	13
Securities, commodity contracts, investments	523	462	475	0.1	0.1	13
Professional and Technical Services	54	355,386	381,981	4.8	5.0	26,595
Professional and technical services	541	355,386	381,981	4.8	5.0	26,595
Legal services	5411	–[4]	–[4]	–[4]	–[4]	–
Architectural and engineering services	5413	184,628	192,393	14.4	14.9	7,765
Engineering services	54133	113,031	122,619	13.0	14.0	9,588
Architectural and related services excl. engineering services	54131,2,5,6,7,8	71,597	69,774	17.7	17.0	-1,823
Specialized design services	5414	3,088	3,077	2.7	2.7	-11
Computer systems design and related services	5415	54,792	67,348	3.8	4.4	12,556
Management and technical consulting services	5416	68,476	72,121	6.8	6.7	3,645
Scientific research and development services	5417	36,949	39,590	6.0	6.3	2,641
Research and development in the physical, engineering, and life sciences	54171	36,949	39,590	6.6	6.9	2,641
Physical, engineering and biological research	541711	3,680	3,884	2.7	2.8	204
Other physical and biological research	541712	33,268	35,706	7.8	8.2	2,438
Advertising, PR, and related services	5418	–[4]	–[4]	–[4]	–[4]	–
Other professional and technical services	5419	–[4]	–[4]	–[4]	–[4]	–
Management of companies and enterprises	55	62,630	69,310	3.4	3.6	6,680
Management of companies and enterprises	551	62,630	69,310	3.4	3.6	6,680
Management of companies and enterprises	5511	62,630	69,310	3.4	3.6	6,680
Administrative and waste services	56	330,650	335,417	4.5	4.3	4,767
Administrative and support services	561	24,963	20,440	0.4	0.3	-4,523
Travel arrangement and reservation services	5615	405	537	0.2	0.3	132
Services to buildings and dwellings	5617	24,557	19,903	1.4	1.1	-4,654
Waste management and remediation services	562	305,688	314,977	85.9	86.6	9,289
Waste collection	5621	124,712	131,048	89.8	90.1	6,336
Waste treatment and disposal	5622	89,090	87,951	93.2	93.1	-1,139
Waste treatment and disposal	56221	89,090	87,951	93.2	93.1	-1,139
Hazardous waste treatment and disposal	562211	35,287	34,211	94.6	93.4	-1,076
Solid waste landfill	562212	35,485	35,039	94.0	93.2	-446
Solid waste combustors and incinerators	562213	5,854	5,555	95.2	96.8	-299
Other nonhazardous waste disposal	562219	12,465	13,146	86.7	90.6	681
Remediation and other waste services	5629	91,886	95,979	75.6	77.6	4,093
Remediation services	56291	57,474	58,251	75.5	75.9	777

See footnotes at end of table.

Table 3. Green Goods and Services (GGS) private sector employment by detailed industry, annual averages — Continued

Industry	NAICS[1]	GGS employment[2]		GGS percent[3]		GGS employment change from: 2010 - 2011
		2010	2011	2010	2011	
Materials recovery facilities	56292	11,219	12,474	90.6	93.0	1,255
All other waste management services	56299	23,193	25,254	70.3	75.3	2,061
Septic tank and related services	562991	14,395	15,994	73.6	81.0	1,599
Miscellaneous waste management services	562998	8,798	9,260	65.5	67.2	462
Education and health services	61,62	28,789	26,123	0.2	0.1	-2,666
Educational services	611	28,789	26,123	1.2	1.0	-2,666
Leisure and hospitality	71,72	20,642	23,696	0.2	0.2	3,054
Museums, historical sites, zoos, and parks	712	20,642	23,696	16.2	18.1	3,054
Museums, historical sites, zoos, and parks	7121	20,642	23,696	16.2	18.1	3,054
Other services, except public administration	81	51,841	56,257	1.2	1.3	4,416
Repair and maintenance	811	21,134	22,100	1.9	1.9	966
Automotive repair and maintenance	8111	7,757	6,652	1.0	0.8	-1,105
Electronic equipment repair and maintenance	8112	5,247	4,857	5.4	4.9	-390
Commercial machinery repair and maintenance	8113	5,319	7,200	3.1	3.9	1,881
Household goods repair and maintenance	8114	2,811	3,391	4.2	5.0	580
Membership associations and organizations	813	30,707	34,157	2.3	2.6	3,450
Grantmaking and giving services	8132	2,817	3,662	2.3	2.9	845
Social advocacy organizations	8133	20,277	20,800	10.6	10.7	523
Professional and similar organizations	8139	7,613	9,695	1.8	2.3	2,082

1 North American Industry Classification System, 2012.
2 GGS employment is the number of jobs related to the production of Green Goods and Services. This table reflects private ownership only.
3 GGS percent is the percentage of the GGS employment compared to the total employment. This value is derived by dividing the GGS employment by the total employment.
4 Data do not meet BLS disclosure standards.
5 Estimate cannot be created due to the conversion from NAICS 2007 to NAICS 2012.
6 The 2012 NAICS conversion changed the GGS scope for this industry. BLS utilized backcasting to make the 2010 and 2011 estimates comparable. See the extended technical note for more detail.

NOTE: GGS data for 2010 have been revised to incorporate methodological changes explained in the Technical Note. Please also note data may not add to total due to rounding.

Table 4. Green Goods and Services (GGS) employment by state, annual averages

State	Total, all ownerships					Private ownership				
	2010		2011		GGS employment change from: 2010 - 2011	2010		2011		GGS employment change from: 2010 - 2011
	GGS employment[1]	GGS percent[2]	GGS employment[1]	GGS percent[2]		GGS employment[1]	GGS percent[2]	GGS employment[1]	GGS percent[2]	
United States	3,243,533	2.5	3,401,279	2.6	157,746	2,342,562	2.2	2,515,200	2.3	172,638
Alabama	51,372	2.8	54,077	3.0	2,705	36,215	2.5	39,703	2.7	3,488
Alaska	11,999	3.8	12,119	3.8	120	5,591	2.4	5,893	2.4	302
Arizona	43,161	1.8	48,851	2.1	5,690	33,181	1.7	39,535	2.0	6,354
Arkansas	32,311	2.8	33,420	2.9	1,109	24,509	2.6	26,351	2.8	1,842
California	342,879	2.4	360,245	2.5	17,366	239,416	2.0	268,486	2.2	29,070
Colorado	72,657	3.3	72,629	3.3	-28	53,895	3.0	52,859	2.9	-1,036
Connecticut	41,385	2.6	43,722	2.7	2,337	34,397	2.5	36,577	2.7	2,180
Delaware	8,973	2.2	9,872	2.4	899	6,440	1.9	7,331	2.1	891
District of Columbia	33,742	4.9	35,799	5.1	2,057	10,570	2.4	11,115	2.4	545
Florida	108,948	1.5	117,433	1.6	8,485	93,160	1.5	98,249	1.6	5,089
Georgia	79,680	2.1	84,356	2.2	4,676	58,987	1.9	64,205	2.0	5,218
Hawaii	15,528	2.6	17,596	3.0	2,068	9,483	2.0	11,425	2.4	1,942
Idaho	23,676	3.9	24,250	4.0	574	14,515	2.9	15,138	3.0	623
Illinois	134,153	2.4	136,447	2.5	2,294	103,244	2.2	105,751	2.2	2,507
Indiana	68,108	2.5	70,156	2.5	2,048	58,720	2.5	61,159	2.6	2,439
Iowa	40,540	2.8	43,791	3.0	3,251	32,946	2.7	35,879	2.9	2,933
Kansas	26,339	2.0	25,632	2.0	-707	19,126	1.8	19,097	1.8	-29
Kentucky	40,726	2.4	43,027	2.5	2,301	27,729	2.0	28,770	2.0	1,041
Louisiana	43,808	2.4	44,373	2.4	565	32,970	2.2	33,328	2.2	358
Maine	15,352	2.7	16,951	2.9	1,599	11,166	2.3	12,680	2.6	1,514
Maryland	77,346	3.2	91,489	3.7	14,143	50,880	2.6	63,638	3.2	12,758
Massachusetts	84,198	2.7	88,924	2.8	4,726	70,720	2.6	75,071	2.7	4,351
Michigan	85,228	2.3	82,644	2.1	-2,584	71,473	2.2	69,116	2.1	-2,357
Minnesota	78,709	3.1	75,302	2.9	-3,407	62,545	2.9	60,509	2.7	-2,036
Mississippi	21,167	2.0	21,933	2.0	766	14,780	1.8	16,114	1.9	1,334
Missouri	65,271	2.5	68,534	2.7	3,263	42,093	2.0	46,625	2.2	4,532
Montana	14,596	3.5	14,306	3.4	-290	8,709	2.6	8,211	2.4	-498
Nebraska	20,896	2.3	22,392	2.5	1,496	14,640	2.0	16,491	2.2	1,851
Nevada	21,360	1.9	21,861	2.0	501	13,676	1.4	15,569	1.6	1,893
New Hampshire	14,011	2.3	16,244	2.7	2,233	12,309	2.4	14,471	2.8	2,162
New Jersey	73,411	2.0	81,018	2.2	7,607	53,449	1.7	61,160	1.9	7,711
New Mexico	22,884	2.9	24,337	3.1	1,453	14,208	2.4	15,481	2.6	1,273
New York	255,315	3.1	266,308	3.2	10,993	141,307	2.0	156,397	2.2	15,090
North Carolina	101,415	2.7	108,094	2.8	6,679	77,036	2.5	83,017	2.6	5,981
North Dakota	8,783	2.4	9,481	2.5	698	5,972	2.1	6,891	2.2	919
Ohio	129,063	2.6	137,143	2.8	8,080	95,718	2.3	103,917	2.4	8,199
Oklahoma	25,893	1.7	29,035	1.9	3,142	16,800	1.4	20,343	1.7	3,543
Oregon	60,878	3.8	68,709	4.3	7,831	40,254	3.1	49,249	3.7	8,995
Pennsylvania	160,494	2.9	167,397	3.0	6,903	129,372	2.7	136,557	2.8	7,185
Rhode Island	12,420	2.8	12,327	2.7	-93	9,557	2.5	9,401	2.4	-156
South Carolina	43,592	2.5	44,210	2.5	618	32,591	2.3	33,002	2.3	411
South Dakota	10,078	2.6	10,578	2.7	500	6,325	2.0	6,865	2.1	540
Tennessee	68,145	2.7	71,111	2.7	2,966	50,132	2.3	53,979	2.5	3,847
Texas	233,304	2.3	227,532	2.2	-5,772	179,744	2.1	177,155	2.1	-2,589
Utah	27,544	2.4	27,864	2.4	320	17,844	1.9	17,098	1.8	-746
Vermont	11,483	3.9	12,159	4.1	676	9,080	3.8	9,571	3.9	491
Virginia	96,490	2.7	107,773	3.0	11,283	65,142	2.3	74,990	2.6	9,848
Washington	95,769	3.4	101,593	3.6	5,824	64,985	2.8	69,332	3.0	4,347
West Virginia	14,626	2.1	16,221	2.3	1,595	7,931	1.4	9,013	1.6	1,082
Wisconsin	63,754	2.4	69,647	2.6	5,893	52,328	2.3	57,318	2.5	4,990
Wyoming	10,071	3.7	10,369	3.8	298	4,700	2.3	5,117	2.4	417

1 GGS employment is the number of jobs related to the production of Green Goods and Services.
2 GGS percent is the percentage of the GGS employment compared to the total employment. This value is derived by dividing the GGS employment by the total employment.
NOTE: GGS data for 2010 have been revised to incorporate methodological changes explained in the Technical Note. Please also note data may not add to total due to rounding.

Table 5. Green Goods and Services (GGS) private sector employment percent by state and industry sector, 2011 annual averages[1]

State	Total private	Natural resources and mining	Utilities	Construction	Manufacturing	Trade	Transportation and warehousing	Information	Financial activities	Professional, scientific, and technical services	Management of companies and enterprises	Administrative and waste services	Education and health services	Leisure and hospitality	Other services, except public administration
United States	2.3	3.4	12.9	8.9	4.3	1.1	5.9	1.1	0.0	5.0	3.6	4.3	0.1	0.2	1.3
Alabama	2.7	6.2	–[2]	6.2	5.7	1.8	2.9	–[2]	–[2]	3.4	–[2]	5.5	–[2]	0.1	–[2]
Alaska	2.4	–[2]	11.3	8.1	–[2]	0.9	5.5	–[2]	–[2]	7.6	–[2]	12.0	–[2]	–[2]	3.7
Arizona	2.0	5.5	3.0	10.4	1.7	1.5	5.2	–[2]	–[2]	5.0	–[2]	2.8	–[2]	0.3	1.5
Arkansas	2.8	5.2	20.3	9.4	6.9	1.1	–[2]	–[2]	–[2]	4.6	–[2]	6.2	–[2]	–[2]	–[2]
California	2.2	4.1	13.6	9.7	2.9	1.1	3.5	–[2]	–[2]	4.1	–[2]	5.7	–[2]	0.3	1.3
Colorado	2.9	–[2]	7.0	8.0	5.1	1.6	3.9	4.5	–[2]	8.7	–[2]	6.3	–[2]	0.3	1.6
Connecticut	2.7	–[2]	26.2	10.3	3.2	0.8	20.5	–[2]	–[2]	7.4	–[2]	6.8	–[2]	0.3	–[2]
Delaware	2.1	–[2]	–[2]	10.2	4.4	–[2]	14.9	–[2]	–[2]	3.9	–[2]	4.0	–[2]	–[2]	1.7
District of Columbia	2.4	–[3]	–[2]	10.5	–[2]	–[2]	–[2]	–[2]	–[2]	5.8	–[2]	1.0	–[2]	–[2]	2.9
Florida	1.6	3.5	9.9	8.2	3.1	0.7	3.0	–[2]	–[2]	3.0	–[2]	3.3	–[2]	0.1	1.4
Georgia	2.0	6.4	13.3	8.1	5.0	1.1	1.4	–[2]	–[2]	3.8	–[2]	2.6	–[2]	0.3	3.3
Hawaii	2.4	–[2]	6.8	13.2	–[2]	1.2	9.1	–[2]	–[2]	7.7	–[2]	3.4	–[2]	0.2	0.9
Idaho	3.0	4.8	16.4	11.2	3.3	1.0	7.8	–[2]	–[2]	6.2	–[2]	5.7	–[2]	–[2]	–[2]
Illinois	2.2	2.4	–[2]	9.4	3.0	1.0	8.0	2.3	–[2]	3.8	–[2]	4.1	–[2]	–[2]	0.9
Indiana	2.6	5.8	6.0	10.0	4.6	1.9	1.9	2.3	–[2]	5.5	–[2]	3.8	–[2]	–[2]	1.3
Iowa	2.9	3.9	16.5	11.8	8.5	1.2	2.6	–[2]	–[2]	2.9	6.6	3.2	–[2]	–[2]	–[2]
Kansas	1.8	1.8	–[2]	6.0	2.5	1.0	6.6	–[2]	–[2]	4.0	–[2]	3.4	–[2]	–[2]	–[2]
Kentucky	2.0	–[2]	3.2	8.8	4.5	1.5	0.7	–[2]	–[2]	3.9	–[2]	4.9	–[2]	0.1	–[2]
Louisiana	2.2	2.1	24.1	4.4	2.9	0.9	3.1	–[2]	–[2]	4.5	–[2]	8.7	–[2]	–[2]	–[2]
Maine	2.6	11.0	37.7	9.9	3.4	1.1	6.5	–[2]	–[2]	10.0	–[2]	7.3	–[2]	0.1	2.1
Maryland	3.2	–[2]	–[2]	13.4	6.3	1.2	9.0	–[2]	–[2]	6.8	–[2]	5.3	–[2]	–[2]	1.1
Massachusetts	2.7	–[2]	9.2	7.7	3.7	0.7	15.9	4.4	–[2]	5.7	–[2]	5.5	1.2	0.2	1.8
Michigan	2.1	5.9	8.2	10.0	4.1	1.1	3.2	2.5	–[2]	3.3	4.0	3.7	–[2]	–[2]	1.1
Minnesota	2.7	5.1	5.7	10.1	5.8	1.1	12.6	–[2]	–[2]	6.7	–[2]	4.3	–[2]	–[2]	1.2
Mississippi	1.9	7.7	16.6	5.9	1.7	0.9	2.1	–[2]	–[2]	5.8	–[2]	5.3	–[2]	–[2]	1.6
Missouri	2.2	3.7	4.8	7.6	3.9	1.4	6.7	–[2]	–[2]	5.7	–[2]	4.5	–[2]	–[2]	0.9
Montana	2.4	2.2	–[2]	6.0	4.0	1.0	8.4	–[2]	–[2]	11.0	–[2]	6.6	–[2]	–[2]	2.5
Nebraska	2.2	3.3	–[2]	10.1	4.3	0.9	3.1	–[2]	–[2]	4.2	–[2]	4.3	–[2]	–[2]	–[2]
Nevada	1.6	–[2]	8.8	9.4	3.1	1.3	4.9	–[2]	–[2]	3.6	–[2]	3.0	–[2]	–[2]	1.3
New Hampshire	2.8	–[2]	42.6	8.4	5.0	0.9	19.6	–[2]	–[2]	6.6	–[2]	5.1	–[2]	–[2]	2.3
New Jersey	1.9	–[2]	15.5	8.1	2.5	0.8	12.0	–[2]	–[2]	3.4	–[2]	3.1	–[2]	0.1	–[2]
New Mexico	2.6	–[2]	3.1	11.8	3.4	1.0	11.3	–[2]	–[2]	6.4	–[2]	3.6	–[2]	0.1	3.5
New York	2.2	4.9	9.4	10.0	4.8	0.7	17.7	–[2]	–[2]	3.8	–[2]	4.3	–[2]	0.3	0.8
North Carolina	2.6	3.2	19.8	9.9	6.4	1.2	2.2	–[2]	–[2]	4.7	10.6	2.4	–[2]	–[2]	0.8
North Dakota	2.2	1.2	4.2	6.0	10.7	0.9	3.0	–[2]	–[2]	4.7	–[2]	5.5	–[2]	–[2]	–[2]
Ohio	2.4	–[2]	11.6	13.0	4.5	1.5	2.6	–[2]	–[2]	5.4	–[2]	4.5	–[2]	0.2	–[2]
Oklahoma	1.7	–[2]	2.5	8.8	5.7	1.2	–[2]	–[2]	–[2]	–[2]	–[2]	2.2	–[2]	–[2]	–[2]
Oregon	3.7	7.4	9.1	9.0	9.3	1.5	5.7	–[2]	–[2]	6.9	12.3	6.1	–[2]	0.2	3.1
Pennsylvania	2.8	1.8	20.7	6.1	6.3	1.0	11.9	–[2]	–[2]	5.6	7.5	5.7	–[2]	0.3	1.2
Rhode Island	2.4	–[2]	–[2]	6.3	5.1	1.3	18.1	–[2]	–[2]	8.3	–[2]	6.4	–[2]	–[2]	–[2]
South Carolina	2.3	7.6	32.1	8.3	4.1	1.0	2.1	–[2]	–[2]	4.5	–[2]	3.6	–[2]	0.1	1.0
South Dakota	2.1	6.8	5.9	7.8	4.5	1.1	7.1	–[2]	–[2]	–[2]	–[2]	6.3	–[2]	–[2]	2.2
Tennessee	2.5	4.2	6.0	6.5	7.4	1.4	2.8	–[2]	–[2]	5.9	–[2]	3.5	–[2]	0.2	0.9
Texas	2.1	0.8	10.2	8.2	3.3	1.1	2.6	2.1	–[2]	5.7	–[2]	3.2	–[2]	0.2	1.1
Utah	1.8	–[2]	6.1	4.1	3.0	0.8	1.0	–[2]	–[2]	3.5	–[2]	6.7	–[2]	–[2]	1.1
Vermont	3.9	10.2	–[2]	12.1	6.9	0.8	13.3	1.8	–[2]	13.5	–[2]	9.5	–[2]	–[2]	2.7
Virginia	2.6	–[2]	18.0	9.8	4.5	1.2	2.7	–[2]	–[2]	6.5	–[2]	3.5	–[2]	0.1	2.1
Washington	3.0	10.7	12.2	9.3	2.4	1.3	3.0	–[2]	–[2]	8.2	–[2]	9.4	–[2]	–[2]	1.7
West Virginia	1.6	–[2]	4.6	6.2	3.1	0.9	–[2]	1.7	–[2]	5.2	–[2]	6.1	–[2]	–[2]	1.7

See footnotes at end of table.

Table 5. Green Goods and Services (GGS) private sector employment percent by state and industry sector, 2011 annual averages[1] — Continued

State	Total private	Natural resources and mining	Utilities	Construction	Manufacturing	Trade	Transportation and warehousing	Information	Financial activities	Professional, scientific, and technical services	Management of companies and enterprises	Administrative and waste services	Education and health services	Leisure and hospitality	Other services, except public administration
Wisconsin.......	2.5	7.1	18.2	8.4	3.9	1.5	11.3	_[2]	_[2]	6.6	_[2]	2.6	_[2]	_[2]	_[2]
Wyoming........	2.4	_[2]	4.2	8.3	3.7	1.2	_[2]	_[2]	_[2]	13.9	_[2]	7.9	_[2]	_[2]	2.7

1 GGS percent is the percentage of the GGS employment compared to the total employment. This value is derived by dividing the GGS employment (Table 6) by the Quarterly Census of Employment and Wages twelve month average employment ending December 2011 for the corresponding state and industry sector.

2 Data do not meet BLS disclosure standards.

3 No private sector establishments are classified in this industry.

NOTE: Data may not add to total due to rounding.

Table 6. Green Goods and Services (GGS) private sector employment by state and industry sector, 2011 annual averages[1]

State	Total private	Natural resources and mining	Utilities	Construction	Manufacturing	Trade	Transportation and warehousing	Information	Financial activities	Professional, scientific, and technical services	Management of companies and enterprises	Administrative and waste services	Education and health services	Leisure and hospitality	Other services, except public administration
United States	2,515,200	64,689	71,129	487,709	507,168	223,079	238,755	29,412	475	381,981	69,310	335,417	26,123	23,696	56,257
Alabama	39,703	1,238	–[2]	4,988	13,518	5,237	1,432	–[2]	–[2]	3,165	–[2]	5,659	–[2]	217	–[2]
Alaska	5,893	–[2]	238	1,273	–[2]	376	1,052	–[2]	–[2]	1,097	–[2]	1,381	–[2]	–[2]	375
Arizona	39,535	1,962	359	11,517	2,501	5,953	3,466	–[2]	–[2]	6,165	–[2]	5,535	–[2]	701	1,018
Arkansas	26,351	1,105	1,457	4,424	11,019	1,900	–[2]	–[2]	–[2]	1,795	–[2]	3,464	–[2]	–[2]	–[2]
California	268,486	16,906	7,899	54,070	36,417	23,789	14,151	–[2]	–[2]	43,279	–[2]	50,022	–[2]	4,103	9,069
Colorado	52,859	–[2]	572	8,969	6,551	5,312	2,269	3,205	–[2]	14,900	–[2]	8,604	–[2]	685	1,066
Connecticut	36,577	–[2]	1,614	5,280	5,261	1,857	8,112	–[2]	–[2]	6,486	–[2]	5,478	–[2]	434	–[2]
Delaware	7,331	–[2]	–[2]	1,972	1,131	–[2]	1,327	–[2]	–[2]	1,009	–[2]	873	–[2]	–[2]	216
District of Columbia	11,115	–[2]	–[2]	1,265	–[2]	–[2]	–[2]	–[2]	–[2]	5,958	–[2]	438	–[2]	–[2]	1,839
Florida	98,249	3,028	2,219	27,289	9,615	8,482	6,230	–[2]	–[2]	13,278	–[2]	17,278	–[2]	1,247	3,370
Georgia	64,205	1,861	2,631	11,792	17,513	7,012	2,178	–[2]	–[2]	8,527	–[2]	7,008	–[2]	1,297	3,117
Hawaii	11,425	–[2]	227	3,743	–[2]	973	2,152	–[2]	–[2]	1,867	–[2]	1,501	–[2]	201	215
Idaho	15,138	1,174	460	3,292	1,818	1,021	1,302	–[2]	–[2]	1,966	–[2]	2,111	–[2]	–[2]	–[2]
Illinois	105,751	596	–[2]	18,351	17,089	9,084	17,625	2,290	–[2]	13,551	–[2]	15,423	–[2]	–[2]	1,870
Indiana	61,159	1,152	887	11,988	21,469	8,016	1,992	787	–[2]	5,438	–[2]	6,196	–[2]	–[2]	1,021
Iowa	35,879	735	1,088	7,353	17,525	2,854	1,371	–[2]	–[2]	1,249	974	2,154	–[2]	–[2]	–[2]
Kansas	19,097	340	–[2]	3,148	4,023	1,969	2,635	–[2]	–[2]	2,386	–[2]	2,560	–[2]	–[2]	–[2]
Kentucky	28,770	–[2]	208	5,935	9,651	4,011	593	–[2]	–[2]	2,718	–[2]	4,788	–[2]	149	–[2]
Louisiana	33,328	1,249	2,244	5,322	3,981	2,526	2,084	–[2]	–[2]	3,653	–[2]	7,901	–[2]	–[2]	–[2]
Maine	12,680	670	606	2,503	1,731	1,119	970	–[2]	–[2]	2,349	–[2]	1,946	–[2]	48	342
Maryland	63,638	–[2]	–[2]	19,243	7,081	4,243	5,672	–[2]	–[2]	15,573	–[2]	7,718	–[2]	–[2]	989
Massachusetts	75,071	–[2]	958	8,582	9,299	3,048	11,067	3,674	–[2]	14,736	–[2]	8,917	7,351	708	2,426
Michigan	69,116	1,921	1,575	12,467	20,650	6,389	3,025	1,342	–[2]	7,723	2,121	9,924	–[2]	–[2]	1,362
Minnesota	60,509	1,276	733	9,279	17,352	4,476	9,286	–[2]	–[2]	8,566	–[2]	5,557	–[2]	–[2]	991
Mississippi	16,114	1,501	1,287	2,900	2,276	1,478	805	–[2]	–[2]	1,832	–[2]	2,754	–[2]	–[2]	353
Missouri	46,625	558	598	7,858	9,575	5,663	5,336	–[2]	–[2]	7,029	–[2]	6,497	–[2]	–[2]	806
Montana	8,211	264	–[2]	1,351	671	738	910	–[2]	–[2]	2,090	–[2]	1,299	–[2]	–[2]	394
Nebraska	16,491	443	–[2]	4,100	4,005	1,346	1,200	–[2]	–[2]	1,795	–[2]	1,821	–[2]	–[2]	–[2]
Nevada	15,569	–[2]	367	4,899	1,166	2,051	2,261	–[2]	–[2]	1,674	–[2]	2,224	–[2]	–[2]	355
New Hampshire	14,471	–[2]	1,054	1,866	3,349	1,070	2,371	–[2]	–[2]	1,958	–[2]	1,464	–[2]	–[2]	455
New Jersey	61,160	–[2]	2,093	10,410	6,198	5,436	17,623	–[2]	–[2]	9,302	–[2]	7,647	–[2]	174	–[2]
New Mexico	15,481	–[2]	137	4,988	1,000	1,162	1,862	–[2]	–[2]	3,423	–[2]	1,514	–[2]	54	722
New York	156,397	1,369	3,507	30,657	21,719	8,785	38,670	–[2]	–[2]	21,830	–[2]	18,309	–[2]	2,025	2,486
North Carolina	83,017	997	2,400	17,154	27,616	7,097	2,329	–[2]	–[2]	8,804	8,196	6,017	–[2]	–[2]	742
North Dakota	6,891	240	142	1,461	2,538	628	426	–[2]	–[2]	595	–[2]	697	–[2]	–[2]	–[2]
Ohio	103,917	–[2]	2,234	22,893	28,771	11,659	4,121	–[2]	–[2]	13,152	–[2]	13,017	–[2]	1,204	–[2]
Oklahoma	20,343	–[2]	276	6,030	7,390	2,696	–[2]	–[2]	–[2]	–[2]	–[2]	2,110	–[2]	–[2]	–[2]
Oregon	49,249	3,430	407	6,067	15,564	3,870	2,640	–[2]	–[2]	5,075	3,730	5,092	–[2]	294	1,929
Pennsylvania	136,557	1,007	4,627	13,551	35,852	8,748	24,409	–[2]	–[2]	17,382	9,293	16,020	–[2]	1,336	2,259
Rhode Island	9,401	–[2]	–[2]	992	2,061	791	1,662	–[2]	–[2]	1,747	–[2]	1,490	–[2]	–[2]	–[2]
South Carolina	33,002	923	3,830	6,404	8,759	2,840	963	–[2]	–[2]	3,567	–[2]	4,832	–[2]	216	460
South Dakota	6,865	356	123	1,573	1,767	751	674	–[2]	–[2]	–[2]	–[2]	857	–[2]	–[2]	223
Tennessee	53,979	469	200	6,831	22,502	6,164	3,543	–[2]	–[2]	6,395	–[2]	6,401	–[2]	580	619
Texas	177,155	2,341	5,021	46,559	27,554	18,727	9,476	4,074	–[2]	33,558	–[2]	21,159	–[2]	1,574	3,299
Utah	17,098	–[2]	246	2,681	3,371	1,555	446	–[2]	–[2]	2,412	–[2]	4,840	–[2]	–[2]	342
Vermont	9,571	328	–[2]	1,701	2,133	399	901	90	–[2]	1,847	–[2]	915	–[2]	–[2]	233
Virginia	74,990	–[2]	1,955	17,382	10,367	6,218	2,587	–[2]	–[2]	25,584	–[2]	7,015	–[2]	430	2,632
Washington	69,332	9,846	588	11,797	6,291	5,540	2,415	–[2]	–[2]	13,405	–[2]	12,804	–[2]	–[2]	2,302
West Virginia	9,013	–[2]	251	2,054	1,536	1,044	–[2]	171	–[2]	1,290	–[2]	1,943	–[2]	–[2]	361

See footnotes at end of table.

Table 6. Green Goods and Services (GGS) private sector employment by state and industry sector, 2011 annual averages[1] — Continued

State	Total private	Natural resources and mining	Utilities	Construction	Manufacturing	Trade	Transportation and warehousing	Information	Financial activities	Professional, scientific, and technical services	Management of companies and enterprises	Administrative and waste services	Education and health services	Leisure and hospitality	Other services, except public administration
Wisconsin.......	57,318	1,796	1,978	7,755	17,398	6,026	9,770	–[2]	–[2]	6,300	–[2]	3,623	–[2]	–[2]	–[2]
Wyoming........	5,117	–[2]	105	1,751	340	467	–[2]	–[2]	–[2]	1,264	–[2]	621	–[2]	–[2]	221

1 GGS employment is the number of jobs related to the production of Green Goods and Services. This table reflects private ownership only.
2 Data do not meet BLS disclosure standards.
3 No private sector establishments are classified in this industry.
NOTE: Data may not add to total due to rounding.

enough to minorities, despite having no evidence of discriminatory purpose.

The Supreme Court has never ruled on

let an Administration official mess with their docket for his own political purposes.

California's Cap-and-Tax Grab

Democrats in Sacramento are taking a victory lap for balancing this year's budget without raising taxes (not counting the $6 billion retroactive hike voters approved at political gunpoint in November). The dirty little secret is they're instead tapping California's new cap-and-trade program.

Democrats raid carbon auction cash to finance more welfare spending.

California expects to generate $500 million this year from auctioning off permits to emit carbon, and between $2 billion and $14 billion annually by 2015. This rich new vein of revenues was supposed to flow to green programs (e.g., solar subsidies), but Governor Jerry Brown cut a deal with Democrats in the legislature to seize this year's proceeds to finance more generous welfare and Medicaid benefits. Environmentalists are suddenly stunned to discover that they're not exempt from Sacramento's generally accepted accounting principle of raiding internal accounts to backfill the budget.

Mr. Brown has vowed to repay the $500 million cap-and-trade "loan" in short order. But as a matter of law, he has until the California Air Resources Board (CARB) says it needs the cash to administer the cap-and-trade program. That may be never since CARB's expenditures are discretionary, and the quarterly auctions will produce gushers of revenues that guarantee the cap-and-trade fund never runs dry.

The board's chairwoman Mary Nichols, who's endorsing the raid, has tried to quell enraged environmentalists by reminding them that "the part about the cap-and-trade program that is reducing greenhouse gas emissions, it's the cap," and "not the revenue that we get from the allowances."

Good point, and one which businesses are making in a lawsuit that contends the state is levying an unconstitutional tax under the guise of a "regulatory fee." California's Prop. 13 (1978) requires a supermajority vote of the legislature to raise taxes. CARB circumvented this requirement in 2011 by setting up a state-run auction to sell permits and calling the profits "regulatory fees" that would be used to mitigate emissions.

But as the state Supreme Court underscored in its 1997 *Sinclair Paint Co.* opinion, regulatory fees cannot "exceed in amount the reasonable cost of providing the protective services for which the fees are charged" or be imposed for "unrelated revenue purposes."

California has never quantified the "reasonable cost" to protect the public from carbon emissions, and it's hard to argue that spending cap-and-trade dollars on welfare checks advances environmental objectives. The state doesn't need to auction off permits to reduce greenhouse gas emissions. It could achieve its emissions targets by giving away permits for free and ratcheting the cap down over time.

In short, California Democrats are proving that the real point of cap and trade is to give politicians another revenue stream for income redistribution while dodging accountability for raising taxes. That's worth keeping in mind when liberals resurrect the scheme for the entire U.S.

model for other nations.

JAMES DYSON
Founder and Chief Engineer
Dyson
Malmesbury, U.K.

A Nonfuzzy Take

The June 15 letter from the Texas legislature's Jim Pitts and Tommy Williams takes exception to your June 8 editorial "Texas Goes Sacramento," which notes that the Texas Public Policy Foundation calculated a 26% increase in general revenue spending by the Texas Legislature in 2013. However, our numbers are simple to follow: The legislature spent $95 billion of general revenue in the general appropriations bill for the 2014-15 budget, $7 billion more in two supplemental appropriations bills for the current budget and another $4 billion from the state's reserve fund in both budgets. This $106 billion in spending is difficult to discern in official documents, with some of it being spent in 2013, some in 2014 and some in 2015, some of it appropriated in 2013 but spent in 2014 and 2015, and $2 billion of it being potentially taken "off budget" by Texas voters in the coming November constitutional amendment election. After all these maneuvers the appropriators are able to claim the new budget rose only by 8%. The truth, though, is that the legislature spent $22 billion more this

Wall Street Journal
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United States Senate
Environment and Public Works Committee

Minority Report

Critical Thinking on Climate Change

Questions to Consider Before Taking Regulatory Action and Implementing Economic Policies

July 18, 2013

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U.S. Senate Environment and Public Works Committee (Minority)

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INTRODUCTION

The climate has always and will always be changing, and that is unquestionable. What is in question is the amount of influence human activity has on climate patterns, and this report is intended to provide an opportunity to think critically and review some of the more important global warming predictions made over the last several decades.

For more than thirty years, a litany of predictions and claims have been made about what impact anthropogenic (human-caused) greenhouse gases (GHGs) would be on the earth's climate, and on plant and animal life directly. Much of the concern that has been raised—and which continues to be raised—focuses on carbon dioxide (CO_2) emissions, an otherwise naturally occurring gas that makes the process of photosynthesis and life on earth possible. Over nearly four decades, numerous predictions have had adequate time to come to fruition, providing an opportunity to analyze and compare them to today's statistics.

There is little doubt that affordable reliable energy is one of the greatest equalizers in our society. Our use of fossil energy has established a standard of living in the United States that provides families of any income level the ability to heat and cool their home, drive to work or their children to school, or even visit far away family members. In fact, the National Academy of Engineering dubbed electrification "the greatest engineering achievement of the 20th Century."[1] Inevitably, the use and production of this energy releases some CO_2 into our atmosphere.

The use of fossil energy has increased and expanded internationally, and GHG emissions are anticipated to continue to grow in developing nations such as China and India. This report posits that as the developing world has greatly expanded its use of fossil energy and CO_2 emissions have increased, then the predictions and claims regarding human influence on climate patterns should be apparent and easily proven. It is important to keep in mind that many of the predictions and claims analyzed in this report were made prior to China surpassing the United States in 2011 as the largest global GHG emitter. Accordingly, if things are "worse than predicted" as many climate activists and politicians have recently asserted, impacts should prove themselves out as worse than the predictions and claims reviewed in this report.

> *"In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual."*[2] - Galileo Galilei, Italian physicist, mathematician, astronomer, and philosopher

> *"The truth may be puzzling. It may take some work to grapple with. It may be counterintuitive. It may contradict deeply held prejudices. It may not be consonant with what we desperately want to be true. But our preferences do not determine what's true."*[3] - Carl Sagan, American astronomer and scientist

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[1] *The Greatest Achievements of the 20th Century*, NAT'L ACADEMY OF ENGINEERING, (Dec. 3, 2004), http://www.mae.ncsu.edu/eischen/courses/mae415/docs/GreatestEngineeringAchievements.pdf.
[2] FRANCOIS ARAGO, BIOGRAPHIES OF DISTINGUISHED SCIENTIFIC MEN 365 (Baden Powell, Robert Grant, and William Fairbairn trans.) (1859).
[3] Carl Sagan, *Wonder and Skepticism*, 19 SKEPTICAL ENQUIRER 1(Jan.-Feb. 1995).

I. CLIMATE MODELS: THE 15-YEAR HIATUS IN WARMING

> *"An experiment is a question which science poses to Nature and a measurement is the recording of Nature's answer."* [4] Max Planck, German physicist

Predictions:

> "Most of the climate models...now project that average global temperatures will rise somewhere from 3 to 8 degrees Fahrenheit toward the middle of next century.... A range as high as 14.4 degrees and 18 degrees cannot be ruled out."[5] *New York Times*, January 17, 1989

> "Using computer models, researchers concluded that global warming would raise average annual temperatures nationwide two degrees by 2010."[6] *Associated Press*, May 15, 1989.

> "Children just aren't going to know what snow is." [7] Dr. David Viner, senior research scientist at the climatic research unit (CRU) of the University of East Anglia, interviewed by the *UK Independent*, March 20, 2000.

> "The entire north polar ice cap will be gone in 5 years." [8] Former Vice President Al Gore, December 13, 2008.

Claims:

> "The climate is heating up far faster than scientists had predicted, spurred by sharp increases in greenhouse gas emissions from developing countries like China and India." [9] *Reuters*, February 14, 2009

> "The temperature around the globe is increasing faster than was predicted even 10 years ago." [10] President Barack Obama, November 14, 2012

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[4] MAX PLANCK, SCIENTIFIC AUTOBIOGRAPHY AND OTHER PAPERS (1968).
[5] Philip Shabecoff, *Global Warming: Experts Ponder Bewildering Feedback Effects*, N.Y. TIMES, Jan. 17, 1989, http://www.nytimes.com/1989/01/17/science/global-warming-experts-ponder-bewildering-feedback-effects.html?pagewanted=all&src=pm.
[6] Kirk Myers, *Arctic Ocean warming, icebergs growing scarce, Washington Post reports*, THE EXAMINER, Mar. 2, 2010, http://www.examiner.com/article/arctic-ocean-warming-icebergs-growing-scarce-washington-post-reports (*quoting* Associated Press).
[7] Charles Onians, *Snowfalls are now just a thing of the past*, THE INDEPENDENT, Mar. 20, 2000, http://www.independent.co.uk/environment/snowfalls-are-now-just-a-thing-of-the-past-724017.html.
[8] Charles J. Hanley, *Gore: Polar Ice May Vanish in 5 Years*, HUFFINGTON POST, Dec. 14, 2009, http://www.huffingtonpost.com/2009/12/14/gore-polar-ice-may-vanish_n_391632.html.
[9] Julie Steenhuysen, *Global warming seen worse than predicted*, REUTERS, Feb. 14, 2009, http://www.reuters.com/article/2009/02/14/us-climate-idUSTRE51D29E20090214.
[10] *Transcript of President Obama's News Conference*, N.Y. TIMES, Nov. 14, 2012, http://www.nytimes.com/2012/11/14/us/politics/running-transcript-of-president-obamas-press-conference.html?pagewanted=10&_r=2&src=twr.

The Latest Science:

The predictions seem unlikely to come true, and the claims contradict the data, as noted by entities generally supportive of the Administration's climate change policies. For instance, *The Economist* recently explained that "temperatures have not really risen over the past ten years"[11] and that "[o]ver the past 15 years air temperatures at the Earth's surface have been flat."[12] Last month, *BBC News* reported, "Since 1998, there has been an unexplained 'standstill' in the heating of the Earth's atmosphere."[13]

Furthering the concern that past climate models have not proven true, Professor Judith Curry, chair of the School of Earth and Atmospheric Sciences at Georgia Institute of Technology in Atlanta, stated on June 14, 2013, "Attention in the public debate seems to be moving away from the 15-17 year 'pause' to the cooling since 2002."[14] She further stated, "This period since 2002 is scientifically interesting, since it coincides with the 'climate shift' circa 2001/2002 posited by Tsonis and others.[15] This shift and the subsequent slight cooling trend provide a rationale for inferring a slight cooling trend over the next decade or so, rather than a flat trend from the 15 year 'pause.'"[16]

Importantly, the U.S. Environmental Protection Agency (EPA) has essentially ignored Members of Congress who asked for EPA data supporting the President's claims about global temperature predictions. For example, on December 4, 2012, Senator Sessions wrote former Administrator Jackson:

> The actual temperature data show no significant change in global temperatures over the past decade and certainly less warming than the climate change models predicted. At an August 1, 2012, hearing before the Senate Committee on Environment and Public Works...climatologist Dr. John Christy of the University of Alabama-Huntsville offered testimony demonstrating that the IPCC climate models, which have been relied upon by alarmists, vastly over-stated the degree of warming in comparison to actual temperature data observed by advanced satellites. Dr. Christy's chart...demonstrates that the IPCC models, on average, predicted a significant amount of warming that has not actually occurred. In fact, contrary to the President's assertion, the chart shows that global average temperatures have not increased at all over the past decade, and certainly less than was predicted 10 years ago.
>
> The President's assertion also conflicts with the views of many other scientists and experts. In an editorial published earlier this year in the Wall Street Journal, scientists and engineers from MIT, Princeton, Cambridge, and other leading

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[11] *Apocalypse perhaps a little later*, ECONOMIST, Mar. 30, 2013, http://www.economist.com/news/leaders/21574490-climate-change-may-be-happening-more-slowly-scientists-thought-world-still-needs.

[12] *Climate Science: A Sensitive Matter*, ECONOMIST, Mar. 30, 2013, http://www.economist.com/news/science-and-technology/21574461-climate-may-be-heating-up-less-response-greenhouse-gas-emissions.

[13] Matt McGrath, *Climate slowdown means extreme rates of warming 'not as likely'*, BBC NEWS, (May 19, 2013, 1: 31 PM), http://www.bbc.co.uk/news/science-environment-22567023.

[14] Judith Curry, *Week in Review*, CLIMATE ETC., (June 14, 2013), http://judithcurry.com/2013/06/14/week-in-review-3/.

[15] Bill Osmulski, *UW-Milwaukee Professor Predicts 50 Years of Global Cooling*, MACIVER INSTITUTE (Jan. 13, 2010, 2:59 PM), http://www.maciverinstitute.com/2010/01/uw-milwaukee-professor-predicts-50-years-of-global-cooling/.

[16] *Id.*

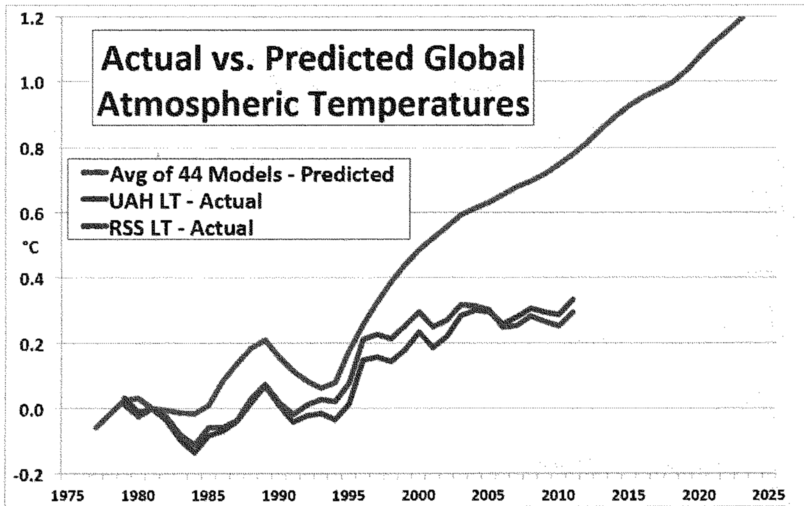
> institutions explained that 'perhaps the most inconvenient fact is the lack of global warming for well over 10 years now' and that there has been a 'smaller-than-predicted warming over the 22 years since the U.N.'s Intergovernmental Panel on Climate Change (IPCC) began issuing projections.' Additionally, the lead author of the 2007 IPCC climate report stated in an email that 'we can't account for the lack of warming at the moment...'
>
> As policymakers consider proposals aimed at addressing concerns about rising temperatures predicted by the IPCC climate models, a critical question is whether the planet is warming to the extent predicted by these models. The data suggest to me that the planet is not warming to the extent predicted 10 years ago.[17]

To shed light on this issue, Senator Sessions asked EPA to "provide the best available data that EPA would rely upon to support the President's assertion,"[18] along with an EPA-prepared chart comparing "actual global average temperature increases since 1979 (when satellite temperature data became available) versus the latest IPCC predictions..." [19]

Gina McCarthy, nominee to be EPA Administrator, responded to Senator Sessions in a letter dated February 14, 2013, by asserting that "there are multiple lines of evidence that clearly demonstrate that average global temperatures are rising,"[20] yet she did not provide any of the requested data relating to average global temperatures. Instead, the letter seems to dodge Senator Sessions' data request by claiming that "only looking at 10 years of a single dataset cannot provide a full picture of climate change trends, and should also not be the sole test by which to judge the usefulness of climate models in either simulating past climates or projecting further climate change." [21]

The lack of responsiveness on these points was raised at McCarthy's April 11, 2013 nomination hearing when Senator Sessions presented the following chart which demonstrates global temperatures have not increased over the last decade and certainly not to the extent predicted by the climate models:

[17] Letter from Sen. Jeff Sessions to Lisa Jackson, EPA Adm'r, (Dec. 4, 2012) (on file with author).
[18] Letter from Sen. Jeff Sessions et al. to Gina McCarthy, EPA Asst. Adm'r Office of Air & Radiation, (June 24, 2013) (on file with author).
[19] *Id.*
[20] *Id.*
[21] *Id.*



Global Bulk Atmospheric Temperatures from the average of 44 CMIP-5 climate models vs. satellite observations of the same bulk layer (sfc to 35,000 ft). 5-year running averages with base of 1979-83. JR Christy Univ. Alabama in Huntsville. Model output: KNMI Climate Explorer

In his questions for the record, Senator Sessions once again requested the data from McCarthy: "Will you provide me with data showing actual global average temperatures since 1979 versus IPCC predictions, as was requested in my letter?"[22]

On April 30, 2013, the EPA responded to Senator Sessions. Yet, instead of providing the requested analysis including a chart showing official predictions versus actual global temperatures, the Agency simply stated that "EPA has not produced its own analysis, but we expect a definitive comparison in the forthcoming [International Panel on Climate Change] Fifth Assessment Report."[23] Unlike EPA, the IPCC is an international body outside the jurisdiction and oversight of the United States Congress. Moreover, EPA is the entity of the United States government that is seeking sweeping regulations on the basis that GHGs are increasing global temperatures. EPA's reliance on the IPCC is not only a violation of the Data Quality Act,[24] but also violates the Agency's own internal policy.[25]

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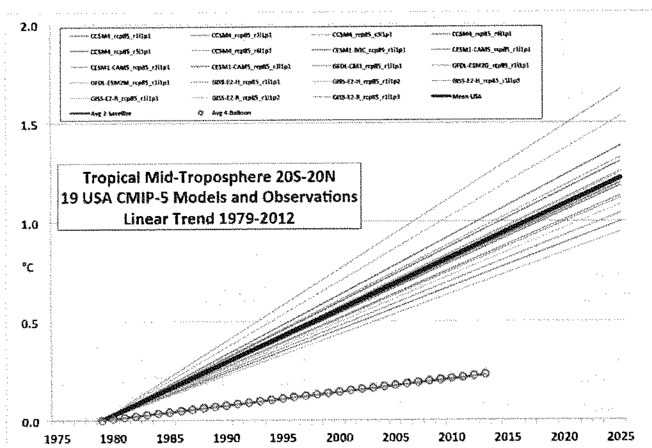
[22] *Hearing on the Nomination of Gina McCarthy to be Administrator of the U.S. Environmental Protection Agency*, 113th Cong. (2013), http://www.epw.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=d71fd4b6-ce77-3a98-46a0-fb02b0cae0cd.

[23] *Id.*

[24] The DQA directs the Office of Management and Budget (OMB) to issue government-wide guidelines that "provide policy and procedural guidance to Federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by Federal agencies." *See* Data Quality Act §515, 42 U.S.C. §502-504.

[25] Peer Review Advisory Grp., *Addendum to: Guidance for Evaluating the Quality of Scientific and Technical Information*, EPA'S SCI. AND TECH. POLICY COUNCIL (Dec. 2012), http://www.epa.gov/spc/pdfs/assess3.pdf.

To support the President's claim that the temperature around the globe is increasing faster than was predicted even 10 years ago, EPA referred to a short paper by Stefan Rahmstorf[26] published in an online journal whose editor-in-chief also happens to be the "coordinating lead author"[27] for the IPCC—during the time the IPCC published the climate models vastly over-predicting global temperature increases. It is remarkable that EPA—without first conducting its own analysis—would endorse that paper's finding that "global temperature continues to increase in good agreement with the best estimates of the IPCC," [28] a view that appears to be contrary to the actual current data and facts. This is shown by a comprehensive comparison of climate models used by the IPCC, which is reflected in the following chart:[29]



The American public should be deeply troubled to learn that EPA is actively working to increase energy prices based on predicted global temperature increases without first undertaking efforts to determine if temperatures are actually increasing to the extent predicted by the climate models they are using. This refusal to provide reasonable data requested by Members of Congress comes on the heels of the EPA Inspector General's highly critical report investigating EPA's review of external data for the GHGs endangerment finding.[30]

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[26] Stefan Rahmstorf et al., *Comparing climate projections to observations up to 2011*, 7 ENVTL. RES. LETTERS 044035 (2012), *available at* http://iopscience.iop.org/1748-9326/7/4/044035/pdf/1748-9326_7_4_044035.pdf; It is also noteworthy that this paper was published on November 27, 2012—almost two weeks after the President stated that "the temperature around the globe is increasing faster than was predicted even 10 years ago." *Transcript of President Obama's News Conference*, N.Y. TIMES, Nov. 14, 2012, http://www.nytimes.com/2012/11/14/us/politics/running-transcript-of-president-obamas-press-conference.html?pagewanted=10&_r=2&src=twr.

[27] Dr. Daniel M. Kammen's Personal Website. BERKELEY.EDU, http://kammen.berkeley.edu// (last visited July 16, 2013).

[28] Stefan Rahmstorf et al., *Comparing climate projections to observations up to 2011*, 7 ENVTL. RES. LETTERS 044035 (2012), *available at* http://iopscience.iop.org/1748-9326/7/4/044035/pdf/1748-9326_7_4_044035.pdf.

[29] Dr. John Christy, *Tropical Mid-Troposphere 20S-20N*, (June 4, 2013), http://www.drroyspencer.com/wp-content/uploads/CMIP5-19-USA-models-vs-obs-20N-20S-MT.png.

[30] ENVTL. PROT. AGENCY, OFFICE OF INSPECTOR GEN., REPORT NO. 11-P-0702, PROCEDURAL REVIEW OF EPA'S GREENHOUSE GASES ENDANGERMENT FINDING DATA QUALITY PROCESSES (2011), *available at* http://www.epa.gov/oig/reports/2011/20110926-11-P-0702.pdf.

Congress continues to wait for the federal agency's supporting data and analysis the President cited which shows actual global average temperatures since 1979 versus IPCC predictions, as was requested in Senator Sessions' December 2012 letter and again during McCarthy's nomination hearing to lead the Agency.

Questions for Critical Thinking:

1. If the computer models and predictions have been inaccurate, why is our federal government relying on these models to take unilateral action?

2. If global warming has been "worse than predicted," why won't the federal government provide the data supporting this claim?

3. As it continues to be recognized that the Earth has not warmed for the past 15 years, will we see the term "global warming" abandoned and replaced in its entirety by "climate change?"

4. Given that many of these models predicted warming trends well before China surpassed the United States as the largest GHG emitter, and given the fact that emissions continue to grow at a pace beyond what was originally incorporated into the models, shouldn't the warming be far worse than what was predicted in the worst case scenarios rather than well below predictions?

II. SEA LEVEL RISE: IT'S MEASURED IN MILLIMETERS, NOT FEET

"Science is built up of facts, as a house is built of stones; but an accumulation of facts is no more science than a heap of stones a house." Jules Henri Poincaré, French mathematician, theoretical physicist, engineer, and philosopher of science

Predictions:

In 1989, Noel Brown, then-Director of the United Nations Environment Program (UNEP) New York office, warned of a "10-year window of opportunity to solve" global warming. "A senior U.N. environmental official says entire nations could be wiped off the face of the Earth by rising sea levels if the global warming trend is not reversed by the year 2000. Coastal flooding and crop failures would create an exodus of 'eco-refugees,' threatening political chaos."[31] *Miami Herald*, July 5, 1989

By the year 2100 "global mean sea level will rise 15 to 95 centimeters."[32] *New York Times*, December 1, 1997

[31] *Gore's Really Inconvenient Timing- 'Consensus' On Man-Made Global Warming Collapses in 2008*, REPUBLICAN ENV'T AND PUB WORKS COMM., July 18, 2008, http://www.epw.senate.gov/public/index.cfm?FuseAction=Minority.Blogs&ContentRecord_id=37ae6e96-802a-23ad-4c8a-edf6d8150789.
[32] *Id.*

> "Rising sea levels, desertification and shrinking freshwater supplies will create up to 50 million environmental refugees by the end of the decade, experts warn today." [33] *UK Guardian*, October 11, 2005

> "The last time the world was three degrees warmer than today – which is what we expect later this century – sea levels were 25m higher (75 feet). So that is what we can look forward to if we don't act soon. None of the current climate and ice models predict this. But I prefer the evidence from the Earth's history and my own eyes. I think sea-level rise is going to be the big issue soon, more even than warming itself." [34] James Hansen, climate activist and adjunct professor at Columbia University, February 17, 2006

Claims:

> "The newer analyses that have been done since the IPCC report came out, indicate that the upper limit for the year 2100 is probably between 1 and 2 meters, and those are the numbers that I now quote, because they are the latest science." [35] John Holdren, White House Science Advisor, February 12, 2009

> "Sea level could rise more than six feet by the end of the century," and "could continue rising a foot each decade after that." [36] Jeff Goodell for *Rolling Stone*, June 20, 2013

The Latest Science:

Both the predictions and claims are highly inconsistent with the latest science. In fact, the United Nations has already made their 2005 prediction disappear.[37] According to the National Oceanic and Atmospheric Administration (NOAA), data indicates that sea levels rose only 1.1 - 1.3 mm/year from 2005-2012.[38] Citing NOAA directly, the "numbers represent the globally averaged changes in sea level and have magnitudes on the order of millimeters per year." [39] Accordingly, at the current rate of sea level rise, it would take approximately 25,000 years (around the year 27013) for the oceans to reach Hansen's 2006 prediction levels rather than something "we expect" to reach by the year 2100. [40]

During his 2009 confirmation hearing, Dr. John Holdren, the present White House science advisor, retracted from his prior claim that sea levels could rise "13 feet" and instead revised

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[33] David Adam, *50m environmental refugees by end of decade, UN warns*, THE GUARDIAN, Oct. 11, 2005, http://www.guardian.co.uk/environment/2005/oct/12/naturaldisasters.climatechange1.

[34] Jim Hansen, *Climate change: On the edge*, THE INDEPENDENT, Feb. 17, 2006, http://www.independent.co.uk/environment/climate-change-on-the-edge-466818.html.

[35] *Hearing before the Comm. On Commerce, Science, and Trans.*, 111th Cong., (2009) (statement of John Holdren, White House Science Advisor).

[36] Jeff Goodell, *Goodbye, Miami*, ROLLING STONE, June 20, 2013, http://www.rollingstone.com/politics/news/why-the-city-of-miami-is-doomed-to-drown-20130620.

[37] Anthony Watts, *The UN "disappears" 50 million climate refugees, then botches the disappointing attempt*, WATTSUPWITHTHAT BLOG (Apr. 15, 2011), http://wattsupwiththat.com/2011/04/15/the-un-disappears-50-million-climate-refugees-then-botches-the-disappearing-attempt/.

[38] U.S. DEP'T OF COMMERCE, NAT'L OCEANIC AND ATMOSPHERIC ADMIN, THE BUDGET OF RECENT GLOBAL SEA LEVEL RISE 2005-2012 (2012).

[39] *Id.*

[40] *Id.*

down his own predictions to match the lower numbers from the IPCC 2007 report. The following is an excerpt from the February 12, 2009, hearing:

> *Senator Vitter*: Final question: In 2006, obviously pretty recently, in an article, "The War on Hot Air," you suggested that global sea levels could rise by 13 feet by the end of this century. And in contrast to that, the IPCC's 2007 report put their estimate at between 7 and 25 inches. So their top line was 25 inches, about 2 feet. What explains the disparity?
>
> *Dr. Holdren*: My statement was based on articles in the journals *Science* and *Nature*, peer reviewed publications by some of the world's leading specialists in studying ice, who had concluded that twice in the last 19,000 years, in natural warming periods of similar pace to the warming period that we're experiencing now, in large part because of human activities, sea level went up by as much as 2 to 5 meters per century.
>
> *Senator Vitter*: The bottom line: Do you think the better worst-case estimate is 25 inches or 13 feet?
>
> *Dr. Holdren*: The newer analyses that have been done since the IPCC report came out indicate that the upper limit for the year 2100 is probably between 1 and 2 meters, and those are the numbers that I now quote, because they are the latest science.[41]

A further review of the science shows that the rate of sea level change has been found to be larger in the early part of last century (2.03 ± 0.35 mm/yr 1904–1953), in comparison with the latter part (1.45 ± 0.34 mm/yr 1954–2003).[42] When compared to NOAA's data on sea level rise from 2005-2012, the 1.1 – 1.3 mm/year rate is below the rate from 1954-2003, indicating that the rate of sea level rise continues to decline. Analysis from a recent peer-reviewed study had findings consistent with the following:[43]

> Although the mean rate of change of global mean sea level is found to be greater in the first half of the twentieth century, the two rates are consistent with being the same at the 95% confidence level, given their individual standard errors. However, a greater rate of rise in the early part of the record is consistent with previous analyses of tide gauge records which suggested a general deceleration in sea level rise during the 20th century [*Woodworth*, 1990; *Douglas*, 1992; *Jevrejeva et al.*, 2006]. A twentieth century deceleration is consistent with the work of *Church and White* [2006] who, although finding evidence for a post-1870 acceleration based on an EOF reconstruction of global sea level, found that much of the overall acceleration occurred in the first half of the 20th century. *Church and White* [2006] suggested that the greater rate of sea level rise observed in the first half of last century was due to reduced volcanic emissions (and hence also lower variability in sea level) during the 1930s to 1960s. This idea is supported by results from the HadCM3 model which suggest that the simulated global

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[41] *Hearing before the Comm. On Commerce, Science, and Trans.*, 111th Cong., (2009) (statement of John Holdren, White House Science Advisor).
[42] S.J. Holgate, *On the decadal rates of sea level change during the twentieth century*, 34 GEOPHYSICAL RES. LETTERS L01602 (2007), *available at* http://onlinelibrary.wiley.com/doi/10.1029/2006GL028492/abstract.
[43] *Id.*

> mean sea level did not accelerate through the twentieth century due to the offsetting of anthropogenic warming by reduced natural forcing [*Gregory et al.*, 2006].[44]

In short, the peer-reviewed scientific evidence can be summed up as follows:

- Sea level rise was greater in the first half of the twentieth century;
- There has been a decline in sea level rise in the latter half of the twentieth century; and
- NOAA's latest data indicates that the rate of sea level rise is less than half that predicted by the IPCC.

Questions for Critical Thinking:

1. If the present rate of sea level rise would put the world on pace to see an increase of less than 7 inches by the end of the century, then where are the data sets the IPCC and other advocates use to come up with estimates that are in feet and/or meters?
2. What science did Al Gore use to come to the conclusion that the oceans would rise 20 feet or more?
3. What exactly is meant by the statement in the scientific literature "is consistent with previous analyses of tide gauge records which suggested a general deceleration in sea level rise during the 20th century?"[45]
4. If empirical evidence indicates that the rate of sea level rise is decreasing, how does the IPCC claim that there definitively is a strong correlation between sea level rise and CO_2 concentrations in the atmosphere? Doesn't the science tend to indicate that there is a lack of correlation?

III. EXTREME WEATHER: HURRICANES, DROUGHTS, HEAT WAVES, AND WILDFIRES

> *"When the number of factors coming into play in a phenomenological complex is too large scientific method in most cases fails. One need only think of the weather, in which case the prediction even for a few days ahead is impossible."*[46] Albert Einstein, German physicist

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[44] *Id.*

[45] S.J. Holgate, *On the decadal rates of sea level change during the twentieth century*, 34 GEOPHYSICAL RES. LETTERS L01602 (2007), *available at* http://onlinelibrary.wiley.com/doi/10.1029/2006GL028492/abstract.

[46] *Science, Philosophy and Religion, A Symposium*, published by the *Conference on Science, Philosophy and Religion in Their Relation to the Democratic Way of Life, Inc.*, New York (1941); later published in *Out of My Later Years* (1950).

Predictions:

> "Increasingly, it is being recognized that other climatic factors, including changes in rainfall patterns and the frequency and intensity of hurricanes, cyclones and wildfire, may have far greater consequences than a rise in temperature."[47] *New York Times*, August 17, 1993

> "Global warming is likely to produce a significant increase in the intensity and rainfall of hurricanes in coming decades, according to the most comprehensive computer analysis done so far."[48] *New York Times*, September 30, 2004

> "From heat waves to storms to floods to fires to massive glacial melts, the global climate seems to be crashing around us."[49] *TIME*, March 26, 2006

Claims:

> "At the same time, we must be very clear. Hurricane Sandy is a wake-up call for all Americans that we must act to reverse global warming. While scientists do not attribute this storm or any single weather disturbance to global warming, it is increasingly clear that global warming is fueling more extreme weather disturbances."[50] Senator Bernie Sanders, November 1, 2012

> "Heat waves, droughts, wildfires, and floods – all are now more frequent and intense."[51] President Obama, February 12, 2013

> "The effects of climate change, driven by carbon pollution, hit Americans harder each year. Extreme weather events like hurricanes, wildfires and droughts are growing ever more frequent and severe."[52] Senator Sheldon Whitehouse, June 19, 2013

The Latest Science:

Wildfires have not increased:

"Historical analysis of wildfires around the world shows that since 1950 their numbers have decreased globally by 15%. Estimates published in the Proceedings of the National Academy of Sciences show that even with global warming proceeding uninterrupted, the level of wildfires will continue to decline until around midcentury and won't resume on the level of 1950—the worst for fire—before the end of the century."[53]

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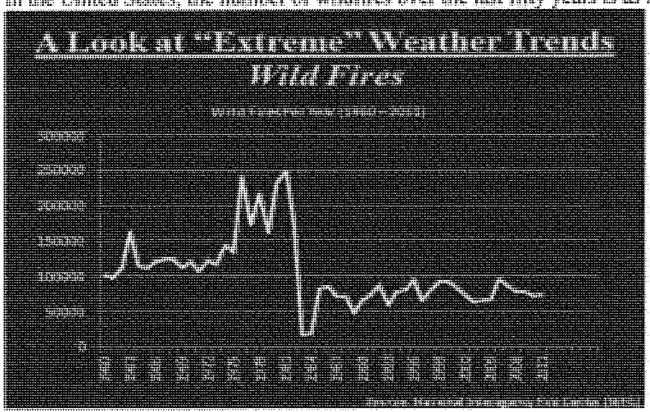
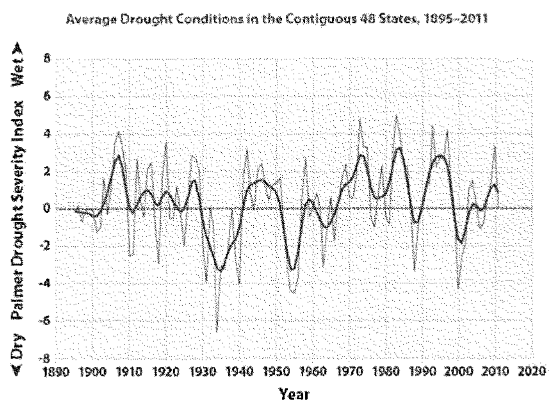
[47] *Dangers to Forests Seen From Warming*, N.Y. TIMES, Aug. 17, 1993, http://www.nytimes.com/1993/08/17/science/dangers-to-forests-seen-from-warming.html.
[48] Andrew C. Revkin, *Global Warming is Expected to Raise Hurricane Intensity*, N.Y. TIMES, Sept. 30, 2004, http://www.nytimes.com/learning/students/pop/articles/30hurricane_LN.html.
[49] Jeffrey Kluger, *Earth at the Tipping Point: Global Warming Heats Up*, TIME, Mar. 26, 2006, http://www.time.com/time/magazine/article/0,9171,1176980,00.html.
[50] Press Release, Office of Sen. Bernie Sanders, Global Warming and Hurricane Sandy (Nov. 1, 2012) http://www.sanders.senate.gov/newsroom/news/?id=ad66348a-d6cc-4d43-8241-c5f2bffaf633.
[51] President Barack Obama, State of the Union Address (Feb. 12, 2013).
[52] Sen. Sheldon Whitehouse, *The Price of Ignoring Climate Change*, REUTERS, June 19, 2013.
[53] Bjorn Lomborg, *Climate-Change Misdirection*, WALL STREET J., Jan. 23, 2013, http://online.wsj.com/article/SB10001424127887323485704578258172660564886.html.

In the United States, the number of wildfires over the last fifty years is as follows:



Droughts have not increased:

"The world has not seen a general increase in drought. A study published in *Nature* in November shows globally that 'there has been little change in drought over the past 60 years.' The U.N. Climate Panel in 2012 concluded: 'Some regions of the world have experienced 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.'"[54]



Data source: NOAA (National Oceanic and Atmospheric Administration). 2012. National Climatic Data Center. Accessed January 2012. www.ncdc.noaa.gov/oa/ncdc.html.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

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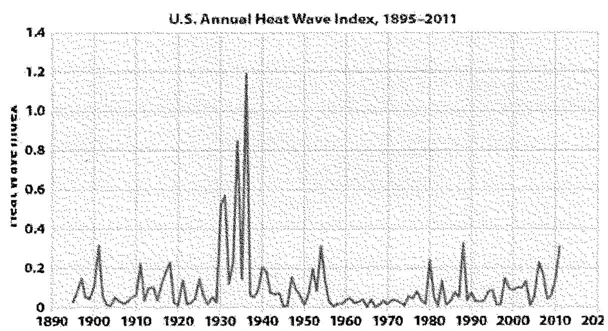
[54] *Id.*

Heat waves have not increased:

"The "Dust Bowl" years of 1930-36 brought some of the hottest summers on record to the United States, especially across the Plains, Upper Midwest and Great Lake States. For the Upper Mississippi River Valley, the first few weeks of July 1936 provided the hottest temperatures of that period, including many all-time record highs. The string of hot, dry days was also deadly. Nationally, around 5000 deaths were associated with the heat wave. In La Crosse, WI, there were 14 consecutive days (July 5th-18th) where the high temperature was 90 degrees or greater, and 9 days that were at or above 100. Six record July temperatures set during this time still stand, including the hottest day on record with 108 on the 14th. The average high temperature for La Crosse during this stretch of extreme heat was 101."[55]



Hurricane activity has not increased:

According to Dr. Bjorn Lomborg, Director of Copenhagen Consênsus Center and Adjunct Professor at Copenhagen Business School, "As for one of the favorites of alarmism, hurricanes in recent years don't indicate that storms are getting worse. Measured by total energy (Accumulated Cyclone Energy), hurricane activity is at a low not encountered since the 1970s. The U.S. is currently experiencing the longest absence of severe landfall hurricanes in over a century—the last Category 3 or stronger storm was Wilma, more than seven years ago."[56]

"While it's hardly mentioned in the media, the U.S. is currently in an extended and intense hurricane 'drought.'"[57]

The source of the following three graphs is Professor Roger Pielke, Jr., in his July 18, 2013, testimony before the Senate EPW Committee:

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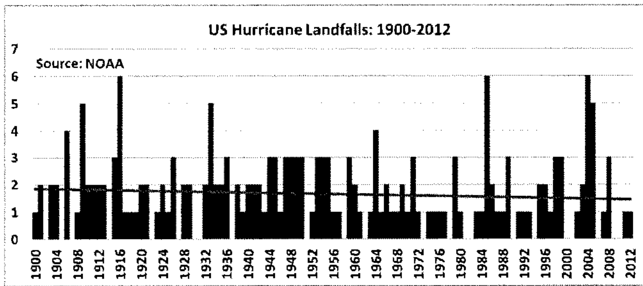
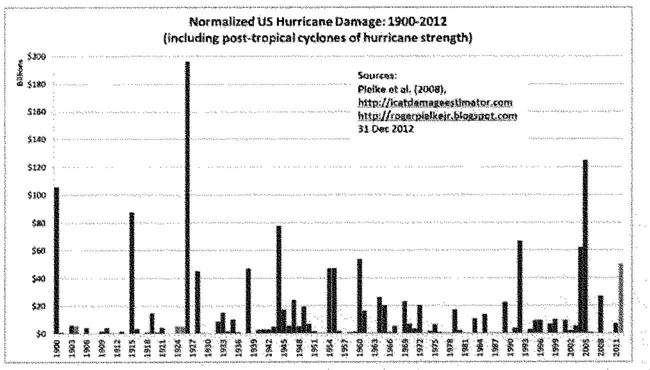
[55] *The Heatwave of July 1936*, Nat'l Oceanic & Atmospheric Admin. Nat'l Weather Serv. Weather Forecast Office, http://www.crh.noaa.gov/arx/events/heatwave36.php.
[56] Bjorn Lomborg, *Climate-Change Misdirection*, WALL STREET J., Jan. 23, 2013, http://online.wsj.com/article/SB10001424127887323485704578258172660564886.html.
[57] Roger Pielke, *Hurricanes and Human Choice*, WALL STREET J., Oct. 31, 2012, http://online.wsj.com/article/SB10001424052970204840504578089413659452702.html.



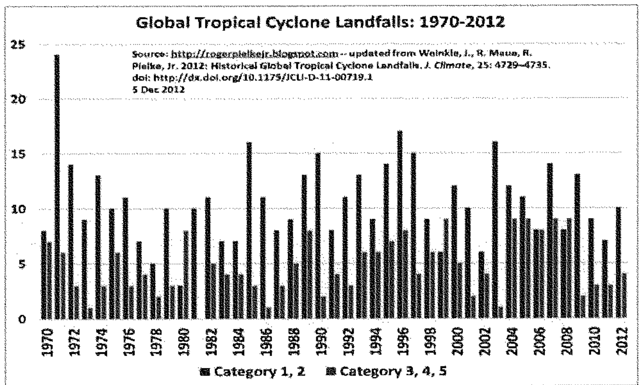
Number of landfalling U.S. hurricanes from 1900-2012. The red line shows the linear trend, exhibiting a decrease from about 2 to 1.5 landfalls per year since 1900. Source: NOAA.[58]



Normalized U.S. hurricane damage 1900-2012, estimated total damage if each past hurricane season occurred with 2012 levels of development. After Pielke et al. 2008.[59] Note that the figure includes "Superstorm" Sandy (2012) in gray and placeholders for the three other post-tropical cyclones of hurricanes which made landfall in 1904, 1924 and 1925.

[58] *Chronological List of All Hurricanes: 1851-2012*, Nat'l Oceanic & Atmospheric Admin. Hurricane Research Div., http://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html.

[59] Roger A. Pielke, Jr. et al., *Normalized Hurricane Damages in the United States: 1900-2005*, 9(1) Natural Hazards Rev. 29-42 (2008). The data is updated to 2012 values using the ICAT Damage Estimator. ICAT Damage Estimator, http://www.icatdamageestimator.com.



Global tropical cyclone (called hurricanes in the North Atlantic) landfalls, 1970-2012, after Weinkle et al. 2012.[60]

Questions for Critical Thinking:

1. When we are unable to predict extreme weather events, and empirical evidence does not show that extreme weather events are increasing, why would some scientists/activists claim that extreme weather events are the product of human activity?

2. Did extreme weather events begin with the advent of the internal combustion engine, or does historical and geological evidence exist indicating extreme weather events have been occurring for hundreds, thousands, or even millions of years?

3. What is the level of confidence that extreme weather events won't decrease in a warming climate? Is there evidence that colder climates can be harsher?

IV. CLIMATE REGULATION: WHAT IS IT REALLY ABOUT?

> *"If you once forfeit the confidence of your fellow citizens, you can never regain their respect and esteem. It is true that you may fool all of the people some of the time; you can even fool some of the people all of the time; but you can't fool all of the people all of the time."* Abraham Lincoln, 16th President of the United States[61]

The following is a list of claims made by key activists and political officials in the climate science community:

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[60] Jessica Weinkle et al., *Historical Global Tropical Cyclone Landfalls*, 25 J. CLIMATE 4729-4735 (2012), *available at* http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-11-00719.1.
[61] President Abraham Lincoln, Speech at Clinton, IL (Sept. 8, 1854).

- Stephen Schneider, who authored *The Genesis Strategy*, a 1976 book warning that global cooling risks posed a threat to humanity, later changed that view 180 degrees when he served as a lead author for important parts of three sequential IPCC reports. In an article published in *Discover*, he said: "On the one hand, as scientists we are ethically bound to the scientific method, on the other hand, we are not just scientists, but human beings as well. And like most people, we'd like to see the world a better place, which in this context translates into our working to reduce the risk of potentially disastrous climatic change. To do that, we need to get some broad-based support, to capture the public's imagination. That, of course, entails getting loads of media coverage. So we have to offer up scary scenarios, make simplified, dramatic statements, and make little mention of the doubts we might have. Each of us has to decide what the right balance is between being effective and being honest."[62]

- In 1988, the former Canadian Minister of the Environment told editors and reporters of the *Calgary Herald*, "No matter if the science of global warming is all phony…climate change [provides] the greatest opportunity to bring about justice and equality in the world."[63]

- Maurice Strong, who organized the first U.N. Earth Climate Summit (1992) in Rio de Janeiro, Brazil, expressed his true position on climate issues: "We may get to the point where the only way of saving the world will be for industrialized civilization to collapse."[64]

- Former U.S. Senator Timothy Wirth (D-CO), and former U.S. Undersecretary of State for global issues, likely agreed with Maurice Strong at the same Rio Climate Summit when he stated: "We have got to ride the global warming issue. Even if the theory of global warming is wrong, we will be doing the right thing in terms of economic policy and environmental policy."[65]

- Also at the Rio conference, then-Deputy Assistant of State Richard Benedick, who headed the policy divisions of the U.S. State Department, stated: "A global warming treaty [such as the Kyoto Protocol] must be implemented even if there is no scientific evidence to back the [enhanced] greenhouse effect."[66]

- Speaking at the 2000 U.N. Conference on Climate Change in the Hague, former President Jacques Chirac of France explained why the IPCC's climate initiative supported a key Western European Kyoto Protocol objective: "For the first time, humanity is instituting a genuine instrument of global governance, one that should find a place within the World Environmental Organization which France and the European Union would like to see established."[67]

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[62] STEPHEN H. SCHNEIDER & LYNNE E. MESIROW, The GENESIS STRATEGY: CLIMATE AND GLOBAL SURVIVAL (1976).
[63] Larry Bell, *Global Warming Alarmism: When Science IS Fiction*, FORBES, May 29, 2012, http://www.forbes.com/sites/larrybell/2012/05/29/global-warming-alarmism-when-science-is-fiction/2/.
[64] LARRY BELL, CLIMATE OF CORRUPTION: POLITICS AND POWER BEHIND THE GLOBAL WARMING HOAX 226 (2011).
[65] Larry Bell, *In Their Own Words: Climate Alarmists Debunk Their 'Science'*, FORBES, Feb. 5, 2013, http://www.forbes.com/sites/larrybell/2013/02/05/in-their-own-words-climate-alarmists-debunk-their-science/.
[66] *Id.*
[67] *Id.*

- On November 14, 2010, Ottmar Edenhofer, a U.N. IPCC Official, stated, "First of all, developed countries have basically expropriated the atmosphere of the world community. 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...."[68]

Just something to ponder:

- As Greenpeace co-founder Patrick Moore observed on Fox Business News in January 2011, "We do not have any scientific proof that we are the cause of the global warming that has occurred in the last 200 years....The alarmism is driving us through scare tactics to adopt energy policies that are going to create a huge amount of energy poverty among the poor people. It's not good for people and it's not good for the environment.... In a warmer world we can produce more food."[69]

- "The World Bank board of directors could today endorse a sweeping new energy policy that for the first time restricts financing for new coal plants in poor countries, bank officials confirmed." Lisa Friedman, *E&E* reporter, July 16, 2013[70]

V. THE SCIENCE IS SETTLED: THE GOVERNMENT CAN'T CONTROL CLIMATE

"Any physical theory is always provisional, in the sense that it is only a hypothesis: you can never prove it. No matter how many times the results of experiments agree with some theory, you can never be sure that the next time the result will not contradict the theory. On the other hand, you can disprove a theory by finding even a single observation that disagrees with the predictions of the theory." Stephen Hawking, English theoretical physicist, cosmologist, author and Director of Research at the Centre for Theoretical Cosmology within the University of Cambridge[71]

Claim:

"Humanity is sitting on a time bomb. If the vast majority of the world's scientists are right, we have just ten years to avert a major catastrophe that could send our entire planet's climate system into a tail-spin of epic destruction involving extreme weather, floods, droughts, epidemics and killer heat waves beyond anything we have ever experienced—a catastrophe of our own making." Al Gore[72]

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[68] *The Science is Settled: U.N. Official Admits Climate Policy is About Wealth Redistribution and Not Global Warming*, MOTOR CITY TIMES, Nov. 18, 2010.
[69] Larry Bell, *In Their Own Words: Climate Alarmists Debunk Their 'Science'*, FORBES, Feb. 5, 2013, http://www.forbes.com/sites/larrybell/2013/02/05/in-their-own-words-climate-alarmists-debunk-their-science/.
[70] Lisa Friedman, *World Bank Approves Landmark Coal Restrictions*, E & E PUBL'G, July 17, 2013.
[71] STEPHEN HAWKING, A BRIEF HISTORY OF TIME: FROM THE BIG BANG TO BLACK HOLES 10 (1988).
[72] Documentary, AN INCONVENIENT TRUTH (2006).

<u>Can our government and the U.N. control these factors</u>:

- <u>Solar Radiation</u>: "Variations in the amount of solar radiation reaching the Earth are thought to influence climate, but the extent of this influence on timescales of millennia to decades is unclear. A number of climate records show correlations between solar cycles and climate, but the absolute changes in solar intensity over the range of decades to millennia are small and the influence of solar flux on climate is not well established."[73]

- <u>Cosmic Rays</u>: "The second type of mechanisms is indirect, through the solar modulation of the cosmic ray flux and the effect that the latter may have on the climate. Cosmic rays are high energy particles (primarily protons) which appear to originate from supernova remnants (the leftovers from the explosive death of massive stars). A possible climatic link through cosmic rays was first suggested by Edward Ney already in 1959. It was well known that the solar wind decreases the flux of these high energy particles and that these particles are the primary source of ionization in the troposphere (which is the lower part of the atmosphere). Ney proposed that the changing levels of ionization can play some climatic role."[74]

- <u>Supernovae</u>: "The hypothesis that a high GCR flux should coincide with cold conditions on the Earth is borne out by comparing the general geological record of climate over the past 510 million years with the fluctuating local SN rates. Surprisingly a simple combination of tectonics (long-term changes in sea level) and astrophysical activity (SN rates) largely accounts for the observed variations in marine biodiversity over the past 510 Myr."[75]

- <u>Ocean Currents</u>: "Understanding the processes that drive sea-ice formation and advancement can help scientists predict the future extent of Arctic ice coverage — an essential factor in detecting climate fluctuations and change. But existing models vary in their predictions for how sea ice will evolve."[76]

<u>Summary Thought</u>:

- Given the dynamic nature of our climate and the factors well outside of human control (many of which are not listed above), including lack of technology to govern these factors, is it possible to control and stop climate change through government regulations?

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[73] U. Neff, et al., *Strong Coherence between Solar Variability and the Monsoon in Oman between 9 and 6 kyr ago*, 411 NATURE J. 290-293 (2001).
[74] Nir Shaviv, *20th Century Global Warming "There is Nothing New Under the Sun"*, Racah Inst. of Physics, Hebrew Univ. of Jerusalem (June 2010), *available at* http://www.sciencebits.com/NothingNewUnderTheSun-1.
[75] Henrik Svensmark, *Evidence of Nearby Supernovae Affecting Life on Earth*, 423 MONTHLY NOTICES OF ROYAL ASTRONOMICAL SOC'Y 1234-1253 (Apr. 2012).
[76] Jennifer Chu, *Ocean Currents Play a Role in Predicting Extent of Arctic Sea Ice*, Mass. Inst. of Tech. News, Nov. 21, 2012, http://web.mit.edu/newsoffice/2012/ocean-currents-and-sea-ice-1121.html.

VI. SUMMARY: POINTS ON U.S. UNILATERAL REGULATION

- On December 7, 2009, the EPA expanded its regulation over air quality through an endangerment finding, determining that GHGs harm public health. This has become a cornerstone of the Obama Administration's regulatory agenda.

- However, EPA's Inspector General released a report in September 2011, "Procedural Review of EPA's Greenhouse Gases Endangerment Finding Data Quality Processes,"[77] revealing that the scientific assessment underpinning the EPA's endangerment finding for GHGs was inadequate and in violation of the Agency's own peer review procedures.

- According to the EPA's own website, total GHG emissions have only risen 1% in the U.S. since 2005,[78] while levels in China, India, and Russia have combined to rise more than 6%.[79] China is responsible for two-thirds of that number.

- China has surpassed the United States as the world's largest producer of CO_2.[80] They emit more CO_2 than the U.S. and Canada combined, and India is now the world's third biggest emitter of CO_2 - pushing Russia into fourth place. Simultaneously, U.S. CO_2 levels have been steadily declining.[81]

- According to a recent report from the World Resources Institute, there are plans to build nearly 1,200 coal-fired power plants in 59 different countries, totaling over 1.4 million megawatts. China and India alone account for 76 % of the proposals.[82] China now burns more coal than all countries combined, and India will surpass the United States as the world's second-largest consumer of coal by 2017.[83]

- Future emissions will come overwhelmingly from the developing world, and the most significant emitters (China, India, and Russia) do not ascribe to international GHG reduction agreements. Regardless, the Obama Administration maintains that it is in our best interest to regulate CO_2 domestically.

- Senator Joe Manchin (D-WV) had this to say about EPA's approach to climate and energy: "You know my concerns about the EPA not having an all-in energy policy. If we're talking about climate change and we're talking about the world consuming 8 billion

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[77] ENVTL. PROT. AGENCY, OFFICE OF INSPECTOR GEN., REPORT NO. 11-P-0702, PROCEDURAL REVIEW OF EPA'S GREENHOUSE GASES ENDANGERMENT FINDING DATA QUALITY PROCESSES (2011), *available at* http://www.epa.gov/oig/reports/2011/20110926-11-P-0702.pdf.

[78] *Global Greenhouse Gas Emissions Data*, U.S. Envtl. Prot. Agency, http://www.epa.gov/climatechange/ghgemissions/global.html.

[79] *Canada's Emissions Trends*, Env't Canada (2011) http://www.ec.gc.ca/doc/publications/cc/COM1374/ec-com1374-en-es.htm.

[80] *World Carbon Dioxide Emissions Data by Country: China Speeds Ahead of the Rest*, THE GUARDIAN DATA BLOG, http://www.guardian.co.uk/news/datablog/2011/jan/31/world-carbon-dioxide-emissions-country-data-co2.

[81] *Id.*

[82] Ailun Yang & Yiyun Cui, *Global Coal Risk Assessment: Data Analysis and Market Research*, (World Res. Inst., Working Paper, Nov. 2012), *available at* http://pdf.wri.org/global_coal_risk_assessment.pdf.

[83] Brad Plumer, *China Now Burning as much Coal as the Rest of the World*, WASH. POST, (Jan. 29, 2013), http://www.washingtonpost.com/blogs/wonkblog/wp/2013/01/29/china-is-burning-nearly-as-much-coal-as-the-rest-of-the-world-combined/.

tons of coal and the United States of America consuming less than 1 billion tons of coal, what's their proposal for cleaning up the environment on a global market?"[84]

- Even former EPA Administrator Lisa Jackson confirms that only having the United States regulate carbon will not have any impact on worldwide carbon levels. She testified at the July 7, 2009, EPW hearing, "Moving America toward a Clean Energy Economy and Reducing Global Warming Pollution: Legislative Tools," "I believe the central parts of the [EPA] chart are that U.S. action alone will not impact world CO_2 levels."[85]

- Regardless of her admission, EPA perseveres in moving forward with regulations targeting GHG emissions while justifying these rules as being beneficial to the economy, as well as public health and welfare. However, in February 2013, the U.S. Chamber of Commerce released a study examining dozens of air pollution rules dating from the 1990s. It reveals flawed analyses that do not take into account economy-wide impacts or negative impacts of the rules, raising significant concerns with the underlying economic modeling EPA utilizes.[86]

- President Obama's "green jobs" movement represents the epitome of failed government based on the false belief that U.S action alone is sound policy. Estimates from the National Renewable Energy Laboratory show that the government spent about $9 billion on green jobs and created just 910 new, long-term jobs. This means taxpayers spent $9.8 million per job.[87]

- The EU Emissions Trading Scheme (ETS) has cost their consumers $287 billion for "almost zero impact" on cutting carbon emissions, according to a 2011 UBS study. [88]

- Imposing a carbon tax on corporations and private business, which ultimately impacts consumers, is no wiser than unilateral regulation. In November 2012, the Congressional Budget Office released a study noting a carbon tax would "impose a larger burden, relative to income, on low-income households than on high-income households."[89] Furthermore, there exists zero evidence that carbon trading schemes in the EU, much less the United States, are having any impact on climate nor are they resulting in positive economic impacts or job creation in those regions.

- In late February 2013, the National Association of Manufacturers (NAM) released a study demonstrating the devastating effects a carbon tax would have on the economy,

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[84] Jason Plautz, *Former McCarthy Skeptic Signals 2nd-round Battle over Nomination*, ENV'T & ENERGY DAILY, March 5, 2013, http://www.eenews.net/EEDaily/2013/03/05/1.
[85] Hearing before the S. Comm. on Env't & Public Works, 111th Cong. (2009) (statement of Lisa Jackson, former EPA Administrator).
[86] *See generally* IMPACTS OF REGULATIONS ON EMPLOYMENT: EXAMINING EPA's OFT-REPEATED CLAIMS THAT REGULATIONS CREATE JOBS, U.S. CHAMBER OF COMMERCE (Feb. 2013), *available at* http://www.uschamber.com/sites/default/files/reports/020360_ETRA_Briefing_NERA_Study_final.pdf.
[87] David Horowitz & Jacob Laksin, *Obama's Green Jobs Bust*, THE DAILY CALLER, July 10, 2012, http://dailycaller.com/2012/07/10/obamas-green-jobs-bust/.
[88] Sid Maher, *Europe's $287bn Carbon 'Waste': UBS Report*, THE AUSTRALIAN, Nov. 23, 2011, http://www.theaustralian.com.au/national-affairs/europes-287bn-carbon-waste-ubs-report/story-fn59niix-1226203068972.
[89] Terry Dinan, *Offsetting a Carbon Tax's Costs on Low-Income Households* (Cong. Budget Office, Working Paper No. 16, 2012), *available at* http://www.cbo.gov/sites/default/files/cbofiles/attachments/11-13LowIncomeOptions.pdf.

> including manufacturing output falling up to 15 percent, millions of jobs lost, and approximately a $1 trillion reduction in economic growth.[90] Unilateral regulatory action by the EPA is set to similarly undermine our national economy.

"The energy of the mind is the essence of life."[91] Aristotle, Greek philosopher and polymath, a student of Plato and teacher of Alexander the Great

[90] ECONOMIC OUTCOME OF A U.S. CARBON TAX, NERA ECONOMIC CONSULTING (Feb. 26, 2013) http://www.nam.org/~/media/64FDD87B13C44C3E8E95CC805E4E5952.ashx?utm_source=nam&utm_medium=alias&utm_campaign=CarbonTax+Full+Report.

[91] *See The Power of the Mind: Quotes to Get You Thinking*, PSYCHOLOGY TODAY (Jan. 4, 2012) http://www.psychologytoday.com/blog/high-octane-women/201201/the-power-the-mind-quotes-get-you-thinking.

Ten Lessons of the Solyndra Failure

September 14, 2012

With National Debt Surpassing $16 Trillion, "No More Solyndras Act" Needed Now More Than Ever To Protect Taxpayer Dollars

WASHINGTON, DC – Today, the House of Representatives will vote on the Energy and Commerce Committee's "No More Solyndras Act," H.R. 6213. The legislation was authored by full committee Chairman Fred Upton (R-MI) and Oversight and Investigations Subcommittee Chairman Cliff Stearns (R-FL), drawing upon the lessons of the committee's investigation into the Department of Energy's (DOE's) $535 million loan guarantee to Solyndra, the California solar panel manufacturer that ultimately went bankrupt last September.

Here are some of the startling facts discovered during the committee's investigation into the Obama administration's highly touted stimulus "success story":

1) The White House ignored its own experts' warnings.

The administration was warned that Solyndra was a bad bet from the beginning. One Obama administration Office of Management and Budget (OMB) employee wrote in an email in March of 2009 that the Solyndra "deal is NOT ready for prime time." Another DOE employee prophetically warned that Solyndra would be out of cash in September 2011 – the exact month that the company was raided by the FBI and its doors were shuttered.

2) Solyndra's rushed approval was for a previously scheduled press event

Documents obtained by the committee show the White House rushed to approve the loan in spite of the warning signs to coincide with the press event for Solyndra's groundbreaking. An e-mail between OMB staff noted, "Given the time pressure we are under to sign-off on Solyndra, we don't have time to change the model. ." As scheduled, Vice President Biden appeared via satellite at the groundbreaking ceremony just days later and touted Solyndra's ability to create "permanent jobs."

3) DOE failed to monitor Solyndra's financial condition.

While a 2010 SEC filing showed Solyndra had never reported a profit, was experiencing negative cash flows, and had cancelled a $300 million initial public stock offering, the DOE failed to adequately monitor Solyndra's financial condition. After this filing, and after Solyndra laid off employees, Republican members on the House Energy and Commerce Committee began asking questions about the Solyndra loan. Solyndra later attempted to mislead members of the committee by producing a document in July of 2011, entitled "Exceeding Expectations: Solyndra Today" that claimed the company's financial condition was improving.

4) The Obama administration stonewalled the committee's investigation.

After OMB's refusal to provide any of its communications and internal documents regarding Solyndra, the Subcommittee on Oversight and Investigations was forced to issue a subpoena in July 2011, for documents pertaining to the loan. Four months later, after the White House refused to respond to the committee's request for documents, the committee issued two subpoenas to President Obama's and Vice President Biden's Chiefs of Staff for Solyndra-related documents.

5) Solyndra went belly up precisely when predicted.

On September 6, 2011, Solyndra, the company that President Obama heralded as "leading the way toward a brighter and more prosperous future," filed for bankruptcy, resulting in the loss of nearly 1,900 jobs. Just 2 days later on September 8, 2011, the FBI raided the Fremont, California company. Regrettably, the bankruptcy wouldn't have come as a surprise to the Obama administration. In an August 2009 email, DOE staff warned that Solyndra would be out of cash in September 2011: "(T)he issue is cash balances. . (T)he model runs out of cash in September 2011 even in the best case..." *(See Footnote 191 for The Solyndra Failure HERE.)*

6) No regrets.

In an interview on October 3, 2011, ABC News asked President Obama whether he had any regrets over the Solyndra deal. The president replied, "No I don't," and simply that, "hindsight is always 20-20." Several months later the president doubled down on deflecting responsibility for Solyndra's failure by stating, "But understand: This was not our program, per se." Even as recently as July of 2012, the Acting Executive Director of the DOE Loan Program Office called the program responsible for Solyndra an "enormous success."

7) The Department of Energy's restructuring of the Solyndra loan violated the law.

The committee's investigation discovered that DOE knowingly violated the law when it restructured the terms of the loan guarantee and put the interests of wealthy investors ahead of taxpayers. The committee also found DOE employed the "Clinton Defense" in distorting the definition of the word "is" in the statute to legally justify subordination. OMB's oversight and review of Solyndra's restructuring occured under then-director, now White House Chief of Staff Jack Lew's tenure. Despite warnings from an agency analyst that saving Solyndra could cost taxpayers more than allowing the solar company to fail, Lew failed to stop the restructuring when he had the opportunity. *(See section VII of The Solyndra Failure HERE.)*

8) It wasn't just Solyndra.

Documents obtained by the committee exposed a startling relationship between Solyndra and another stimulus-backed project. Solyndra was a key supplier for Prologis' Project Amp, a solar panel installation project and the recipient of a partial loan guarantee for $1.4 billion. The committee's investigation showed the White House was well aware of Solyndra's deteriorating financial condition when it allowed DOE to move forward with Project Amp. DOE would later use the relationship between Project Amp and Solyndra as a key bargaining tool to push for a second restructuring while directly engaging in last minute negotiations between Solyndra and the Project Amp sponsor. Additionally, other DOE loan guarantee recipients under the same loan guarantee program have either failed or are running out of cash. It is this program that the "No More Solyndas Act" phases out.

9) Solyndra backers had close political connections to the White House.

As reported by ABC News, "One of Solyndra's major investors was George Kaiser, an Oklahoma billionaire who raised between $50,000 and $100,000 for Obama during the 2008 election." ABC also reported that "Kaiser is one of several Obama campaign supporters who had a stake in companies that later received federal loans..." George Kaiser was closely involved in important decisions related to Solyndra through the life of the loan guarantee. According to the committee's report, "Individuals connected to the George Kaiser Family Foundation (GKFF) — whose primary investment arm, Argonaut, was Solyndra's largest shareholder — played important roles in a series of critical discussions and negotiations with DOE. George Kaiser, whose fortune funds the GKFF, was closely involved in financial decisions related to Solyndra, often authorizing key disbursements and restructuring proposals, as well as in Solyndra's lobbying, public relations, and government procurement strategies in Washington." *(See page 4-5 of The Solyndra Failure [illegible])*

10) As Solyndra's bankruptcy unfolds, it's like rubbing salt into the taxpayers' wound.

While American taxpayers are stuck footing the bill for the Solyndra failure, Solyndra's private investors, including George Kaiser, now stand to gain hundreds of millions of dollars in tax breaks from Solyndra's bankruptcy

For more information on the "No More Solyndras Act," click here.

To view the committee report, **The Solyndra Failure**, click here.

To view The Solyndra Failure's supporting documents, click here.

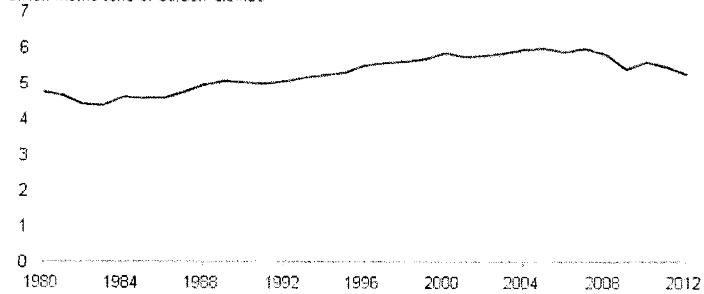
eia U.S. Energy Information Administration

Today in Energy

April 5, 2013

Energy-related carbon dioxide emissions declined in 2012

Annual carbon dioxide emissions from U.S. energy consumption
(1980-2012)
billion metric tons of carbon dioxide



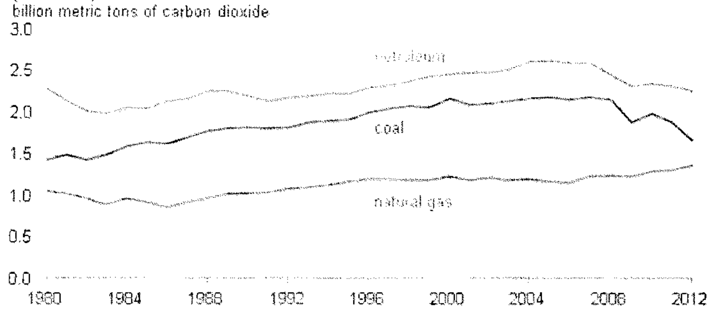
Source: U.S. Energy Information Administration, Monthly Energy Review
Download CSV Data

Energy-related carbon dioxide (CO_2) emissions in 2012 were the lowest in the United States since 1994, at 5.3 billion metric tons of CO_2 (see figure above). With the exception of 2010, emissions have declined every year since 2007.

The largest drop in emissions in 2012 came from coal, which is used almost exclusively for electricity generation (see figure below). During 2012, particularly in the spring and early summer, low natural gas prices led to competition between natural gas- and coal-fired electric power generators. Lower natural gas prices resulted in reduced levels of coal generation, and increased natural gas generation—a less carbon-intensive fuel for power generation, which shifted power generation from the most carbon-intensive fossil fuel (coal) to the least carbon-intensive fossil fuel (natural gas).

Other factors contributing to the lower emissions include decreased demand for transportation fuels and mild winter temperatures that reduced demand for heating. The warm winter months during 2012 (particularly in the first quarter) more than offset a slight increase in cooling degree days during the summer months. EIA recently published preliminary data for January-December 2012 in the March 2013 edition of the Monthly Energy Review, which includes statistics covering all aspects of energy. EIA will publish a full analysis of 2012 energy-related CO_2 emissions later this year.

Annual carbon dioxide emissions from U.S. energy consumption by major source
(1980-2012)
billion metric tons of carbon dioxide



Source: U.S. Energy Information Administration, Monthly Energy Review
Download CSV Data

EXTENSION GRANTED

Form 990-PF — Return of Private Foundation

or Section 4947(a)(1) Nonexempt Charitable Trust Treated as a Private Foundation

Department of the Treasury, Internal Revenue Service

Note: The foundation may be able to use a copy of this return to satisfy state reporting requirements

OMB No 1545-0052 — 2009

For calendar year 2009, or tax year beginning , 2009, and ending , 20

G Check all that apply: [ ] Initial return [ ] Initial return of a former public charity [ ] Final return [ ] Amended return [ ] Address change [ ] Name change

Use the IRS label. Otherwise, print or type. See Specific Instructions

Name of foundation: CLAUDE R. LAMBE CHARITABLE FOUNDATION

A Employer identification number: 48-0935563

Number and street (or P O box number if mail is not delivered to street address) / Room/suite: P.O. BOX 2256

B Telephone number (see page 10 of the instructions): (316) 828-5552

City or town, state, and ZIP code: WICHITA, KS 67201-2256

C If exemption application is pending, check here ▶ [ ]

D 1 Foreign organizations, check here ▶ [ ]

2 Foreign organizations meeting the 85% test, check here and attach computation ▶ [ ]

H Check type of organization: [X] Section 501(c)(3) exempt private foundation [ ] Section 4947(a)(1) nonexempt charitable trust [ ] Other taxable private foundation

E If private foundation status was terminated under section 507(b)(1)(A), check here ▶ [ ]

I Fair market value of all assets at end of year (from Part II, col (c), line 16) ▶ $ 7,349,000.

J Accounting method [ ] Cash [X] Accrual [ ] Other (specify) (Part I, column (d) must be on cash basis.)

F If the foundation is in a 60-month termination under section 507(b)(1)(B), check here ▶ [ ]

Part I Analysis of Revenue and Expenses (The total of amounts in columns (b), (c), and (d) may not necessarily equal the amounts in column (a) (see page 11 of the instructions).)

		(a) Revenue and expenses per books	(b) Net investment income	(c) Adjusted net income	(d) Disbursements for charitable purposes (cash basis only)
Revenue	1 Contributions, gifts, grants, etc., received (attach schedule)				
	2 Check ▶ [X] if the foundation is not required to attach Sch B				
	3 Interest on savings and temporary cash investments	81,536.	81,536.		
	4 Dividends and interest from securities	32,478.	32,478.		
	5a Gross rents				
	b Net rental income or (loss)				
	6a Net gain or (loss) from sale of assets not on line 10	-19,155.			
	b Gross sales price for all assets on line 6a 1,206,072.				
	7 Capital gain net income (from Part IV, line 2)				
	8 Net short-term capital gain				
	9 Income modifications				
	10a Gross sales less returns and allowances				
	b Less Cost of goods sold				
	c Gross profit or (loss) (attach schedule)				
	11 Other income (attach schedule)				
	12 Total. Add lines 1 through 11	94,859.	114,014.		
Operating and Administrative Expenses	13 Compensation of officers, directors, trustees, etc				
	14 Other employee salaries and wages				
	15 Pension plans, employee benefits				
	16a Legal fees (attach schedule)				
	b Accounting fees (attach schedule) ATCH 1	22,320.	3,525.	0.	16,150.
	c Other professional fees (attach schedule) *	15,982.	15,982.		
	17 Interest				
	18 Taxes (attach schedule) (see page 14 of the instructions) **	945.			
	19 Depreciation (attach schedule) and depletion				
	20 Occupancy				
	21 Travel, conferences, and meetings				
	22 Printing and publications				
	23 Other expenses (attach schedule) ATCH 4	1,778.			1,339.
	24 Total operating and administrative expenses. Add lines 13 through 23	41,025.	19,507.	0.	17,489.
	25 Contributions, gifts, grants paid	2,819,461.			2,713,796.
	26 Total expenses and disbursements Add lines 24 and 25	2,860,486.	19,507.	0.	2,731,285.
	27 Subtract line 26 from line 12				
	a Excess of revenue over expenses and disbursements	-2,765,627.			
	b Net investment income (if negative, enter -0-)		94,507.		
	c Adjusted net income (if negative, enter -0-)			-0-	

RECEIVED NOV 19 2010 OGDEN, UT IRS-OSC

SCANNED NOV 24 2010

For Privacy Act and Paperwork Reduction Act Notice, see page 30 of the instructions. * ATCH 2 JSA ** ATCH 3 Form 990-PF (2009)

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7

Form 990-PF (2009) 48-0935563 Page 2

Part II Balance Sheets Attached schedules and amounts in the description column should be for end-of-year amounts only (See instructions)

		Beginning of year (a) Book Value	End of year (b) Book Value	End of year (c) Fair Market Value
Assets	1 Cash - non-interest-bearing			
	2 Savings and temporary cash investments	7,337,267.	4,509,294.	4,509,294.
	3 Accounts receivable ▶ 168. Less allowance for doubtful accounts ▶	0.	168.	168.
	4 Pledges receivable ▶ Less allowance for doubtful accounts ▶			
	5 Grants receivable			
	6 Receivables due from officers, directors, trustees, and other disqualified persons (attach schedule) (see page 16 of the instructions)			
	7 Other notes and loans receivable (attach schedule) ▶ Less allowance for doubtful accounts ▶			
	8 Inventories for sale or use			
	9 Prepaid expenses and deferred charges	9,021.	9,378.	9,378.
	10 a Investments - U S and state government obligations (attach schedule)			
	b Investments - corporate stock (attach schedule)			
	c Investments - corporate bonds (attach schedule)			
	11 Investments - land, buildings, and equipment basis ▶ Less accumulated depreciation (attach schedule) ▶			
	12 Investments - mortgage loans			
	13 Investments - other (attach schedule) ATCH 5	2,623,804.	2,663,574.	2,830,160.
	14 Land, buildings, and equipment basis ▶ Less accumulated depreciation (attach schedule) ▶			
	15 Other assets (describe ▶)			
	16 Total assets (to be completed by all filers - see the instructions Also, see page 1, item I)	9,970,092.	7,182,414.	7,349,000.
Liabilities	17 Accounts payable and accrued expenses	28,146.	6,095.	
	18 Grants payable			
	19 Deferred revenue			
	20 Loans from officers, directors, trustees, and other disqualified persons			
	21 Mortgages and other notes payable (attach schedule)			
	22 Other liabilities (describe ▶)			
	23 Total liabilities (add lines 17 through 22)	28,146.	6,095.	
Net Assets or Fund Balances	Foundations that follow SFAS 117, check here ▶ [X] and complete lines 24 through 26 and lines 30 and 31.			
	24 Unrestricted	9,941,946.	7,176,319.	
	25 Temporarily restricted			
	26 Permanently restricted			
	Foundations that do not follow SFAS 117, check here and complete lines 27 through 31. ▶ [ ]			
	27 Capital stock, trust principal, or current funds			
	28 Paid-in or capital surplus, or land, bldg, and equipment fund			
	29 Retained earnings, accumulated income, endowment, or other funds			
	30 Total net assets or fund balances (see page 17 of the instructions)	9,941,946.	7,176,319.	
	31 Total liabilities and net assets/fund balances (see page 17 of the instructions)	9,970,092.	7,182,414.	

Part III Analysis of Changes in Net Assets or Fund Balances

1	Total net assets or fund balances at beginning of year - Part II, column (a), line 30 (must agree with end-of-year figure reported on prior year's return)	1	9,941,946.
2	Enter amount from Part I, line 27a	2	-2,765,627.
3	Other increases not included in line 2 (itemize) ▶	3	
4	Add lines 1, 2, and 3	4	7,176,319.
5	Decreases not included in line 2 (itemize) ▶	5	
6	Total net assets or fund balances at end of year (line 4 minus line 5) - Part II, column (b), line 30	6	7,176,319.

Part IV Capital Gains and Losses for Tax on Investment Income

	(a) List and describe the kind(s) of property sold (e g , real estate, 2-story brick warehouse, or common stock, 200 shs MLC Co)	(b) How acquired P-Purchase D-Donation	(c) Date acquired (mo , day, yr)	(d) Date sold (mo , day, yr)
1a	SEE PART IV SCHEDULE			
b				
c				
d				
e				

	(e) Gross sales price	(f) Depreciation allowed (or allowable)	(g) Cost or other basis plus expense of sale	(h) Gain or (loss) (e) plus (f) minus (g)
a				
b				
c				
d				
e				

Complete only for assets showing gain in column (h) and owned by the foundation on 12/31/69

	(i) F M V as of 12/31/69	(j) Adjusted basis as of 12/31/69	(k) Excess of col (i) over col (j), if any	(l) Gains (Col (h) gain minus col (k), but not less than -0-) or Losses (from col (h))
a				
b				
c				
d				
e				

2 Capital gain net income or (net capital loss) { If gain, also enter in Part I, line 7 / If (loss), enter -0- in Part I, line 7 }	2	-19,155.
3 Net short-term capital gain or (loss) as defined in sections 1222(5) and (6) If gain, also enter in Part I, line 8, column (c) (see pages 13 and 17 of the instructions) If (loss), enter -0- in Part I, line 8	3	

Part V Qualification Under Section 4940(e) for Reduced Tax on Net Investment Income

(For optional use by domestic private foundations subject to the section 4940(a) tax on net investment income)

If section 4940(d)(2) applies, leave this part blank

Was the foundation liable for the section 4942 tax on the distributable amount of any year in the base period? ☐ Yes ☒ No

If "Yes," the foundation does not qualify under section 4940(e) Do not complete this part

1 Enter the appropriate amount in each column for each year, see page 18 of the instructions before making any entries

(a) Base period years Calendar year (or tax year beginning in)	(b) Adjusted qualifying distributions	(c) Net value of noncharitable-use assets	(d) Distribution ratio (col (b) divided by col (c))
2008	2,456,244.	11,492,427.	0.213727
2007	4,085,883.	15,540,497.	0.262918
2006	4,231,735.	17,229,773.	0.245606
2005	3,796,938.	19,799,454.	0.191770
2004	3,110,086.	21,925,067.	0.141851

2	Total of line 1, column (d)	2	1.055872
3	Average distribution ratio for the 5-year base period - divide the total on line 2 by 5, or by the number of years the foundation has been in existence if less than 5 years	3	0.211174
4	Enter the net value of noncharitable-use assets for 2009 from Part X, line 5	4	8,782,857.
5	Multiply line 4 by line 3	5	1,854,711.
6	Enter 1% of net investment income (1% of Part I, line 27b)	6	945.
7	Add lines 5 and 6	7	1,855,656.
8	Enter qualifying distributions from Part XII, line 4	8	2,731,285.

If line 8 is equal to or greater than line 7, check the box in Part VI, line 1b, and complete that part using a 1% tax rate See the Part VI instructions on page 18

Part VI Excise Tax Based on Investment Income (Section 4940(a), 4940(b), 4940(e), or 4948 - see page 18 of the instructions)

1a	Exempt operating foundations described in section 4940(d)(2), check here ▶ ☐ and enter "N/A" on line 1. Date of ruling or determination letter ___________ (attach copy of ruling letter if necessary - see instructions)		
b	Domestic foundations that meet the section 4940(e) requirements in Part V, check here ▶ ☒ and enter 1% of Part I, line 27b	1	945.
c	All other domestic foundations enter 2% of line 27b Exempt foreign organizations enter 4% of Part I, line 12, col (b)		
2	Tax under section 511 (domestic section 4947(a)(1) trusts and taxable foundations only Others enter -0-)	2	
3	Add lines 1 and 2	3	945.
4	Subtitle A (income) tax (domestic section 4947(a)(1) trusts and taxable foundations only Others enter -0-)	4	0.
5	**Tax based on investment income** Subtract line 4 from line 3 If zero or less, enter -0-	5	945.
6	Credits/Payments		
a	2009 estimated tax payments and 2008 overpayment credited to 2009 — 6a: 9,021.		
b	Exempt foreign organizations-tax withheld at source — 6b: 0.		
c	Tax paid with application for extension of time to file (Form 8868) — 6c: 0.		
d	Backup withholding erroneously withheld — 6d:		
7	Total credits and payments Add lines 6a through 6d	7	9,021.
8	Enter any **penalty** for underpayment of estimated tax Check here ☐ if Form 2220 is attached	8	
9	**Tax due.** If the total of lines 5 and 8 is more than line 7, enter **amount owed** ▶	9	
10	**Overpayment.** If line 7 is more than the total of lines 5 and 8, enter the **amount overpaid** ▶	10	8,076.
11	Enter the amount of line 10 to be **Credited to 2010 estimated tax** ▶ 8,076. **Refunded** ▶	11	

Part VII-A Statements Regarding Activities

			Yes	No
1a	During the tax year, did the foundation attempt to influence any national, state, or local legislation or did it participate or intervene in any political campaign?	1a		X
b	Did it spend more than $100 during the year (either directly or indirectly) for political purposes (see page 19 of the instructions for definition)?	1b		X
	If the answer is "Yes" to 1a or 1b, attach a detailed description of the activities and copies of any materials published or distributed by the foundation in connection with the activities			
c	Did the foundation file **Form 1120-POL** for this year?	1c		X
d	Enter the amount (if any) of tax on political expenditures (section 4955) imposed during the year (1) On the foundation ▶ $ ________ (2) On foundation managers ▶ $ ________			
e	Enter the reimbursement (if any) paid by the foundation during the year for political expenditure tax imposed on foundation managers ▶ $ ________			
2	Has the foundation engaged in any activities that have not previously been reported to the IRS? *If "Yes," attach a detailed description of the activities*	2		X
3	Has the foundation made any changes, not previously reported to the IRS, in its governing instrument, articles of incorporation, or bylaws, or other similar instruments? *If "Yes," attach a conformed copy of the changes*	3		X
4a	Did the foundation have unrelated business gross income of $1,000 or more during the year?	4a		X
b	If "Yes," has it filed a tax return on **Form 990-T** for this year?	4b		
5	Was there a liquidation, termination, dissolution, or substantial contraction during the year? *If "Yes," attach the statement required by General Instruction T*	5		X
6	Are the requirements of section 508(e) (relating to sections 4941 through 4945) satisfied either • By language in the governing instrument, or • By state legislation that effectively amends the governing instrument so that no mandatory directions that conflict with the state law remain in the governing instrument?	6	X	
7	Did the foundation have at least $5,000 in assets at any time during the year? *If "Yes," complete Part II, col (c), and Part XV*	7	X	
8a	Enter the states to which the foundation reports or with which it is registered (see page 19 of the instructions) ▶ KS, VA,			
b	If the answer is "Yes" to line 7, has the foundation furnished a copy of Form 990-PF to the Attorney General (or designate) of each state as required by *General Instruction G? If "No," attach explanation*	8b	X	
9	Is the foundation claiming status as a private operating foundation within the meaning of section 4942(j)(3) or 4942(j)(5) for calendar year 2009 or the taxable year beginning in 2009 (see instructions for Part XIV on page 27)? *If "Yes," complete Part XIV*	9		X
10	Did any persons become substantial contributors during the tax year? *If "Yes," attach a schedule listing their names and addresses*	10		X

Part VII-A Statements Regarding Activities *(continued)*

			Yes	No
11	At any time during the year, did the foundation, directly or indirectly, own a controlled entity within the meaning of section 512(b)(13)? If "Yes," attach schedule (see page 20 of the instructions)	11		X
12	Did the foundation acquire a direct or indirect interest in any applicable insurance contract before August 17, 2008?	12		X
13	Did the foundation comply with the public inspection requirements for its annual returns and exemption application?	13	X	

Website address ▶ N/A

14 The books are in care of ▶ VONDA HOLLIMAN Telephone no ▶ (316) 828-5552

Located at ▶ 4111 E. 37TH STREET NORTH WICHITA, KS ZIP + 4 ▶ 67220

15 Section 4947(a)(1) nonexempt charitable trusts filing Form 990-PF in lieu of Form 1041 - Check here ▶ ☐
and enter the amount of tax-exempt interest received or accrued during the year ▶ 15

Part VII-B Statements Regarding Activities for Which Form 4720 May Be Required

File Form 4720 if any item is checked in the "Yes" column, unless an exception applies.

			Yes	No
1a	During the year did the foundation (either directly or indirectly)			
	(1) Engage in the sale or exchange, or leasing of property with a disqualified person? ☐ Yes ☒ No			
	(2) Borrow money from, lend money to, or otherwise extend credit to (or accept it from) a disqualified person? ☐ Yes ☒ No			
	(3) Furnish goods, services, or facilities to (or accept them from) a disqualified person? ☒ Yes ☐ No			
	(4) Pay compensation to, or pay or reimburse the expenses of, a disqualified person? ☒ Yes ☐ No			
	(5) Transfer any income or assets to a disqualified person (or make any of either available for the benefit or use of a disqualified person)? ☐ Yes ☒ No			
	(6) Agree to pay money or property to a government official? (**Exception.** Check "No" if the foundation agreed to make a grant to or to employ the official for a period after termination of government service, if terminating within 90 days) ☐ Yes ☒ No			
b	If any answer is "Yes" to 1a(1)-(6), did any of the acts fail to qualify under the exceptions described in Regulations section 53 4941(d)-3 or in a current notice regarding disaster assistance (see page 20 of the instructions)?	1b		X
	Organizations relying on a current notice regarding disaster assistance check here ▶ ☐			
c	Did the foundation engage in a prior year in any of the acts described in 1a, other than excepted acts, that were not corrected before the first day of the tax year beginning in 2009?	1c		X
2	Taxes on failure to distribute income (section 4942) (does not apply for years the foundation was a private operating foundation defined in section 4942(j)(3) or 4942(j)(5))			
a	At the end of tax year 2009, did the foundation have any undistributed income (lines 6d and 6e, Part XIII) for tax year(s) beginning before 2009? ☐ Yes ☒ No			
	If "Yes," list the years ▶			
b	Are there any years listed in 2a for which the foundation is not applying the provisions of section 4942(a)(2) (relating to incorrect valuation of assets) to the year's undistributed income? (If applying section 4942(a)(2) to all years listed, answer "No" and attach statement - see page 20 of the instructions)	2b		
c	If the provisions of section 4942(a)(2) are being applied to any of the years listed in 2a, list the years here ▶			
3a	Did the foundation hold more than a 2% direct or indirect interest in any business enterprise at any time during the year? ☐ Yes ☒ No			
b	If "Yes," did it have excess business holdings in 2009 as a result of (1) any purchase by the foundation or disqualified persons after May 26, 1969, (2) the lapse of the 5-year period (or longer period approved by the Commissioner under section 4943(c)(7)) to dispose of holdings acquired by gift or bequest, or (3) the lapse of the 10-, 15-, or 20-year first phase holding period? *(Use Schedule C, Form 4720, to determine if the foundation had excess business holdings in 2009.)*	3b		
4a	Did the foundation invest during the year any amount in a manner that would jeopardize its charitable purposes?	4a		X
b	Did the foundation make any investment in a prior year (but after December 31, 1969) that could jeopardize its charitable purpose that had not been removed from jeopardy before the first day of the tax year beginning in 2009?	4b		X

Part VII-B Statements Regarding Activities for Which Form 4720 May Be Required *(continued)*

			Yes	No
5a During the year did the foundation pay or incur any amount to:				
(1) Carry on propaganda, or otherwise attempt to influence legislation (section 4945(e))? . . . . . . ☐ Yes ☒ No				
(2) Influence the outcome of any specific public election (see section 4955); or to carry on, directly or indirectly, any voter registration drive? . . . . . . ☐ Yes ☒ No				
(3) Provide a grant to an individual for travel, study, or other similar purposes? . . . . . . ☐ Yes ☒ No				
(4) Provide a grant to an organization other than a charitable, etc., organization described in section 509(a)(1), (2), or (3), or section 4940(d)(2)? (see page 22 of the instructions) . . . . . . ☒ Yes ☐ No				
(5) Provide for any purpose other than religious, charitable, scientific, literary, or educational purposes, or for the prevention of cruelty to children or animals? . . . . . . ☐ Yes ☒ No				
b If any answer is "Yes" to 5a(1)-(5), did any of the transactions fail to qualify under the exceptions described in Regulations section 53.4945 or in a current notice regarding disaster assistance (see page 22 of the instructions)?	5b			X
Organizations relying on a current notice regarding disaster assistance check here . . . . . . ▶ ☐				
c If the answer is "Yes" to question 5a(4), does the foundation claim exemption from the tax because it maintained expenditure responsibility for the grant? . . ATTACHMENT 6 . . . . ☒ Yes ☐ No				
If "Yes," attach the statement required by Regulations section 53.4945-5(d).				
6a Did the foundation, during the year, receive any funds, directly or indirectly, to pay premiums on a personal benefit contract? . . . . . . ☐ Yes ☒ No				
b Did the foundation, during the year, pay premiums, directly or indirectly, on a personal benefit contract?	6b			X
If "Yes" to 6b, file Form 8870.				
7a At any time during the tax year, was the foundation a party to a prohibited tax shelter transaction? . . ☐ Yes ☒ No				
b If yes, did the foundation receive any proceeds or have any net income attributable to the transaction?	7b			

Part VIII Information About Officers, Directors, Trustees, Foundation Managers, Highly Paid Employees, and Contractors

1 List all officers, directors, trustees, foundation managers and their compensation (see page 22 of the instructions).

(a) Name and address	(b) Title, and average hours per week devoted to position	(c) Compensation (If not paid, enter -0-)	(d) Contributions to employee benefit plans and deferred compensation	(e) Expense account, other allowances
SEE ATTACHMENT C		-0-	-0-	-0-

2 Compensation of five highest-paid employees (other than those included on line 1 - see page 23 of the instructions). If none, enter "NONE."

(a) Name and address of each employee paid more than $50,000	(b) Title, and average hours per week devoted to position	(c) Compensation	(d) Contributions to employee benefit plans and deferred compensation	(e) Expense account, other allowances
NONE				

Total number of other employees paid over $50,000 . . . . . . ▶

Part VIII Information About Officers, Directors, Trustees, Foundation Managers, Highly Paid Employees, and Contractors *(continued)*

3 Five highest-paid independent contractors for professional services (see page 23 of the instructions). If none, enter "NONE."

(a) Name and address of each person paid more than $50,000	(b) Type of service	(c) Compensation
NONE		

Total number of others receiving over $50,000 for professional services ▶ NONE

Part IX-A Summary of Direct Charitable Activities

List the foundation's four largest direct charitable activities during the tax year Include relevant statistical information such as the number of organizations and other beneficiaries served, conferences convened, research papers produced, etc	Expenses
1 NONE	
2	
3	
4	

Part IX-B Summary of Program-Related Investments (see page 23 of the instructions)

Describe the two largest program-related investments made by the foundation during the tax year on lines 1 and 2	Amount
1 NONE	
2	
All other program-related investments See page 24 of the instructions	
3 NONE	
Total. Add lines 1 through 3 ▶	

Part X Minimum Investment Return (All domestic foundations must complete this part Foreign foundations, see page 24 of the instructions)

1	Fair market value of assets not used (or held for use) directly in carrying out charitable, etc, purposes		
a	Average monthly fair market value of securities	1a	2,381,950.
b	Average of monthly cash balances	1b	6,534,656.
c	Fair market value of all other assets (see page 24 of the instructions)	1c	0.
d	**Total** (add lines 1a, b, and c)	1d	8,916,606.
e	Reduction claimed for blockage or other factors reported on lines 1a and 1c (attach detailed explanation) 1e		
2	Acquisition indebtedness applicable to line 1 assets	2	0.
3	Subtract line 2 from line 1d	3	8,916,606.
4	Cash deemed held for charitable activities Enter 1 1/2 % of line 3 (for greater amount, see page 25 of the instructions)	4	133,749.
5	**Net value of noncharitable-use assets.** Subtract line 4 from line 3 Enter here and on Part V, line 4	5	8,782,857.
6	**Minimum investment return.** Enter 5% of line 5	6	439,143.

Part XI Distributable Amount (see page 25 of the instructions) (Section 4942(j)(3) and (j)(5) private operating foundations and certain foreign organizations check here ▶ ☐ and do not complete this part)

1	Minimum investment return from Part X, line 6		1	439,143.
2a	Tax on investment income for 2009 from Part VI, line 5	2a 945.		
b	Income tax for 2009 (This does not include the tax from Part VI)	2b		
c	Add lines 2a and 2b		2c	945.
3	Distributable amount before adjustments Subtract line 2c from line 1		3	438,198.
4	Recoveries of amounts treated as qualifying distributions		4	
5	Add lines 3 and 4		5	438,198.
6	Deduction from distributable amount (see page 25 of the instructions)		6	
7	**Distributable amount** as adjusted Subtract line 6 from line 5 Enter here and on Part XIII, line 1		7	438,198.

Part XII Qualifying Distributions (see page 25 of the instructions)

1	Amounts paid (including administrative expenses) to accomplish charitable, etc, purposes		
a	Expenses, contributions, gifts, etc - total from Part I, column (d), line 26	1a	2,731,285.
b	Program-related investments - total from Part IX-B	1b	0.
2	Amounts paid to acquire assets used (or held for use) directly in carrying out charitable, etc, purposes	2	0.
3	Amounts set aside for specific charitable projects that satisfy the		
a	Suitability test (prior IRS approval required)	3a	0.
b	Cash distribution test (attach the required schedule)	3b	0.
4	**Qualifying distributions.** Add lines 1a through 3b Enter here and on Part V, line 8, and Part XIII, line 4	4	2,731,285.
5	Foundations that qualify under section 4940(e) for the reduced rate of tax on net investment income Enter 1% of Part I, line 27b (see page 26 of the instructions)	5	945.
6	**Adjusted qualifying distributions.** Subtract line 5 from line 4	6	2,730,340.

Note: The amount on line 6 will be used in Part V, column (b), in subsequent years when calculating whether the foundation qualifies for the section 4940(e) reduction of tax in those years

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Part XIII Undistributed Income (see page 26 of the instructions)

	(a) Corpus	(b) Years prior to 2008	(c) 2008	(d) 2009
1 Distributable amount for 2009 from Part XI, line 7				438,198.
2 Undistributed income, if any, as of the end of 2009				
a Enter amount for 2008 only				
b Total for prior years 20____,20____,20____				
3 Excess distributions carryover, if any, to 2009				
a From 2004 ...... 2,020,055.				
b From 2005 ...... 2,373,221.				
c From 2006 ...... 3,384,774.				
d From 2007 ...... 3,348,840.				
e From 2008 ...... 1,896,993.				
f Total of lines 3a through e	13,023,883.			
4 Qualifying distributions for 2009 from Part XII, line 4 ▶ $ 2,731,285.				
a Applied to 2008, but not more than line 2a				
b Applied to undistributed income of prior years (Election required - see page 26 of the instructions)				
c Treated as distributions out of corpus (Election required - see page 26 of the instructions)				
d Applied to 2009 distributable amount				438,198.
e Remaining amount distributed out of corpus	2,293,087.			
5 Excess distributions carryover applied to 2009 (If an amount appears in column (d), the same amount must be shown in column (a).)				
6 **Enter the net total of each column as indicated below:**				
a Corpus Add lines 3f, 4c, and 4e Subtract line 5	15,316,970.			
b Prior years' undistributed income Subtract line 4b from line 2b				
c Enter the amount of prior years' undistributed income for which a notice of deficiency has been issued, or on which the section 4942(a) tax has been previously assessed				
d Subtract line 6c from line 6b Taxable amount - see page 27 of the instructions				
e Undistributed income for 2008 Subtract line 4a from line 2a Taxable amount - see page 27 of the instructions				
f Undistributed income for 2009 Subtract lines 4d and 5 from line 1 This amount must be distributed in 2010				
7 Amounts treated as distributions out of corpus to satisfy requirements imposed by section 170(b)(1)(F) or 4942(g)(3) (see page 27 of the instructions)				
8 Excess distributions carryover from 2004 not applied on line 5 or line 7 (see page 27 of the instructions)	2,020,055.			
9 **Excess distributions carryover to 2010.** Subtract lines 7 and 8 from line 6a	13,296,915.			
10 Analysis of line 9				
a Excess from 2005 ... 2,373,221.				
b Excess from 2006 ... 3,384,774.				
c Excess from 2007 ... 3,348,840.				
d Excess from 2008 ... 1,896,993.				
e Excess from 2009 ... 2,293,087.				

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Part XIV Private Operating Foundations (see page 27 of the instructions and Part VII-A, question 9) NOT APPLICABLE

1a If the foundation has received a ruling or determination letter that it is a private operating foundation, and the ruling is effective for 2009, enter the date of the ruling . . . . ▶

b Check box to indicate whether the foundation is a private operating foundation described in section ☐ 4942(j)(3) or ☐ 4942(j)(5)

	Tax year	Prior 3 years			(e) Total
	(a) 2009	(b) 2008	(c) 2007	(d) 2006	
2a Enter the lesser of the adjusted net income from Part I or the minimum investment return from Part X for each year listed					
b 85% of line 2a					
c Qualifying distributions from Part XII, line 4 for each year listed					
d Amounts included in line 2c not used directly for active conduct of exempt activities					
e Qualifying distributions made directly for active conduct of exempt activities. Subtract line 2d from line 2c					
3 Complete 3a, b, or c for the alternative test relied upon					
a "Assets" alternative test - enter					
(1) Value of all assets					
(2) Value of assets qualifying under section 4942(j)(3)(B)(i)					
b "Endowment" alternative test- enter 2/3 of minimum investment return shown in Part X, line 6 for each year listed					
c "Support" alternative test - enter					
(1) Total support other than gross investment income (interest, dividends, rents, payments on securities loans (section 512(a)(5)), or royalties)					
(2) Support from general public and 5 or more exempt organizations as provided in section 4942 (j)(3)(B)(iii)					
(3) Largest amount of support from an exempt organization					
(4) Gross investment income					

Part XV Supplementary Information (Complete this part only if the foundation had $5,000 or more in assets at any time during the year - see page 28 of the instructions.)

1 **Information Regarding Foundation Managers:**

a List any managers of the foundation who have contributed more than 2% of the total contributions received by the foundation before the close of any tax year (but only if they have contributed more than $5,000) (See section 507(d)(2))

NONE

b List any managers of the foundation who own 10% or more of the stock of a corporation (or an equally large portion of the ownership of a partnership or other entity) of which the foundation has a 10% or greater interest

NONE

2 **Information Regarding Contribution, Grant, Gift, Loan, Scholarship, etc., Programs:**

Check here ▶ ☐ if the foundation only makes contributions to preselected charitable organizations and does not accept unsolicited requests for funds If the foundation makes gifts, grants, etc (see page 28 of the instructions) to individuals or organizations under other conditions, complete items 2a, b, c, and d

a The name, address, and telephone number of the person to whom applications should be addressed

ATTACHMENT 7

b The form in which applications should be submitted and information and materials they should include

ATTACHMENT 8

c Any submission deadlines

NONE

d Any restrictions or limitations on awards, such as by geographical areas, charitable fields, kinds of institutions, or other factors

ATTACHMENT 9

Part XV Supplementary Information (continued)

3 Grants and Contributions Paid During the Year or Approved for Future Payment

Recipient Name and address (home or business)	If recipient is an individual, show any relationship to any foundation manager or substantial contributor	Foundation status of recipient	Purpose of grant or contribution	Amount
a Paid during the year				
SEE ATTACHMENT D				2,819,461.
Total . . . . ▶ 3a				2,819,461.
b Approved for future payment				
Total . . . . ▶ 3b				

Part XVI-A Analysis of Income-Producing Activities

Enter gross amounts unless otherwise indicated	Unrelated business income (a) Business code	(b) Amount	Excluded by section 512, 513, or 514 (c) Exclusion code	(d) Amount	(e) Related or exempt function income (See page 28 of the instructions.)
1 Program service revenue					
a					
b					
c					
d					
e					
f					
g Fees and contracts from government agencies					
2 Membership dues and assessments					
3 Interest on savings and temporary cash investments			14	81,536.	
4 Dividends and interest from securities			14	32,478.	
5 Net rental income or (loss) from real estate					
a Debt-financed property					
b Not debt-financed property					
6 Net rental income or (loss) from personal property					
7 Other investment income					
8 Gain or (loss) from sales of assets other than inventory			18	-19,155.	
9 Net income or (loss) from special events					
10 Gross profit or (loss) from sales of inventory					
11 Other revenue a					
b					
c					
d					
e					
12 Subtotal Add columns (b), (d), and (e)				94,859.	

13 Total. Add line 12, columns (b), (d), and (e) . . . 13 94,859.

(See worksheet in line 13 instructions on page 28 to verify calculations.)

Part XVI-B Relationship of Activities to the Accomplishment of Exempt Purposes

Line No. ▼	Explain below how each activity for which income is reported in column (e) of Part XVI-A contributed importantly to the accomplishment of the foundation's exempt purposes (other than by providing funds for such purposes). (See page 29 of the instructions.)
	NOT APPLICABLE

Part XVII Information Regarding Transfers To and Transactions and Relationships With Noncharitable Exempt Organizations

			Yes	No
1	Did the organization directly or indirectly engage in any of the following with any other organization described in section 501(c) of the Code (other than section 501(c)(3) organizations) or in section 527, relating to political organizations?			
a	Transfers from the reporting foundation to a noncharitable exempt organization of			
	(1) Cash	1a(1)		X
	(2) Other assets	1a(2)		X
b	Other transactions			
	(1) Sales of assets to a noncharitable exempt organization	1b(1)		X
	(2) Purchases of assets from a noncharitable exempt organization	1b(2)		X
	(3) Rental of facilities, equipment, or other assets	1b(3)		X
	(4) Reimbursement arrangements	1b(4)		X
	(5) Loans or loan guarantees	1b(5)		X
	(6) Performance of services or membership or fundraising solicitations	1b(6)		X
c	Sharing of facilities, equipment, mailing lists, other assets, or paid employees	1c		X

d If the answer to any of the above is "Yes," complete the following schedule Column (b) should always show the fair market value of the goods, other assets, or services given by the reporting foundation If the foundation received less than fair market value in any transaction or sharing arrangement, show in column (d) the value of the goods, other assets, or services received

(a) Line no	(b) Amount involved	(c) Name of noncharitable exempt organization	(d) Description of transfers, transactions, and sharing arrangements
	N/A		N/A

2a Is the foundation directly or indirectly affiliated with, or related to, one or more tax-exempt organizations described in section 501(c) of the Code (other than section 501(c)(3)) or in section 527? ☐ Yes ☒ No

b If "Yes," complete the following schedule

(a) Name of organization	(b) Type of organization	(c) Description of relationship

Sign Here

Under penalties of perjury, I declare that I have examined this return, including accompanying schedules and statements, and to the best of my knowledge and belief, it is true, correct, and complete Declaration of preparer (other than taxpayer or fiduciary) is based on all information of which preparer has any knowledge

Vonda Holliman | 11-15-2010 | Treasurer

Signature of officer or trustee | Date | Title

Paid Preparer's Use Only

Preparer's signature Amanda A. Coleman	Date 11/13/2010	Check if self-employed ☐	Preparer's identifying number (See Signature on page 30 of the instructions) P00770702
Firm's name (or yours if self-employed), address, and ZIP code	BKD, LLP 1551 N WATERFRONT PKWY, STE 300 WICHITA, KS 67206-6601	EIN 44-0160260 Phone no 316-265-2811

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990-PF - PART IV
CAPITAL GAINS AND LOSSES FOR TAX ON INVESTMENT INCOME

Kind of Property		Description				P or D	Date acquired	Date sold
Gross sale price less expenses of sale	Depreciation allowed/ allowable	Cost or other basis	FMV as of 12/31/69	Adj basis as of 12/31/69	Excess of FMV over adj basis		Gain or (loss)	
		SEE ATTACHMENT A PROPERTY TYPE: SECURITIES				P	VAR	VAR
1,206,072.		1,225,227.					-19,155.	
TOTAL GAIN (LOSS)							-19,155.	

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
SCHEDULE OF INFORMATION FOR 2009 form 990-PF

Part IV Capital Gains and Losses for Tax on Investment Income **ATTACHMENT A**

	(a) List and describe the kind(s) of property sold (e.g., real estate, 2-story brick warehouse; or common stock, 200 shs MLC Co)	(b) How acquired P - Purchase D - Donation	(c) Date acquired (mo., day, yr.)	(d) Date sold (mo., day, yr)
1a	Zazove Associates, LLC Bond Fund - Sale of Bonds	P	04/04 - 07/09	01/09 - 12/09
b	Mellon Bonds & Cash - Corporate Actions	P	12/31/08	01/15/09
c				
d				
e				
f				
g				

	(e) Gross sales price minus expense of sale	(f) Depreciation allowed (or allowable)	(g) Cost or other basis	(h) Gain or (loss) (e) plus (f) minus (g)
a	1,205,742	0	1,225,227	(19,485)
b	330	0	0	330
c				0
d				0
e				0
f				0
g				0

Complete only for assets showing gain in column (h) and owned by the foundation on 12/31/69

	(i) F M V as of 12/31/69	(j) Adjusted basis as of 12/31/69	(k) Excess of col (i) over col (j), if any	(l) Gains (Col (h) gain minus col (k), but not less than -0-) or Losses (from col. (h))
a			0	(19,485)
b			0	330
c			0	0
d			0	0
e			0	0
f			0	0
g			0	0

2 Capital gain net income or (net capital loss)	If gain, also enter in Part I, line 7 If (loss), enter -0- in Part I, line 7	2	(19,155)
3 Net short-term capital gain or (loss) as defined in sections 1222(5) and (6) If gain, also enter in Part I, line 8, column (c) (see pages 11 and 16 of the instructions) If (loss), enter -0- in Part I, line 8		3	0

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
ATTACHMENT TO FORM 990-PF TO REPORT
EXPENDITURE RESPONSIBILITY GRANT
For the Year Ended 12/31/09

PART VII-B, Question on Line 5c:	**ATTACHMENT B**

Expenditure Responsibility Statement for the year 2009

Pursuant to IRC Regulation section 53.4945-5(d)(2), the CLAUDE R. LAMBE CHARITABLE FOUNDATION provides the following information:

(i)	Name & Address of Grantee:	Allen-Lambe House Foundation 255 N. Roosevelt Wichita, KS 67208
(ii)	Date and Amount of Grants:	April 11, 2008 $110,800 September 30, 2009 $105,665
(iii)	Purpose of Grants:	General program operating support for the Allen-Lambe House Foundation, an educational foundation which operates a museum and study center in a house located in Wichita, Kansas, designed by Frank Lloyd Wright in 1915. The house museum is open to the general public. The program of the Foundation includes restoration and conservation of the house, gardens, and its interiors, with furnishings to showcase the "Prairie Style" designs of Frank Lloyd Wright; and to maintain a library archive study center for the study of Frank Lloyd Wnght and other interrelated areas of design.
(iv)	Amounts expended:	Reports received from the Allen-Lambe House Foundation show the following expenditures: $100,717 total funds were spent from the April, 2008 grant for operating support of the museum. No funds of the September, 2009 grant were spent in the calendar year 2009.
(v)	Diversions:	To the knowledge of this grantor foundation, no funds have been diverted to any activity other than the activity for which the grant was originally made.
(vi)	Date of Reports:	On March 30, 2010, the Allen-Lambe House Foundation submitted a full and complete report of its expenditures of the April 2008 and September 2009 operating support grants.
(vi)	Verification:	The grantor has no reason to doubt the accuracy or reliability of the report from the grantee; therefore, no independent verification of the reports were made.

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
SCHEDULE OF INFORMATION FOR 2009 FORM 990 PF

PART VIII, Line 1 - Officers, Directors, Trustees, Managers, Etc. **ATTACHMENT C**

(a) Name and Address	(b) Title, and average hours per week devoted to position	(c) Compensation	(d) Contributions to employee benefit plans	(e) Expense account, other allowances
Richard H Fink 1515 N. Courthouse Rd, Suite 200 Arlington, VA 22201	President / Director 1 hour per week	0	0	0
Logan Moore 1515 N Courthouse Rd, Suite 200 Arlington, VA 22201	Secretary 1 hour per week average	0	0	0
Vonda Holliman P O. Box 2256 Wichita, KS 67201	Treasurer 1 hour per week average	0	0	0
Charles G Koch P.O. Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
Elizabeth B. Koch P.O. Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
Elizabeth R. Koch PO Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
Charles C. Koch PO Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
	TOTAL	0	0	0

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
SCHEDULE OF INFORMATION FOR 2009 FORM 990 PF

Part XV, Line 3a& b - Grants and Contributions Paid During the Year or Approved for Future Payment ATTACHMENT D

Recipient Name and address (home or business)	If recipient is an individual, show any relationship to any foundation manager or substantial contributor	Foundation status of recipient	Purpose of grant or contribution	Amount
a Paid during the year:				
Allen-Lambe House Foundation Wichita, KS		Private	General Operating Support	$ 105,665
American Council for Capital Formation, Center for Policy Research Washington, DC		Public	General Operating Support	100,000
American Spectator Arlington, VA		Public	Educational Programs	4,500
American Council on Science & Health New York, NY		Public	Return of General Operating Grant Paid in Prior Year	(30,000)
American Legislative Exchange Council Washington, DC		Public	Educational Programs General Operating Support	75,000 50,000
Americans for Prosperity Foundation Washington, DC		Public	Educational Programs General Operating Support	12,000 354,725
Ayn Rand Institute Irvine, CA		Public	General Operating Support	25,000
Cato Institute Washington, DC		Public	General Operating Support	250,000
Center for Independent Thought New York, NY		Public	Educational Programs	35,000
Competitive Enterprise Institute Washington, DC		Public	General Operating Support	10,000
ConSource Inc Washington, DC		Public	General Operating Support	4,000
Federalist Society Washington, DC		Public	Educational Programs	175,000
Foundation for Research on Economics & the Environment (FREE) Bozeman, MT		Public	General Operating Support	65,000
George Marshall Institute Arlington, VA		Public	General Operating Support	70,000
George Mason University Foundation Fairfax, VA		Public	Educational Programs	20,000
The Heritage Foundation Washington, DC		Public	Educational Programs	618,571
Independent Women's Forum Washington, DC		Public	Educational Programs	150,000
Manhattan Institute for Policy Research New York, NY		Public	Educational Programs	200,000

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
SCHEDULE OF INFORMATION FOR 2009 FORM 990 PF

Part XV, Line 3a& b - Grants and Contributions Paid During the Year or Approved for Future Payment **ATTACHMENT D**

Recipient Name and address (home or business)	If recipient is an individual, show any relationship to any foundation manager or substantial contributor	Foundation status of recipient	Purpose of grant or contribution	Amount
a Paid during the year:				
National Center for Policy Analysis Dallas, TX		Public	Educational Programs	25,000
Pacific Research Institute San Francisco, CA		Public	General Operating Support	100,000
Reason Foundation Los Angeles, CA		Public	Educational Programs	50,000
Tax Foundation Washington, DC		Public	Educational Programs	50,000
Texas Public Policy Foundation Austin, TX		Public	General Operating Support	100,000
Washington Legal Foundation Washington, DC		Public	General Operating Support	200,000
TOTAL GRANTS PAID TO ORGANIZATIONS				$ 2,819,461

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 1

FORM 990PF, PART I - ACCOUNTING FEES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	NET INVESTMENT INCOME	ADJUSTED NET INCOME	CHARITABLE PURPOSES
ACCOUNTING FEES	18,795.			16,150.
INVESTMENT ACCTG SERVICE FEES	3,525.	3,525.		
TOTALS	22,320.	3,525.	0.	16,150.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 2

FORM 990PF, PART I - OTHER PROFESSIONAL FEES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	NET INVESTMENT INCOME
INVESTMENT MANAGEMENT FEES	15,982.	15,982.
TOTALS	15,982.	15,982.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 3

FORM 990PF, PART I - TAXES

DESCRIPTION		REVENUE AND EXPENSES PER BOOKS
FEDERAL EXCISE TAX		945.
	TOTALS	945.

CLAUDE R. LAMBE CHARITABLE FOUNDATION

48-0935563

ATTACHMENT 4

FORM 990PF, PART I - OTHER EXPENSES

DESCRIPTION		REVENUE AND EXPENSES PER BOOKS	CHARITABLE PURPOSES
INSURANCE		875.	875.
BANK FEES		317.	317.
SUPPLIES		147.	147.
MISC EXPENSES		439.	
	TOTALS	1,778.	1,339.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990PF, PART II - OTHER INVESTMENTS

ATTACHMENT 5

DESCRIPTION	ENDING BOOK VALUE	ENDING FMV
ZAZOVE ASSOC CONVERTIBLE BONDS	2,663,574.	2,830,160.
TOTALS	2,663,574.	2,830,160.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 6

FORM 990PF, PART VII-B, LINE 5C-EXPENDITURE RESPONSIBILITY STATEMENT

GRANTEE'S NAME: SEE ATTACHMENT B
GRANTEE'S ADDRESS:
CITY, STATE & ZIP:
GRANT DATE:
GRANT AMOUNT:
GRANT PURPOSE:
AMOUNT EXPENDED:
ANY DIVERSION? NO
DATES OF REPORTS:
VERIFICATION DATE:
RESULTS OF VERIFICATION:

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 7

FORM 990PF, PART XV - NAME, ADDRESS AND PHONE FOR APPLICATIONS

GRANT ADMINISTRATOR
1515 N. COURTHOUSE RD., SUITE 200
ARLINGTON, VA 22201
703-875-1601

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 8

990PF, PART XV - FORM AND CONTENTS OF SUBMITTED APPLICATIONS

LETTER EXPLAINING PROJECT AND AMOUNT REQUESTED, PLUS A COPY OF THE IRS DETERMINATION LETTER SHOWING EXEMPTION.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 9

990PF, PART XV - RESTRICTIONS OR LIMITATIONS ON AWARDS

GRANTS ARE GENERALLY RESTRICTED TO PUBLIC CHARITY ORGANIZATIONS AS DEFINED IN SECTION 501(C)(3) OF THE INTERNAL REVENUE CODE. THE FOUNDATION DOES NOT MAKE GRANTS TO INDIVIDUALS OR FOR-PROFIT CORPORATIONS.

Form 8868 (Rev 4-2009) Page 2

- If you are filing for an **Additional (Not Automatic) 3-Month Extension, complete only Part II** and check this box . . . . ▶ X

Note. Only complete Part II if you have already been granted an automatic 3-month extension on a previously filed Form 8868

- If you are filing for an **Automatic 3-Month Extension, complete only Part I** (on page 1).

Part II Additional (Not Automatic) 3-Month Extension of Time. Only file the original (no copies needed).

Type or print	Name of Exempt Organization	Employer identification number
File by the extended due date for filing the return See instructions.	CLAUDE R. LAMBE CHARITABLE FOUNDATION	48-0935563
	Number, street, and room or suite no If a P.O box, see instructions P.O. BOX 2256	For IRS use only
	City, town or post office, state, and ZIP code. For a foreign address, see instructions. WICHITA, KS 67201-2256	

Check type of return to be filed (File a separate application for each return):

☐ Form 990	X Form 990-PF	☐ Form 1041-A	☐ Form 6069
☐ Form 990-BL	☐ Form 990-T (sec 401(a) or 408(a) trust)	☐ Form 4720	☐ Form 8870
☐ Form 990-EZ	☐ Form 990-T (trust other than above)	☐ Form 5227	

STOP! Do not complete Part II if you were not already granted an automatic 3-month extension on a previously filed Form 8868.

- The books are in the care of ▶ VONDA HOLLIMAN
  Telephone No. ▶ 316 828-5552 FAX No. ▶
- If the organization does not have an office or place of business in the United States, check this box . . . . ▶ ☐
- If this is for a Group Return, enter the organization's four digit Group Exemption Number (GEN) ______ If this is for the whole group, check this box . . . ▶ ☐. If it is for part of the group, check this box . . . ▶ ☐ and attach a list with the names and EINs of all members the extension is for.

4 I request an additional 3-month extension of time until NOVEMBER 15, 2010

5 For calendar year 2009 , or other tax year beginning ______ and ending ______.

6 If this tax year is for less than 12 months, check reason: ☐ Initial return ☐ Final return ☐ Change in accounting period

7 State in detail why you need the extension
THE TAXPAYER REQUESTS ADDITIONAL TIME IN ORDER TO GATHER THE NECESSARY INFORMATION FOR A COMPLETE AND ACCURATE RETURN.

8a	If this application is for Form 990-BL, 990-PF, 990-T, 4720, or 6069, enter the tentative tax, less any nonrefundable credits. See instructions.	8a	$
b	If this application is for Form 990-PF, 990-T, 4720, or 6069, enter any refundable credits and estimated tax payments made Include any prior year overpayment allowed as a credit and any amount paid previously with Form 8868	8b	$
c	**Balance Due.** Subtract line 8b from line 8a. Include your payment with this form, or, if required, deposit with FTD coupon or, if required, by using EFTPS (Electronic Federal Tax Payment System) See instructions	8c	$ 0

Signature and Verification

Under penalties of perjury, I declare that I have examined this form, including accompanying schedules and statements, and to the best of my knowledge and belief, it is true, correct, and complete, and that I am authorized to prepare this form.

Signature ▶ Amanda A. Coleman Title ▶ C.P.A. Date ▶ 8/27/2010

Form **8868** (Rev. 4-2009)

BKD, LLP
1551 N. Waterfront Parkway, Suite 300
Wichita, KS 67206-6601
44-0160260

JSA
9F8055 3 000

EXTENSION GRANTED

Form **990-PF**

Department of the Treasury
Internal Revenue Service

Return of Private Foundation

or Section 4947(a)(1) Nonexempt Charitable Trust Treated as a Private Foundation

Note. The foundation may be able to use a copy of this return to satisfy state reporting requirements.

OMB No 1545-0052

2010

For calendar year 2010, or tax year beginning JANUARY 1, 2010, and ending DECEMBER 31, 2010

G Check all that apply: ☐ Initial return ☐ Initial return of a former public charity ☐ Final return ☐ Amended return ☐ Address change ☐ Name change

Name of foundation: CLAUDE R. LAMBE CHARITABLE FOUNDATION

A Employer identification number: 48-0935563

Number and street (or P O box number if mail is not delivered to street address): P.O. BOX 2256 | Room/suite

B Telephone number (see page 10 of the instructions): (316) 828-8286

City or town, state, and ZIP code: WICHITA, KS 67201-2256

C If exemption application is pending, check here ▶ ☐

D 1 Foreign organizations, check here ▶ ☐

2 Foreign organizations meeting the 85% test, check here and attach computation ▶ ☐

H Check type of organization: ☒ Section 501(c)(3) exempt private foundation ☐ Section 4947(a)(1) nonexempt charitable trust ☐ Other taxable private foundation

E If private foundation status was terminated under section 507(b)(1)(A), check here ▶ ☐

I Fair market value of all assets at end of year *(from Part II, col. (c), line 16)* ▶ $ 5,537,935.

J Accounting method: ☐ Cash ☒ Accrual ☐ Other (specify) *(Part I, column (d) must be on cash basis.)*

F If the foundation is in a 60-month termination under section 507(b)(1)(B), check here ▶ ☐

Part I Analysis of Revenue and Expenses

(The total of amounts in columns (b), (c), and (d) may not necessarily equal the amounts in column (a) (see page 11 of the instructions).)

		(a) Revenue and expenses per books	(b) Net investment income	(c) Adjusted net income	(d) Disbursements for charitable purposes (cash basis only)
Revenue	1 Contributions, gifts, grants, etc., received (attach schedule)	0.			
	2 Check ▶ ☒ if the foundation is not required to attach Sch B				
	3 Interest on savings and temporary cash investments	78.	78.		
	4 Dividends and interest from securities	159,624.	159,624.		
	5a Gross rents				
	b Net rental income or (loss)				
	6a Net gain or (loss) from sale of assets not on line 10	68,860.			
	b Gross sales price for all assets on line 6a 899,869.				
	7 Capital gain net income (from Part IV, line 2)		68,860.		
	8 Net short-term capital gain				
	9 Income modifications				
	10a Gross sales less returns and allowances				
	b Less Cost of goods sold				
	c Gross profit or (loss) (attach schedule)				
	11 Other income (attach schedule)				
	12 **Total.** Add lines 1 through 11	228,562.	228,562.		
Operating and Administrative Expenses	13 Compensation of officers, directors, trustees, etc				
	14 Other employee salaries and wages				
	15 Pension plans, employee benefits				
	16a Legal fees (attach schedule)				
	b Accounting fees (attach schedule) ATCH 1	29,206.	7,448.	0.	25,599.
	c Other professional fees (attach schedule) *	17,010.	17,010.		
	17 Interest				
	18 Taxes (attach schedule) (see page 14 of the instructions) **	2,041.			
	19 Depreciation (attach schedule) and depletion				
	20 Occupancy				
	21 Travel, conferences, and meetings	2,200.	0.		2,200.
	22 Printing and publications				
	23 Other expenses (attach schedule) ATCH 4	1,544.			1,544.
	24 **Total operating and administrative expenses.** Add lines 13 through 23	52,001.	24,458.	0.	29,343.
	25 Contributions, gifts, grants paid	2,069,615.			1,946,550.
	26 **Total expenses and disbursements.** Add lines 24 and 25	2,121,616.	24,458.	0.	1,975,893.
	27 Subtract line 26 from line 12				
	a **Excess of revenue over expenses and disbursements**	-1,893,054.			
	b **Net investment income** (if negative, enter -0-)		204,104.		
	c **Adjusted net income** (if negative, enter -0-)				

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SCANNED MAY 29 2012

For Paperwork Reduction Act Notice, see page 30 of the instructions. *ATCH 2 JSA **ATCH 3 Form **990-PF** (2010)

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Form 990-PF (2010) 48-0935563 Page 2

Part II Balance Sheets Attached schedules and amounts in the description column should be for end-of-year amounts only (See instructions)

		Beginning of year (a) Book Value	End of year (b) Book Value	End of year (c) Fair Market Value
1	Cash - non-interest-bearing			
2	Savings and temporary cash investments	4,509,294.	2,404,746.	2,404,746.
3	Accounts receivable ▶ 0.			
	Less allowance for doubtful accounts ▶	168.	0.	0.
4	Pledges receivable ▶			
	Less allowance for doubtful accounts ▶			
5	Grants receivable			
6	Receivables due from officers, directors, trustees, and other disqualified persons (attach schedule) (see page 15 of the instructions)			
7	Other notes and loans receivable (attach schedule) ▶			
	Less allowance for doubtful accounts ▶			
8	Inventories for sale or use			
9	Prepaid expenses and deferred charges	9,378.	6,035.	6,035.
10 a	Investments - U S and state government obligations (attach schedule)			
b	Investments - corporate stock (attach schedule)			
c	Investments - corporate bonds (attach schedule)			
11	Investments - land, buildings, and equipment basis ▶ Less accumulated depreciation (attach schedule) ▶			
12	Investments - mortgage loans			
13	Investments - other (attach schedule) ATCH 5	2,663,574.	2,874,209.	3,127,154.
14	Land, buildings, and equipment basis ▶ Less accumulated depreciation (attach schedule) ▶			
15	Other assets (describe ▶)			
16	Total assets (to be completed by all filers - see the instructions Also, see page 1, item I)	7,182,414.	5,284,990.	5,537,935.
17	Accounts payable and accrued expenses	6,095.	1,725.	
18	Grants payable			
19	Deferred revenue			
20	Loans from officers, directors, trustees, and other disqualified persons			
21	Mortgages and other notes payable (attach schedule)			
22	Other liabilities (describe ▶)			
23	Total liabilities (add lines 17 through 22)	6,095.	1,725.	
	Foundations that follow SFAS 117, check here ▶ [X] and complete lines 24 through 26 and lines 30 and 31.			
24	Unrestricted	7,176,319.	5,283,265.	
25	Temporarily restricted			
26	Permanently restricted			
	Foundations that do not follow SFAS 117, check here and complete lines 27 through 31. ▶ [ ]			
27	Capital stock, trust principal, or current funds			
28	Paid-in or capital surplus, or land, bldg, and equipment fund			
29	Retained earnings, accumulated income, endowment, or other funds			
30	Total net assets or fund balances (see page 17 of the instructions)	7,176,319.	5,283,265.	
31	Total liabilities and net assets/fund balances (see page 17 of the instructions)	7,182,414.	5,284,990.	

Assets: lines 1–16; Liabilities: lines 17–23; Net Assets or Fund Balances: lines 24–31.

Part III Analysis of Changes in Net Assets or Fund Balances

1	Total net assets or fund balances at beginning of year - Part II, column (a), line 30 (must agree with end-of-year figure reported on prior year's return)	1	7,176,319.
2	Enter amount from Part I, line 27a	2	-1,893,054.
3	Other increases not included in line 2 (itemize) ▶	3	
4	Add lines 1, 2, and 3	4	5,283,265.
5	Decreases not included in line 2 (itemize) ▶	5	
6	Total net assets or fund balances at end of year (line 4 minus line 5) - Part II, column (b), line 30	6	5,283,265.

Form 990-PF (2010)

Part IV Capital Gains and Losses for Tax on Investment Income

(a) List and describe the kind(s) of property sold (e g , real estate, 2-story brick warehouse, or common stock, 200 shs MLC Co)	(b) How acquired P-Purchase D-Donation	(c) Date acquired (mo , day, yr)	(d) Date sold (mo., day, yr)
1a SEE ATTACHMENT 9			
b			
c			
d			
e			

	(e) Gross sales price	(f) Depreciation allowed (or allowable)	(g) Cost or other basis plus expense of sale	(h) Gain or (loss) (e) plus (f) minus (g)
a				
b				
c				
d				
e				

Complete only for assets showing gain in column (h) and owned by the foundation on 12/31/69

	(i) F M V as of 12/31/69	(j) Adjusted basis as of 12/31/69	(k) Excess of col (i) over col (j), if any	(l) Gains (Col (h) gain minus col (k), but not less than -0-) or Losses (from col (h))
a				
b				
c				
d				
e				

2 Capital gain net income or (net capital loss) { If gain, also enter in Part I, line 7 / If (loss), enter -0- in Part I, line 7 }	2	68,860.
3 Net short-term capital gain or (loss) as defined in sections 1222(5) and (6): If gain, also enter in Part I, line 8, column (c) (see pages 13 and 17 of the instructions). If (loss), enter -0- in Part I, line 8	3	

Part V Qualification Under Section 4940(e) for Reduced Tax on Net Investment Income

(For optional use by domestic private foundations subject to the section 4940(a) tax on net investment income.)

If section 4940(d)(2) applies, leave this part blank.

Was the foundation liable for the section 4942 tax on the distributable amount of any year in the base period? ☐ Yes ☒ No

If "Yes," the foundation does not qualify under section 4940(e). Do not complete this part.

1 Enter the appropriate amount in each column for each year; see page 18 of the instructions before making any entries

(a) Base period years Calendar year (or tax year beginning in)	(b) Adjusted qualifying distributions	(c) Net value of noncharitable-use assets	(d) Distribution ratio (col (b) divided by col (c))
2009	2,730,340.	8,782,857.	0.310872
2008	2,456,244.	11,492,427.	0.213727
2007	4,085,883.	15,540,497.	0.262918
2006	4,231,735.	17,229,773.	0.245606
2005	3,796,938.	19,799,454.	0.191770

2 **Total** of line 1, column (d)	2	1.224893
3 Average distribution ratio for the 5-year base period - divide the total on line 2 by 5, or by the number of years the foundation has been in existence if less than 5 years	3	0.244979
4 Enter the net value of noncharitable-use assets for 2010 from Part X, line 5	4	6,651,320.
5 Multiply line 4 by line 3	5	1,629,434.
6 Enter 1% of net investment income (1% of Part I, line 27b)	6	2,041.
7 Add lines 5 and 6	7	1,631,475.
8 Enter qualifying distributions from Part XII, line 4	8	1,975,893.

If line 8 is equal to or greater than line 7, check the box in Part VI, line 1b, and complete that part using a 1% tax rate. See the Part VI instructions on page 18.

Part VI Excise Tax Based on Investment Income (Section 4940(a), 4940(b), 4940(e), or 4948 - see page 18 of the instructions)

1a	Exempt operating foundations described in section 4940(d)(2), check here ▶ ☐ and enter "N/A" on line 1. Date of ruling or determination letter ___________ (attach copy of ruling letter if necessary - see instructions)		
b	Domestic foundations that meet the section 4940(e) requirements in Part V, check here ▶ ☒ and enter 1% of Part I, line 27b	1	2,041.
c	All other domestic foundations enter 2% of line 27b Exempt foreign organizations enter 4% of Part I, line 12, col (b)		
2	Tax under section 511 (domestic section 4947(a)(1) trusts and taxable foundations only Others enter -0-)	2	
3	Add lines 1 and 2	3	2,041.
4	Subtitle A (income) tax (domestic section 4947(a)(1) trusts and taxable foundations only Others enter -0-)	4	0.
5	**Tax based on investment income.** Subtract line 4 from line 3 If zero or less, enter -0-	5	2,041.
6	Credits/Payments		
a	2010 estimated tax payments and 2009 overpayment credited to 2010 — 6a: 8,076.		
b	Exempt foreign organizations-tax withheld at source — 6b: 0.		
c	Tax paid with application for extension of time to file (Form 8868) — 6c: 0.		
d	Backup withholding erroneously withheld — 6d:		
7	Total credits and payments Add lines 6a through 6d	7	8,076.
8	Enter any **penalty** for underpayment of estimated tax Check here ☐ if Form 2220 is attached	8	
9	**Tax due.** If the total of lines 5 and 8 is more than line 7, enter **amount owed** ▶	9	
10	**Overpayment.** If line 7 is more than the total of lines 5 and 8, enter the **amount overpaid** ▶	10	6,035.
11	Enter the amount of line 10 to be: **Credited to 2011 estimated tax** ▶ 6,035. **Refunded** ▶	11	

Part VII-A Statements Regarding Activities

			Yes	No
1a	During the tax year, did the foundation attempt to influence any national, state, or local legislation or did it participate or intervene in any political campaign?	1a		X
b	Did it spend more than $100 during the year (either directly or indirectly) for political purposes (see page 19 of the instructions for definition)?	1b		X
	If the answer is "Yes" to 1a or 1b, attach a detailed description of the activities and copies of any materials published or distributed by the foundation in connection with the activities			
c	Did the foundation file **Form 1120-POL** for this year?	1c		X
d	Enter the amount (if any) of tax on political expenditures (section 4955) imposed during the year (1) On the foundation ▶ $ ______ (2) On foundation managers ▶ $ ______			
e	Enter the reimbursement (if any) paid by the foundation during the year for political expenditure tax imposed on foundation managers ▶ $ ______			
2	Has the foundation engaged in any activities that have not previously been reported to the IRS? *If "Yes," attach a detailed description of the activities*	2		X
3	Has the foundation made any changes, not previously reported to the IRS, in its governing instrument, articles of incorporation, or bylaws, or other similar instruments? *If "Yes," attach a conformed copy of the changes*	3		X
4a	Did the foundation have unrelated business gross income of $1,000 or more during the year?	4a		X
b	If "Yes," has it filed a tax return on Form 990-T for this year?	4b		
5	Was there a liquidation, termination, dissolution, or substantial contraction during the year? *If "Yes," attach the statement required by General Instruction T.*	5		X
6	Are the requirements of section 508(e) (relating to sections 4941 through 4945) satisfied either • By language in the governing instrument, or • By state legislation that effectively amends the governing instrument so that no mandatory directions that conflict with the state law remain in the governing instrument?	6	X	
7	Did the foundation have at least $5,000 in assets at any time during the year? *If "Yes," complete Part II, col (c), and Part XV*	7	X	
8a	Enter the states to which the foundation reports or with which it is registered (see page 19 of the instructions) ▶ KS, VA,			
b	If the answer is "Yes" to line 7, has the foundation furnished a copy of Form 990-PF to the Attorney General (or designate) of each state as required by *General Instruction G? If "No," attach explanation*	8b	X	
9	Is the foundation claiming status as a private operating foundation within the meaning of section 4942(j)(3) or 4942(j)(5) for calendar year 2010 or the taxable year beginning in 2010 (see instructions for Part XIV on page 27)? *If "Yes," complete Part XIV*	9		X
10	Did any persons become substantial contributors during the tax year? *If "Yes," attach a schedule listing their names and addresses*	10		X

Part VII-A Statements Regarding Activities *(continued)*

			Yes	No
11	At any time during the year, did the foundation, directly or indirectly, own a controlled entity within the meaning of section 512(b)(13)? If "Yes," attach schedule (see page 20 of the instructions)	11		X
12	Did the foundation acquire a direct or indirect interest in any applicable insurance contract before August 17, 2008?	12		X
13	Did the foundation comply with the public inspection requirements for its annual returns and exemption application?	13	X	

Website address ▶ N/A

14 The books are in care of ▶ HEATHER LOVE Telephone no. ▶ (316)828-8286

Located at ▶ 4111 E. 37TH STREET NORTH WICHITA, KS ZIP + 4 ▶ 67220

15 Section 4947(a)(1) nonexempt charitable trusts filing Form 990-PF in lieu of Form 1041 - Check here ▶ ☐

and enter the amount of tax-exempt interest received or accrued during the year ▶ 15

			Yes	No
16	At any time during calendar year 2010, did the foundation have an interest in or a signature or other authority over a bank, securities, or other financial account in a foreign country?	16		X
	See page 20 of the instructions for exceptions and filing requirements for Form TD F 90-22.1. If "Yes," enter the name of the foreign country ▶			

Part VII-B Statements Regarding Activities for Which Form 4720 May Be Required

File Form 4720 if any item is checked in the "Yes" column, unless an exception applies.

			Yes	No
1a	During the year did the foundation (either directly or indirectly)			
	(1) Engage in the sale or exchange, or leasing of property with a disqualified person? ☐ Yes ☒ No			
	(2) Borrow money from, lend money to, or otherwise extend credit to (or accept it from) a disqualified person? ☐ Yes ☒ No			
	(3) Furnish goods, services, or facilities to (or accept them from) a disqualified person? ☒ Yes ☐ No			
	(4) Pay compensation to, or pay or reimburse the expenses of, a disqualified person? ☒ Yes ☐ No			
	(5) Transfer any income or assets to a disqualified person (or make any of either available for the benefit or use of a disqualified person)? ☐ Yes ☒ No			
	(6) Agree to pay money or property to a government official? (**Exception.** Check "No" if the foundation agreed to make a grant to or to employ the official for a period after termination of government service, if terminating within 90 days.) ☐ Yes ☒ No			
b	If any answer is "Yes" to 1a(1)-(6), did any of the acts fail to qualify under the exceptions described in Regulations section 53.4941(d)-3 or in a current notice regarding disaster assistance (see page 22 of the instructions)?	1b		X
	Organizations relying on a current notice regarding disaster assistance check here ▶ ☐			
c	Did the foundation engage in a prior year in any of the acts described in 1a, other than excepted acts, that were not corrected before the first day of the tax year beginning in 2010?	1c		X
2	Taxes on failure to distribute income (section 4942) (does not apply for years the foundation was a private operating foundation defined in section 4942(j)(3) or 4942(j)(5))			
a	At the end of tax year 2010, did the foundation have any undistributed income (lines 6d and 6e, Part XIII) for tax year(s) beginning before 2010? ☐ Yes ☒ No			
	If "Yes," list the years ▶			
b	Are there any years listed in 2a for which the foundation is not applying the provisions of section 4942(a)(2) (relating to incorrect valuation of assets) to the year's undistributed income? (If applying section 4942(a)(2) to all years listed, answer "No" and attach statement - see page 22 of the instructions.)	2b		
c	If the provisions of section 4942(a)(2) are being applied to any of the years listed in 2a, list the years here ▶			
3a	Did the foundation hold more than a 2% direct or indirect interest in any business enterprise at any time during the year? ☐ Yes ☒ No			
b	If "Yes," did it have excess business holdings in 2010 as a result of (1) any purchase by the foundation or disqualified persons after May 26, 1969, (2) the lapse of the 5-year period (or longer period approved by the Commissioner under section 4943(c)(7)) to dispose of holdings acquired by gift or bequest, or (3) the lapse of the 10-, 15-, or 20-year first phase holding period? *(Use Schedule C, Form 4720, to determine if the foundation had excess business holdings in 2010.)*	3b		
4a	Did the foundation invest during the year any amount in a manner that would jeopardize its charitable purposes?	4a		X
b	Did the foundation make any investment in a prior year (but after December 31, 1969) that could jeopardize its charitable purpose that had not been removed from jeopardy before the first day of the tax year beginning in 2010?	4b		X

Part VII-B Statements Regarding Activities for Which Form 4720 May Be Required *(continued)*

5a During the year did the foundation pay or incur any amount to

(1) Carry on propaganda, or otherwise attempt to influence legislation (section 4945(e))? ☐ Yes ☒ No

(2) Influence the outcome of any specific public election (see section 4955), or to carry on, directly or indirectly, any voter registration drive? ☐ Yes ☒ No

(3) Provide a grant to an individual for travel, study, or other similar purposes? ☐ Yes ☒ No

(4) Provide a grant to an organization other than a charitable, etc, organization described in section 509(a)(1), (2), or (3), or section 4940(d)(2)? (see page 22 of the instructions) ☒ Yes ☐ No

(5) Provide for any purpose other than religious, charitable, scientific, literary, or educational purposes, or for the prevention of cruelty to children or animals? ☐ Yes ☒ No

b If any answer is "Yes" to 5a(1)-(5), did any of the transactions fail to qualify under the exceptions described in Regulations section 53 4945 or in a current notice regarding disaster assistance (see page 22 of the instructions)? — 5b: No X

Organizations relying on a current notice regarding disaster assistance check here ▶ ☐

c If the answer is "Yes" to question 5a(4), does the foundation claim exemption from the tax because it maintained expenditure responsibility for the grant? SEE ATTACHMENT 10 ☒ Yes ☐ No

If "Yes," attach the statement required by Regulations section 53 4945-5(d).

6a Did the foundation, during the year, receive any funds, directly or indirectly, to pay premiums on a personal benefit contract? ☐ Yes ☒ No

b Did the foundation, during the year, pay premiums, directly or indirectly, on a personal benefit contract? — 6b: No X

If "Yes" to 6b, file Form 8870

7a At any time during the tax year, was the foundation a party to a prohibited tax shelter transaction? ☐ Yes ☒ No

b If "Yes," did the foundation receive any proceeds or have any net income attributable to the transaction? — 7b

Part VIII Information About Officers, Directors, Trustees, Foundation Managers, Highly Paid Employees, and Contractors

1 List all officers, directors, trustees, foundation managers and their compensation (see page 22 of the instructions).

(a) Name and address	(b) Title, and average hours per week devoted to position	(c) Compensation (If not paid, enter -0-)	(d) Contributions to employee benefit plans and deferred compensation	(e) Expense account, other allowances
SEE ATTACHMENT 11		-0-	-0-	-0-

2 Compensation of five highest-paid employees (other than those included on line 1 - see page 23 of the instructions). If none, enter "NONE."

(a) Name and address of each employee paid more than $50,000	(b) Title, and average hours per week devoted to position	(c) Compensation	(d) Contributions to employee benefit plans and deferred compensation	(e) Expense account, other allowances
NONE				

Total number of other employees paid over $50,000 ▶ NONE

Part VIII **Information About Officers, Directors, Trustees, Foundation Managers, Highly Paid Employees, and Contractors** *(continued)*

3 Five highest-paid independent contractors for professional services (see page 23 of the instructions). If none, enter "NONE."

(a) Name and address of each person paid more than $50,000	(b) Type of service	(c) Compensation
NONE		
Total number of others receiving over $50,000 for professional services ▶		NONE

Part IX-A **Summary of Direct Charitable Activities**

List the foundation's four largest direct charitable activities during the tax year Include relevant statistical information such as the number of organizations and other beneficiaries served, conferences convened, research papers produced, etc	Expenses
1 NONE	
2	
3	
4	

Part IX-B **Summary of Program-Related Investments** (see page 24 of the instructions)

Describe the two largest program-related investments made by the foundation during the tax year on lines 1 and 2	Amount
1 NONE	
2	
All other program-related investments See page 24 of the instructions 3 NONE	
Total. Add lines 1 through 3 ▶	

Part X **Minimum Investment Return** (All domestic foundations must complete this part Foreign foundations, see page 24 of the instructions.)

1	Fair market value of assets not used (or held for use) directly in carrying out charitable, etc., purposes:		
a	Average monthly fair market value of securities	1a	2,918,459.
b	Average of monthly cash balances	1b	3,834,150.
c	Fair market value of all other assets (see page 25 of the instructions)	1c	0.
d	**Total** (add lines 1a, b, and c)	1d	6,752,609.
e	Reduction claimed for blockage or other factors reported on lines 1a and 1c (attach detailed explanation) 1e		
2	Acquisition indebtedness applicable to line 1 assets	2	0.
3	Subtract line 2 from line 1d	3	6,752,609.
4	Cash deemed held for charitable activities. Enter 1 1/2 % of line 3 (for greater amount, see page 25 of the instructions)	4	101,289.
5	**Net value of noncharitable-use assets.** Subtract line 4 from line 3. Enter here and on Part V, line 4	5	6,651,320.
6	**Minimum investment return.** Enter 5% of line 5	6	332,566.

Part XI **Distributable Amount** (see page 25 of the instructions) (Section 4942(j)(3) and (j)(5) private operating foundations and certain foreign organizations check here ▶ ☐ and do not complete this part.)

1	Minimum investment return from Part X, line 6		1	332,566.
2a	Tax on investment income for 2010 from Part VI, line 5	2a 2,041.		
b	Income tax for 2010. (This does not include the tax from Part VI.)	2b		
c	Add lines 2a and 2b		2c	2,041.
3	Distributable amount before adjustments. Subtract line 2c from line 1		3	330,525.
4	Recoveries of amounts treated as qualifying distributions		4	
5	Add lines 3 and 4		5	330,525.
6	Deduction from distributable amount (see page 25 of the instructions)		6	
7	**Distributable amount** as adjusted. Subtract line 6 from line 5. Enter here and on Part XIII, line 1		7	330,525.

Part XII **Qualifying Distributions** (see page 25 of the instructions)

1	Amounts paid (including administrative expenses) to accomplish charitable, etc., purposes.		
a	Expenses, contributions, gifts, etc. - total from Part I, column (d), line 26	1a	1,975,893.
b	Program-related investments - total from Part IX-B	1b	0.
2	Amounts paid to acquire assets used (or held for use) directly in carrying out charitable, etc., purposes	2	0.
3	Amounts set aside for specific charitable projects that satisfy the:		
a	Suitability test (prior IRS approval required)	3a	0.
b	Cash distribution test (attach the required schedule)	3b	0.
4	**Qualifying distributions.** Add lines 1a through 3b Enter here and on Part V, line 8, and Part XIII, line 4	4	1,975,893.
5	Foundations that qualify under section 4940(e) for the reduced rate of tax on net investment income. Enter 1% of Part I, line 27b (see page 26 of the instructions)	5	2,041.
6	**Adjusted qualifying distributions.** Subtract line 5 from line 4	6	1,973,852.

Note: The amount on line 6 will be used in Part V, column (b), in subsequent years when calculating whether the foundation qualifies for the section 4940(e) reduction of tax in those years

Part XIII Undistributed Income (see page 26 of the instructions)

	(a) Corpus	(b) Years prior to 2009	(c) 2009	(d) 2010
1 Distributable amount for 2010 from Part XI, line 7				330,525.
2 Undistributed income, if any, as of the end of 2010				
a Enter amount for 2009 only				
b Total for prior years 20 08 ,20 07 ,20 06				
3 Excess distributions carryover, if any, to 2010:				
a From 2005 ... 2,373,221.				
b From 2006 ... 3,384,774.				
c From 2007 ... 3,348,840.				
d From 2008 ... 1,896,993.				
e From 2009 ... 2,293,087.				
f Total of lines 3a through e	13,296,915.			
4 Qualifying distributions for 2010 from Part XII, line 4 ▶ $ 1,975,893.				
a Applied to 2009, but not more than line 2a				
b Applied to undistributed income of prior years (Election required - see page 26 of the instructions)				
c Treated as distributions out of corpus (Election required - see page 26 of the instructions)				
d Applied to 2010 distributable amount				330,525.
e Remaining amount distributed out of corpus	1,645,368.			
5 Excess distributions carryover applied to 2010 (If an amount appears in column (d), the same amount must be shown in column (a).)				
6 **Enter the net total of each column as indicated below:**				
a Corpus. Add lines 3f, 4c, and 4e. Subtract line 5	14,942,283.			
b Prior years' undistributed income. Subtract line 4b from line 2b				
c Enter the amount of prior years' undistributed income for which a notice of deficiency has been issued, or on which the section 4942(a) tax has been previously assessed				
d Subtract line 6c from line 6b. Taxable amount - see page 27 of the instructions				
e Undistributed income for 2009. Subtract line 4a from line 2a. Taxable amount - see page 27 of the instructions				
f Undistributed income for 2010. Subtract lines 4d and 5 from line 1. This amount must be distributed in 2011				
7 Amounts treated as distributions out of corpus to satisfy requirements imposed by section 170(b)(1)(F) or 4942(g)(3) (see page 27 of the instructions)				
8 Excess distributions carryover from 2005 not applied on line 5 or line 7 (see page 27 of the instructions)	2,373,221.			
9 **Excess distributions carryover to 2011.** Subtract lines 7 and 8 from line 6a	12,569,062.			
10 Analysis of line 9:				
a Excess from 2006 ... 3,384,774.				
b Excess from 2007 ... 3,348,840.				
c Excess from 2008 ... 1,896,993.				
d Excess from 2009 ... 2,293,087.				
e Excess from 2010 ... 1,645,368.				

Part XIV Private Operating Foundations (see page 27 of the instructions and Part VII-A, question 9) NOT APPLICABLE

1a If the foundation has received a ruling or determination letter that it is a private operating foundation, and the ruling is effective for 2010, enter the date of the ruling . . . . ▶

b Check box to indicate whether the foundation is a private operating foundation described in section ☐ 4942(j)(3) or ☐ 4942(j)(5)

	Tax year	Prior 3 years			
	(a) 2010	(b) 2009	(c) 2008	(d) 2007	(e) Total
2a Enter the lesser of the adjusted net income from Part I or the minimum investment return from Part X for each year listed					
b 85% of line 2a					
c Qualifying distributions from Part XII, line 4 for each year listed					
d Amounts included in line 2c not used directly for active conduct of exempt activities					
e Qualifying distributions made directly for active conduct of exempt activities. Subtract line 2d from line 2c					
3 Complete 3a, b, or c for the alternative test relied upon					
a "Assets" alternative test - enter:					
(1) Value of all assets					
(2) Value of assets qualifying under section 4942(j)(3)(B)(i)					
b "Endowment" alternative test - enter 2/3 of minimum investment return shown in Part X, line 6 for each year listed					
c "Support" alternative test - enter:					
(1) Total support other than gross investment income (interest, dividends, rents, payments on securities loans (section 512(a)(5)), or royalties)					
(2) Support from general public and 5 or more exempt organizations as provided in section 4942 (j)(3)(B)(iii)					
(3) Largest amount of support from an exempt organization					
(4) Gross investment income					

Part XV Supplementary Information (Complete this part only if the foundation had $5,000 or more in assets at any time during the year - see page 28 of the instructions.)

1 **Information Regarding Foundation Managers:**

a List any managers of the foundation who have contributed more than 2% of the total contributions received by the foundation before the close of any tax year (but only if they have contributed more than $5,000). (See section 507(d)(2).)

NONE

b List any managers of the foundation who own 10% or more of the stock of a corporation (or an equally large portion of the ownership of a partnership or other entity) of which the foundation has a 10% or greater interest.

NONE

2 **Information Regarding Contribution, Grant, Gift, Loan, Scholarship, etc., Programs:**

Check here ▶ ☐ if the foundation only makes contributions to preselected charitable organizations and does not accept unsolicited requests for funds. If the foundation makes gifts, grants, etc (see page 28 of the instructions) to individuals or organizations under other conditions, complete items 2a, b, c, and d.

a The name, address, and telephone number of the person to whom applications should be addressed

ATTACHMENT 6

b The form in which applications should be submitted and information and materials they should include:

ATTACHMENT 7

c Any submission deadlines:

NONE

d Any restrictions or limitations on awards, such as by geographical areas, charitable fields, kinds of institutions, or other factors:

ATTACHMENT 8

Part XV Supplementary Information (continued)

3 Grants and Contributions Paid During the Year or Approved for Future Payment

Recipient Name and address (home or business)	If recipient is an individual, show any relationship to any foundation manager or substantial contributor	Foundation status of recipient	Purpose of grant or contribution	Amount
a Paid during the year SEE ATTACHMENT 12				2,069,615.
Total ▶ 3a				2,069,615.
b Approved for future payment				
Total ▶ 3b				NONE

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Part XVI-A Analysis of Income-Producing Activities

Enter gross amounts unless otherwise indicated	Unrelated business income		Excluded by section 512, 513, or 514		(e) Related or exempt function income (See page 28 of the instructions.)
	(a) Business code	(b) Amount	(c) Exclusion code	(d) Amount	
1 Program service revenue:					
a					
b					
c					
d					
e					
f					
g Fees and contracts from government agencies					
2 Membership dues and assessments					
3 Interest on savings and temporary cash investments			14	78.	
4 Dividends and interest from securities			14	159,624.	
5 Net rental income or (loss) from real estate					
a Debt-financed property					
b Not debt-financed property					
6 Net rental income or (loss) from personal property					
7 Other investment income					
8 Gain or (loss) from sales of assets other than inventory			18	68,860.	
9 Net income or (loss) from special events					
10 Gross profit or (loss) from sales of inventory					
11 Other revenue: a					
b					
c					
d					
e					
12 Subtotal. Add columns (b), (d), and (e)				228,562.	

13 Total. Add line 12, columns (b), (d), and (e) . . . 13 228,562.

(See worksheet in line 13 instructions on page 29 to verify calculations.)

Part XVI-B Relationship of Activities to the Accomplishment of Exempt Purposes

Line No. ▼	Explain below how each activity for which income is reported in column (e) of Part XVI-A contributed importantly to the accomplishment of the foundation's exempt purposes (other than by providing funds for such purposes). (See page 29 of the instructions.)
	NOT APPLICABLE

Form 990-PF (2010)

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Part XVII **Information Regarding Transfers To and Transactions and Relationships With Noncharitable Exempt Organizations**

			Yes	No
1	Did the organization directly or indirectly engage in any of the following with any other organization described in section 501(c) of the Code (other than section 501(c)(3) organizations) or in section 527, relating to political organizations?			
a	Transfers from the reporting foundation to a noncharitable exempt organization of			
	(1) Cash	1a(1)		X
	(2) Other assets	1a(2)		X
b	Other transactions			
	(1) Sales of assets to a noncharitable exempt organization	1b(1)		X
	(2) Purchases of assets from a noncharitable exempt organization	1b(2)		X
	(3) Rental of facilities, equipment, or other assets	1b(3)		X
	(4) Reimbursement arrangements	1b(4)		X
	(5) Loans or loan guarantees	1b(5)		X
	(6) Performance of services or membership or fundraising solicitations	1b(6)		X
c	Sharing of facilities, equipment, mailing lists, other assets, or paid employees	1c		X

d If the answer to any of the above is "Yes," complete the following schedule Column (b) should always show the fair market value of the goods, other assets, or services given by the reporting foundation If the foundation received less than fair market value in any transaction or sharing arrangement, show in column (d) the value of the goods, other assets, or services received

(a) Line no	(b) Amount involved	(c) Name of noncharitable exempt organization	(d) Description of transfers, transactions, and sharing arrangements
	N/A		N/A

2a Is the foundation directly or indirectly affiliated with, or related to, one or more tax-exempt organizations described in section 501(c) of the Code (other than section 501(c)(3)) or in section 527? ☐ Yes ☒ No

b If "Yes," complete the following schedule

(a) Name of organization	(b) Type of organization	(c) Description of relationship

Sign Here

Under penalties of perjury, I declare that I have examined this return, including accompanying schedules and statements, and to the best of my knowledge and belief, it is true, correct, and complete Declaration of preparer (other than taxpayer or fiduciary) is based on all information of which preparer has any knowledge

Vonda Holliman | 11-14-11 | Treasurer

Signature of officer or trustee | Date | Title

Paid Preparer Use Only

Print/Type preparer's name	Preparer's signature	Date	Check ☐ if self-employed	PTIN
Mitchell K. Caddell CPA	Mitchell K. Caddell CPA	11/14/11		P00051392

Firm's name ▶ BKD, LLP Firm's EIN ▶ 44-0160260

Firm's address ▶ 1551 N WATERFRONT PKWY, STE 300 WICHITA, KS 67206-6601 Phone no 316-265-2811

Form 990-PF (2010)

Form 8868 (Rev 1-2011) Page 2

• If you are filing for an **Additional (Not Automatic) 3-Month Extension, complete only Part II** and check this box . . . . ▶ [X]

Note. Only complete Part II if you have already been granted an automatic 3-month extension on a previously filed Form 8868.

• If you are filing for an **Automatic 3-Month Extension, complete only Part I** (on page 1).

Part II **Additional (Not Automatic) 3-Month Extension of Time.** Only file the original (no copies needed).

Type or print	Name of exempt organization	Employer identification number
	CLAUDE R. LAMBE CHARITABLE FOUNDATION	48-0935563
File by the extended due date for filing your return See instructions	Number, street, and room or suite no. If a P O box, see instructions	
	P.O. BOX 2256	
	City, town or post office, state, and ZIP code For a foreign address, see instructions	
	WICHITA, KS 67201-2256	

Enter the Return code for the return that this application is for (file a separate application for each return) . . . . [0 4]

Application Is For	Return Code	Application Is For	Return Code
Form 990	01		
Form 990-BL	02	Form 1041-A	08
Form 990-EZ	03	Form 4720	09
Form 990-PF	04	Form 5227	10
Form 990-T (sec 401(a) or 408(a) trust)	05	Form 6069	11
Form 990-T (trust other than above)	06	Form 8870	12

STOP! Do not complete Part II if you were not already granted an automatic 3-month extension on a previously filed Form 8868.

• The books are in the care of ▶ HEATHER LOVE

Telephone No ▶ 316 828-8286 FAX No ▶

• If the organization does not have an office or place of business in the United States, check this box . . . . ▶ [ ]

• If this is for a Group Return, enter the organization's four digit Group Exemption Number (GEN) ______ If this is for the whole group, check this box . . . . . . ▶ [ ] If it is for part of the group, check this box . . . . ▶ [ ] and attach a list with the names and EINs of all members the extension is for

4 I request an additional 3-month extension of time until 11/15 , 20 11

5 For calendar year ______ , or other tax year beginning ______ , 20 ____ , and ending 12/31 , 20 10

6 If the tax year entered in line 5 is for less than 12 months, check reason [ ] Initial return [ ] Final return [ ] Change in accounting period

7 State in detail why you need the extension

ADDITIONAL TIME IS REQUIRED TO ACCUMULATE THE INFORMATION NECESSARY TO FILE A COMPLETE AND ACCURATE RETURN.

8a	If this application is for Form 990-BL, 990-PF, 990-T, 4720, or 6069, enter the tentative tax, less any nonrefundable credits See instructions	8a	$ 0.
b	If this application is for Form 990-PF, 990-T, 4720, or 6069, enter any refundable credits and estimated tax payments made Include any prior year overpayment allowed as a credit and any amount paid previously with Form 8868	8b	$ 0.
c	**Balance Due.** Subtract line 8b from line 8a Include your payment with this form, if required, by using EFTPS (Electronic Federal Tax Payment System) See instructions	8c	$ 0.

Signature and Verification

Under penalties of perjury, I declare that I have examined this form, including accompanying schedules and statements, and to the best of my knowledge and belief, it is true, correct, and complete, and that I am authorized to prepare this form

Signature ▶ Title ▶ Date ▶

Form **8868** (Rev 1-2011)

JSA
0F8055 3 000
29145H K932 8/9/2011 10:37:43 AM V 10-7.2 85651

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 1

FORM 990PF, PART I - ACCOUNTING FEES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	NET INVESTMENT INCOME	ADJUSTED NET INCOME	CHARITABLE PURPOSES
ACCOUNTING FEES	21,758.			25,599.
INVESTMENT ACCTG SERVICE FEES	7,448.	7,448.		
TOTALS	29,206.	7,448.	0.	25,599.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 2

FORM 990PF, PART I - OTHER PROFESSIONAL FEES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	NET INVESTMENT INCOME
INVESTMENT MANAGEMENT FEES	17,010.	17,010.
TOTALS	17,010.	17,010.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 3

FORM 990PF, PART I - TAXES

DESCRIPTION		REVENUE AND EXPENSES PER BOOKS
FEDERAL EXCISE TAX		2,041.
	TOTALS	2,041.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 4

FORM 990PF, PART I - OTHER EXPENSES

DESCRIPTION		REVENUE AND EXPENSES PER BOOKS	CHARITABLE PURPOSES
INSURANCE		913.	913.
BANK FEES		631.	631.
	TOTALS	1,544.	1,544.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 5

FORM 990PF, PART II - OTHER INVESTMENTS

DESCRIPTION	ENDING BOOK VALUE	ENDING FMV
ZAZOVE BOND FUND	2,874,209.	3,127,154.
TOTALS	2,874,209.	3,127,154.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 6

FORM 990PF, PART XV - NAME, ADDRESS AND PHONE FOR APPLICATIONS

GRANT ADMINISTRATOR
1515 N. COURTHOUSE RD., SUITE 200
ARLINGTON, VA 22201
703-875-1600

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 7

990PF, PART XV - FORM AND CONTENTS OF SUBMITTED APPLICATIONS

LETTER EXPLAINING PROJECT AND AMOUNT REQUESTED, PLUS A COPY OF THE IRS DETERMINATION LETTER SHOWING EXEMPTION.

990PF, PART XV - RESTRICTIONS OR LIMITATIONS ON AWARDS

GRANTS ARE GENERALLY RESTRICTED TO PUBLIC CHARITY ORGANIZATIONS AS DEFINED IN SECTION 501(C)(3) OF THE INTERNAL REVENUE CODE. THE FOUNDATION DOES NOT MAKE GRANTS TO INDIVIDUALS OR FOR-PROFIT CORPORATIONS.

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
SCHEDULE OF INFORMATION FOR 2010 form 990-PF

Part IV Capital Gains and Losses for Tax on Investment Income — ATTACHMENT 9

	(a) List and describe the kind(s) of property sold (e g., real estate, 2-story brick warehouse, or common stock, 200 shs MLC Co)	(b) How acquired P - Purchase D - Donation	(c) Date acquired (mo , day, yr)	(d) Date sold (mo , day, yr)
1a	Zazove Associates, LLC Bond Fund - Sale of Bonds	P	7/6/06-4/27/10	1/4/10-12/17/10
b				
c				
d				
e				
f				
g				

	(e) Gross sales price minus expense of sale	(f) Depreciation allowed (or allowable)	(g) Cost or other basis	(h) Gain or (loss) (e) plus (f) minus (g)
a	899,869	0	831,009	68,860
b				
c				0
d				0
e				0
f				0
g				0

Complete only for assets showing gain in column (h) and owned by the foundation on 12/31/10

	(i) F M V as of 12/31/69	(j) Adjusted basis as of 12/31/69	(k) Excess of col (i) over col (j), if any	(l) Gains (Col (h) gain minus col (k), but not less than -0-) or Losses (from col (h))
a			0	68,860
b			0	0
c			0	0
d			0	0
e			0	0
f			0	0
g			0	0

2 Capital gain net income or (net capital loss) — If gain, also enter in Part I, line 7; If (loss), enter -0- in Part I, line 7	2	68,860
3 Net short-term capital gain or (loss) as defined in sections 1222(5) and (6) If gain, also enter in Part I, line 8, column (c) (see pages 11 and 16 of the instructions) If (loss), enter -0- in Part I, line 8	3	0

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
ATTACHMENT TO FORM 990-PF TO REPORT
EXPENDITURE RESPONSIBILITY GRANT
For the Year Ended 12/31/10

PART VII-B, Question on Line 5c:	ATTACHMENT 10

Expenditure Responsibility Statement for the year 2010

Pursuant to IRC Regulation section 53.4945-5(d)(2), the CLAUDE R. LAMBE CHARITABLE FOUNDATION provides the following information

(i)	Name & Address of Grantee	Allen-Lambe House Foundation 255 N Roosevelt Wichita, KS 67208
(ii)	Date and Amount of Grants:	March 2, 2010 $123,065
(iii)	Purpose of Grants	General program operating support for the Allen-Lambe House Foundation, an educational foundation which operates a museum and study center in a house located in Wichita, Kansas, designed by Frank Lloyd Wright in 1915. The house museum is open to the general public. The program of the Foundation includes restoration and conservation of the house, gardens, and its interiors, with furnishings to showcase the "Praire Style" designs of Frank Lloyd Wright, and to maintain a library archive study center for the study of Frank Lloyd Wright and other interrelated areas of design.
(iv)	Amounts expended	Reports received from the Allen-Lambe House Foundation show the following expenditures: $103,281 total funds were spent from grant for operating support of the museum. The remaining $19,784 was designated for major repairs to be paid in 2011.
(v)	Diversions:	To the knowledge of this grantor foundation, no funds have been diverted to any activity other than the activity for which the grant was originally made.
(vi)	Date of Reports:	On March 9, 2011, the Allen-Lambe House Foundation submitted a full and complete report of its expenditures of the March 2, 2010 operating support grant.
(vi)	Verification.	The grantor has no reason to doubt the accuracy or reliability of the report from the grantee; therefore, no independent verification of the reports were made.

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
SCHEDULE OF INFORMATION FOR 2010 FORM 990 PF

PART VIII, Line 1 - Officers, Directors,Trustees, Managers, Etc. **ATTACHMENT 11**

(a) Name and Address	(b) Title, and average hours per week devoted to position	(c) Compensation	(d) Contributions to employee benefit plans	(e) Expense account, other allowances
Richard H Fink 1515 N Courthouse Rd, Suite 200 Arlington, VA 22201	President / Director 1 hour per week	0	0	0
Logan Moore 1515 N Courthouse Rd, Suite 200 Arlington, VA 22201	Secretary 1 hour per week average	0	0	0
Vonda Holliman P O Box 2256 Wichita, KS 67201	Treasurer 1 hour per week average	0	0	0
Charles G Koch P O Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
Elizabeth B Koch P O Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
Elizabeth R Koch PO Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
Charles C. Koch PO Box 2256 Wichita, KS 67201	Director Less than 1 hour per week	0	0	0
	TOTAL	0	0	0

CLAUDE R. LAMBE CHARITABLE FOUNDATION
EIN 48-0935563
SCHEDULE OF INFORMATION FOR 2010 FORM 990 PF

Part XV, Line 3a& b - Grants and Contributions Paid During the Year or Approved for Future Payment ATTACHMENT 12

Recipient Name and address (home or business)	If recipient is an individual, show any relationship to any foundation manager or substantial contributor	Foundation status of recipient	Purpose of grant or contribution	Amount
a Paid during the year				
Allen-Lambe House Foundation Wichita, KS		Private	General Operating Support	$ 123,065
American Council for Capital Formation, Center for Policy Research Washington, DC		Public	General Operating Support	50,000
American Legislative Exchange Council Washington, DC		Public	Educational Programs	100,000
Americans for Prosperity Foundation Washington, DC		Public	General Operating Support	150,000
Ayn Rand Institute Irvine, CA		Public	Educational Programs	25,000
Cato Institute Washington, DC		Public	General Operating Support	7,350
Center for Independent Thought New York, NY		Public	Educational Programs	40,000
Competitive Enterprise Institute Washington, DC		Public	General Operating Support	9,200
Council for National Policy Washington, DC		Public	General Operating Support	25,000
Federalist Society Washington, DC		Public	Educational Programs General Operating Support	85,000 150,000
Free Congress Foundation Alexandria, VA		Public	General Operating Support	10,000
The Heritage Foundation Washington, DC		Public	Educational Programs	500,000
Independent Women's Forum Washington, DC		Public	Educational Programs	350,000
Manhattan Institute for Policy Research New York, NY		Public	Educational Programs	200,000
National Center for Policy Analysis Dallas, TX		Public	General Operating Support	25,000
Tax Foundation Washington, DC		Public	Educational Programs	20,000
Texas Public Policy Foundation Austin, TX		Public	General Operating Support	50,000
Washington Legal Foundation Washington, DC		Public	General Operating Support	150,000
TOTAL GRANTS PAID TO ORGANIZATIONS				$ 2,069,615

Claude R. Lambe Charitable Foundation

Return of Private Foundation

December 31, 2011

BKD LLP
CPAs & Advisors

EXTENSION GRANTED

Form **990-PF**
Department of the Treasury
Internal Revenue Service

Return of Private Foundation
or Section 4947(a)(1) Nonexempt Charitable Trust Treated as a Private Foundation

Note. The foundation may be able to use a copy of this return to satisfy state reporting requirements.

OMB No. 1545-0052
2011

For calendar year 2011 or tax year beginning , 2011, and ending , 20

Name of foundation: CLAUDE R. LAMBE CHARITABLE FOUNDATION
A Employer identification number: 48-0935563

Number and street (or P.O. box number if mail is not delivered to street address): P.O. BOX 2256
Room/suite:
B Telephone number (see instructions): (316) 828-8286

City or town, state, and ZIP code: WICHITA, KS 67201-2256

C If exemption application is pending, check here ▶ [ ]

G Check all that apply: [ ] Initial return [ ] Initial return of a former public charity [ ] Final return [ ] Amended return [ ] Address change [ ] Name change

D 1. Foreign organizations, check here ▶ [ ]
2. Foreign organizations meeting the 85% test, check here and attach computation ▶ [ ]

H Check type of organization: [X] Section 501(c)(3) exempt private foundation
[ ] Section 4947(a)(1) nonexempt charitable trust [ ] Other taxable private foundation

E If private foundation status was terminated under section 507(b)(1)(A), check here ▶ [ ]

I Fair market value of all assets at end of year (from Part II, col. (c), line 16) ▶ $ 4,331,707.
J Accounting method: [ ] Cash [X] Accrual [ ] Other (specify)
(Part I, column (d) must be on cash basis.)

F If the foundation is in a 60-month termination under section 507(b)(1)(B), check here ▶ [ ]

Part I Analysis of Revenue and Expenses (The total of amounts in columns (b), (c), and (d) may not necessarily equal the amounts in column (a) (see instructions).)	(a) Revenue and expenses per books	(b) Net investment income	(c) Adjusted net income	(d) Disbursements for charitable purposes (cash basis only)
Revenue				
1 Contributions, gifts, grants, etc., received (attach schedule)				
2 Check ▶ [X] if the foundation is not required to attach Sch. B				
3 Interest on savings and temporary cash investments	154.	154.		
4 Dividends and interest from securities	71,670.	71,670.		
5a Gross rents				
b Net rental income or (loss)				
6a Net gain or (loss) from sale of assets not on line 10	77,445.			
b Gross sales price for all assets on line 6a 1,234,003.				
7 Capital gain net income (from Part IV, line 2)		77,445.		
8 Net short-term capital gain				
9 Income modifications				
10a Gross sales less returns and allowances				
b Less: Cost of goods sold				
c Gross profit or (loss) (attach schedule)				
11 Other income (attach schedule)	2,134.	20.		
12 **Total.** Add lines 1 through 11	151,403.	149,289.		
Operating and Administrative Expenses				
13 Compensation of officers, directors, trustees, etc.	0			
14 Other employee salaries and wages				
15 Pension plans, employee benefits				
16a Legal fees (attach schedule)				
b Accounting fees (attach schedule) ATCH 1	24,657.	319.		22,706.
c Other professional fees (attach schedule) *	38,818.	38,818.		
17 Interest				
18 Taxes (attach schedule) (see instructions) **	2,203.			
19 Depreciation (attach schedule) and depletion				
20 Occupancy				
21 Travel, conferences, and meetings	800.			800.
22 Printing and publications				
23 Other expenses (attach schedule) ATCH 4	1,540.			1,540.
24 **Total operating and administrative expenses.** Add lines 13 through 23	68,018.	39,137.		25,046.
25 Contributions, gifts, grants paid	1,179,180.			1,179,180.
26 Total expenses and disbursements. Add lines 24 and 25	1,247,198.	39,137.	0	1,204,226.
27 Subtract line 26 from line 12:				
a Excess of revenue over expenses and disbursements	-1,095,795.			
b **Net investment income** (if negative, enter -0-)		110,152.		
c **Adjusted net income** (if negative, enter -0-)				

For Paperwork Reduction Act Notice, see instructions. *ATCH 2 JSA ** ATCH 3 Form **990-PF** (2011)

Form 990-PF (2011) CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563 Page 2

Part II Balance Sheets Attached schedules and amounts in the description column should be for end-of-year amounts only. (See instructions.)

		Beginning of year (a) Book Value	End of year (b) Book Value	End of year (c) Fair Market Value
Assets	1 Cash - non-interest-bearing	2,920.	132,228.	132,228.
	2 Savings and temporary cash investments	2,401,826.	1,069,593.	1,069,593.
	3 Accounts receivable ▶			
	Less: allowance for doubtful accounts ▶			
	4 Pledges receivable ▶			
	Less: allowance for doubtful accounts ▶			
	5 Grants receivable			
	6 Receivables due from officers, directors, trustees, and other disqualified persons (attach schedule) (see instructions)			
	7 Other notes and loans receivable (attach schedule) ▶			
	Less: allowance for doubtful accounts ▶			
	8 Inventories for sale or use			
	9 Prepaid expenses and deferred charges	6,035.	3,832.	3,832.
	10 a Investments - U.S. and state government obligations (attach schedule)			
	b Investments - corporate stock (attach schedule)			
	c Investments - corporate bonds (attach schedule)			
	11 Investments - land, buildings, and equipment: basis ▶			
	Less: accumulated depreciation (attach schedule) ▶			
	12 Investments - mortgage loans			
	13 Investments - other (attach schedule) ATCH 5	2,874,209.	2,984,999.	3,126,054.
	14 Land, buildings, and equipment: basis ▶			
	Less: accumulated depreciation (attach schedule) ▶			
	15 Other assets (describe ▶)			
	16 **Total assets** (to be completed by all filers - see the instructions. Also, see page 1, item I)	5,284,990.	4,190,652.	4,331,707.
Liabilities	17 Accounts payable and accrued expenses	1,725.	3,182.	
	18 Grants payable			
	19 Deferred revenue			
	20 Loans from officers, directors, trustees, and other disqualified persons			
	21 Mortgages and other notes payable (attach schedule)			
	22 Other liabilities (describe ▶)			
	23 **Total liabilities** (add lines 17 through 22)	1,725.	3,182.	
Net Assets or Fund Balances	**Foundations that follow SFAS 117, check here ▶ [X] and complete lines 24 through 26 and lines 30 and 31.**			
	24 Unrestricted	5,283,265.	4,187,470.	
	25 Temporarily restricted			
	26 Permanently restricted			
	Foundations that do not follow SFAS 117, check here and complete lines 27 through 31. ▶ [ ]			
	27 Capital stock, trust principal, or current funds			
	28 Paid-in or capital surplus, or land, bldg., and equipment fund			
	29 Retained earnings, accumulated income, endowment, or other funds			
	30 **Total net assets or fund balances** (see instructions)	5,283,265.	4,187,470.	
	31 **Total liabilities and net assets/fund balances** (see instructions)	5,284,990.	4,190,652.	

Part III Analysis of Changes in Net Assets or Fund Balances

1 Total net assets or fund balances at beginning of year - Part II, column (a), line 30 (must agree with end-of-year figure reported on prior year's return)	1	5,283,265.
2 Enter amount from Part I, line 27a	2	-1,095,795.
3 Other increases not included in line 2 (itemize) ▶	3	
4 Add lines 1, 2, and 3	4	4,187,470.
5 Decreases not included in line 2 (itemize) ▶	5	
6 Total net assets or fund balances at end of year (line 4 minus line 5) - Part II, column (b), line 30	6	4,187,470.

Form **990-PF** (2011)

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

Form 990-PF (2011) Page 3

Part IV Capital Gains and Losses for Tax on Investment Income

(a) List and describe the kind(s) of property sold (e.g., real estate, 2-story brick warehouse; or common stock, 200 shs. MLC Co.)	(b) How acquired P-Purchase D-Donation	(c) Date acquired (mo., day, yr.)	(d) Date sold (mo., day, yr.)
1a SEE PART IV SCHEDULE			
b			
c			
d			
e			

	(e) Gross sales price	(f) Depreciation allowed (or allowable)	(g) Cost or other basis plus expense of sale	(h) Gain or (loss) (e) plus (f) minus (g)
a				
b				
c				
d				
e				

Complete only for assets showing gain in column (h) and owned by the foundation on 12/31/69

	(i) F.M.V. as of 12/31/69	(j) Adjusted basis as of 12/31/69	(k) Excess of col. (i) over col. (j), if any	(l) Gains (Col. (h) gain minus col. (k), but not less than -0-) or Losses (from col. (h))
a				
b				
c				
d				
e				

2 Capital gain net income or (net capital loss) { If gain, also enter in Part I, line 7; If (loss), enter -0- in Part I, line 7 }	2	77,445.
3 Net short-term capital gain or (loss) as defined in sections 1222(5) and (6): If gain, also enter in Part I, line 8, column (c) (see instructions). If (loss), enter -0- in Part I, line 8	3	0

Part V Qualification Under Section 4940(e) for Reduced Tax on Net Investment Income

(For optional use by domestic private foundations subject to the section 4940(a) tax on net investment income.)

If section 4940(d)(2) applies, leave this part blank.

Was the foundation liable for the section 4942 tax on the distributable amount of any year in the base period? ☐ Yes ☒ No

If "Yes," the foundation does not qualify under section 4940(e). Do not complete this part.

1 Enter the appropriate amount in each column for each year; see the instructions before making any entries.

(a) Base period years Calendar year (or tax year beginning in)	(b) Adjusted qualifying distributions	(c) Net value of noncharitable-use assets	(d) Distribution ratio (col. (b) divided by col. (c))
2010	1,973,852.	6,651,320.	0.296761
2009	2,730,340.	8,782,857.	0.310872
2008	2,456,244.	11,492,427.	0.213727
2007	4,085,883.	15,540,497.	0.262918
2006	4,231,735.	17,229,773.	0.245606

2 **Total** of line 1, column (d)	2	1.329884
3 Average distribution ratio for the 5-year base period - divide the total on line 2 by 5, or by the number of years the foundation has been in existence if less than 5 years	3	0.265977
4 Enter the net value of noncharitable-use assets for 2011 from Part X, line 5	4	5,068,581.
5 Multiply line 4 by line 3	5	1,348,126.
6 Enter 1% of net investment income (1% of Part I, line 27b)	6	1,102.
7 Add lines 5 and 6	7	1,349,228.
8 Enter qualifying distributions from Part XII, line 4	8	1,204,226.

If line 8 is equal to or greater than line 7, check the box in Part VI, line 1b, and complete that part using a 1% tax rate. See the Part VI instructions.

Part VI Excise Tax Based on Investment Income (Section 4940(a), 4940(b), 4940(e), or 4948 - see instructions)

1a	Exempt operating foundations described in section 4940(d)(2), check here ▶ ☐ and enter "N/A" on line 1. Date of ruling or determination letter: ____ (attach copy of letter if necessary - see instructions)		
b	Domestic foundations that meet the section 4940(e) requirements in Part V, check here ▶ ☐ and enter 1% of Part I, line 27b	1	2,203.
c	All other domestic foundations enter 2% of line 27b. Exempt foreign organizations enter 4% of Part I, line 12, col. (b).		
2	Tax under section 511 (domestic section 4947(a)(1) trusts and taxable foundations only. Others enter -0-)	2	
3	Add lines 1 and 2	3	2,203.
4	Subtitle A (income) tax (domestic section 4947(a)(1) trusts and taxable foundations only. Others enter -0-)	4	0
5	**Tax based on investment income.** Subtract line 4 from line 3. If zero or less, enter -0-	5	2,203.
6	Credits/Payments:		
a	2011 estimated tax payments and 2010 overpayment credited to 2011 — 6a: 6,035.		
b	Exempt foreign organizations - tax withheld at source — 6b		
c	Tax paid with application for extension of time to file (Form 8868) — 6c		
d	Backup withholding erroneously withheld — 6d		
7	Total credits and payments. Add lines 6a through 6d	7	6,035.
8	Enter any **penalty** for underpayment of estimated tax. Check here ☐ if Form 2220 is attached	8	
9	**Tax due.** If the total of lines 5 and 8 is more than line 7, enter **amount owed** ▶	9	
10	**Overpayment.** If line 7 is more than the total of lines 5 and 8, enter the **amount overpaid** ▶	10	3,832.
11	Enter the amount of line 10 to be: **Credited to 2012 estimated tax** ▶ 3,832. **Refunded** ▶	11	

Part VII-A Statements Regarding Activities

			Yes	No
1a	During the tax year, did the foundation attempt to influence any national, state, or local legislation or did it participate or intervene in any political campaign?	1a		X
b	Did it spend more than $100 during the year (either directly or indirectly) for political purposes (see page 19 of the instructions for definition)?	1b		X
	If the answer is "Yes" to 1a or 1b, attach a detailed description of the activities and copies of any materials published or distributed by the foundation in connection with the activities.			
c	Did the foundation file **Form 1120-POL** for this year?	1c		X
d	Enter the amount (if any) of tax on political expenditures (section 4955) imposed during the year: (1) On the foundation. ▶ $ ____ (2) On foundation managers. ▶ $ ____			
e	Enter the reimbursement (if any) paid by the foundation during the year for political expenditure tax imposed on foundation managers. ▶ $ ____			
2	Has the foundation engaged in any activities that have not previously been reported to the IRS? *If "Yes," attach a detailed description of the activities.*	2		X
3	Has the foundation made any changes, not previously reported to the IRS, in its governing instrument, articles of incorporation, or bylaws, or other similar instruments? *If "Yes," attach a conformed copy of the changes*	3		X
4a	Did the foundation have unrelated business gross income of $1,000 or more during the year?	4a		X
b	If "Yes," has it filed a tax return on **Form 990-T** for this year?	4b		
5	Was there a liquidation, termination, dissolution, or substantial contraction during the year? *If "Yes," attach the statement required by General Instruction T.*	5		X
6	Are the requirements of section 508(e) (relating to sections 4941 through 4945) satisfied either: • By language in the governing instrument, or • By state legislation that effectively amends the governing instrument so that no mandatory directions that conflict with the state law remain in the governing instrument?	6	X	
7	Did the foundation have at least $5,000 in assets at any time during the year? *If "Yes," complete Part II, col. (c), and Part XV*	7	X	
8a	Enter the states to which the foundation reports or with which it is registered (see instructions) ▶ KS, VA,			
b	If the answer is "Yes" to line 7, has the foundation furnished a copy of Form 990-PF to the Attorney General (or designate) of each state as required by *General Instruction G? If "No," attach explanation*	8b	X	
9	Is the foundation claiming status as a private operating foundation within the meaning of section 4942(j)(3) or 4942(j)(5) for calendar year 2011 or the taxable year beginning in 2011 (see instructions for Part XIV)? *If "Yes," complete Part XIV*	9		X
10	Did any persons become substantial contributors during the tax year? *If "Yes," attach a schedule listing their names and addresses*	10		X

Part VII-A Statements Regarding Activities *(continued)*

			Yes	No
11	At any time during the year, did the foundation, directly or indirectly, own a controlled entity within the meaning of section 512(b)(13)? If "Yes," attach schedule (see instructions)	11		X
12	Did the foundation make a distribution to a donor advised fund over which the foundation or a disqualified person had advisory privileges? If "Yes," attach statement (see instructions)	12		X
13	Did the foundation comply with the public inspection requirements for its annual returns and exemption application?	13	X	

Website address ▶ N/A

14 The books are in care of ▶ HEATHER LOVE Telephone no. ▶ (316)828-8286

Located at ▶ 4111 E. 37TH STREET NORTH WICHITA, KS ZIP+4 ▶ 67220

15 Section 4947(a)(1) nonexempt charitable trusts filing Form 990-PF in lieu of Form 1041 - Check here ▶ ☐

and enter the amount of tax-exempt interest received or accrued during the year ▶ 15

			Yes	No
16	At any time during calendar year 2011, did the foundation have an interest in or a signature or other authority over a bank, securities, or other financial account in a foreign country?	16		X
	See the instructions for exceptions and filing requirements for Form TD F 90-22.1. If "Yes," enter the name of the foreign country ▶			

Part VII-B Statements Regarding Activities for Which Form 4720 May Be Required

			Yes	No
	File Form 4720 if any item is checked in the "Yes" column, unless an exception applies.			
1a	During the year did the foundation (either directly or indirectly):			
	(1) Engage in the sale or exchange, or leasing of property with a disqualified person? ☐ Yes ☒ No			
	(2) Borrow money from, lend money to, or otherwise extend credit to (or accept it from) a disqualified person? ☐ Yes ☒ No			
	(3) Furnish goods, services, or facilities to (or accept them from) a disqualified person? ☒ Yes ☐ No			
	(4) Pay compensation to, or pay or reimburse the expenses of, a disqualified person? ☒ Yes ☐ No			
	(5) Transfer any income or assets to a disqualified person (or make any of either available for the benefit or use of a disqualified person)? ☐ Yes ☒ No			
	(6) Agree to pay money or property to a government official? (**Exception.** Check "No" if the foundation agreed to make a grant to or to employ the official for a period after termination of government service, if terminating within 90 days.) ☐ Yes ☒ No			
b	If any answer is "Yes" to 1a(1)-(6), did **any** of the acts fail to qualify under the exceptions described in Regulations section 53.4941(d)-3 or in a current notice regarding disaster assistance (see instructions)?	1b		X
	Organizations relying on a current notice regarding disaster assistance check here ▶ ☐			
c	Did the foundation engage in a prior year in any of the acts described in 1a, other than excepted acts, that were not corrected before the first day of the tax year beginning in 2011?	1c		X
2	Taxes on failure to distribute income (section 4942) (does not apply for years the foundation was a private operating foundation defined in section 4942(j)(3) or 4942(j)(5)):			
a	At the end of tax year 2011, did the foundation have any undistributed income (lines 6d and 6e, Part XIII) for tax year(s) beginning before 2011? ☐ Yes ☒ No			
	If "Yes," list the years ▶			
b	Are there any years listed in 2a for which the foundation is **not** applying the provisions of section 4942(a)(2) (relating to incorrect valuation of assets) to the year's undistributed income? (If applying section 4942(a)(2) to **all** years listed, answer "No" and attach statement - see instructions.)	2b		
c	If the provisions of section 4942(a)(2) are being applied to **any** of the years listed in 2a, list the years here. ▶			
3a	Did the foundation hold more than a 2% direct or indirect interest in any business enterprise at any time during the year? ☐ Yes ☒ No			
b	If "Yes," did it have excess business holdings in 2011 as a result of (1) any purchase by the foundation or disqualified persons after May 26, 1969; (2) the lapse of the 5-year period (or longer period approved by the Commissioner under section 4943(c)(7)) to dispose of holdings acquired by gift or bequest; or (3) the lapse of the 10-, 15-, or 20-year first phase holding period? *(Use Schedule C, Form 4720, to determine if the foundation had excess business holdings in 2011.)*	3b		
4a	Did the foundation invest during the year any amount in a manner that would jeopardize its charitable purposes?	4a		X
b	Did the foundation make any investment in a prior year (but after December 31, 1969) that could jeopardize its charitable purpose that had not been removed from jeopardy before the first day of the tax year beginning in 2011?	4b		X

Part VII-B Statements Regarding Activities for Which Form 4720 May Be Required *(continued)*

5a During the year did the foundation pay or incur any amount to:

(1) Carry on propaganda, or otherwise attempt to influence legislation (section 4945(e))? . . . . . . ☐ Yes ☒ No

(2) Influence the outcome of any specific public election (see section 4955); or to carry on, directly or indirectly, any voter registration drive? . . . . . . ☐ Yes ☒ No

(3) Provide a grant to an individual for travel, study, or other similar purposes? . . . . . . ☐ Yes ☒ No

(4) Provide a grant to an organization other than a charitable, etc., organization described in section 509(a)(1), (2), or (3), or section 4940(d)(2)? (see instructions) . . . . . . ☒ Yes ☐ No

(5) Provide for any purpose other than religious, charitable, scientific, literary, or educational purposes, or for the prevention of cruelty to children or animals? . . . . . . ☐ Yes ☒ No

b If any answer is "Yes" to 5a(1)-(5), did **any** of the transactions fail to qualify under the exceptions described in Regulations section 53.4945 or in a current notice regarding disaster assistance (see instructions)? . . . . . . **5b** No: X

Organizations relying on a current notice regarding disaster assistance check here . . . . . . ▶ ☐

c If the answer is "Yes" to question 5a(4), does the foundation claim exemption from the tax because it maintained expenditure responsibility for the grant? . . ATTACHMENT 6 . . . . . ☒ Yes ☐ No

If "Yes," attach the statement required by Regulations section 53.4945-5(d).

6a Did the foundation, during the year, receive any funds, directly or indirectly, to pay premiums on a personal benefit contract? . . . . . . ☐ Yes ☒ No

b Did the foundation, during the year, pay premiums, directly or indirectly, on a personal benefit contract? . . . . . . **6b** No: X

If "Yes" to 6b, file Form 8870.

7a At any time during the tax year, was the foundation a party to a prohibited tax shelter transaction? . . ☐ Yes ☒ No

b If "Yes," did the foundation receive any proceeds or have any net income attributable to the transaction? **7b**

Part VIII Information About Officers, Directors, Trustees, Foundation Managers, Highly Paid Employees, and Contractors

1 List all officers, directors, trustees, foundation managers and their compensation (see instructions).

(a) Name and address	(b) Title, and average hours per week devoted to position	(c) Compensation (If not paid, enter -0-)	(d) Contributions to employee benefit plans and deferred compensation	(e) Expense account, other allowances
ATTACHMENT 7		0	0	0

2 Compensation of five highest-paid employees (other than those included on line 1 - see instructions). If none, enter "NONE."

(a) Name and address of each employee paid more than $50,000	(b) Title, and average hours per week devoted to position	(c) Compensation	(d) Contributions to employee benefit plans and deferred compensation	(e) Expense account, other allowances
NONE				

Total number of other employees paid over $50,000 . . . . . . ▶

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Part VIII Information About Officers, Directors, Trustees, Foundation Managers, Highly Paid Employees, and Contractors *(continued)*

3 Five highest-paid independent contractors for professional services (see instructions). If none, enter "NONE."

(a) Name and address of each person paid more than $50,000	(b) Type of service	(c) Compensation
NONE		
Total number of others receiving over $50,000 for professional services ▶		

Part IX-A Summary of Direct Charitable Activities

List the foundation's four largest direct charitable activities during the tax year. Include relevant statistical information such as the number of organizations and other beneficiaries served, conferences convened, research papers produced, etc.	Expenses
1 NONE	
2	
3	
4	

Part IX-B Summary of Program-Related Investments (see instructions)

Describe the two largest program-related investments made by the foundation during the tax year on lines 1 and 2.	Amount
1 NONE	
2	
All other program-related investments. See instructions.	
3 NONE	
Total. Add lines 1 through 3 ▶	

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Part X Minimum Investment Return (All domestic foundations must complete this part. Foreign foundations, see instructions.)

1	Fair market value of assets not used (or held for use) directly in carrying out charitable, etc., purposes:		
a	Average monthly fair market value of securities	1a	3,199,686.
b	Average of monthly cash balances	1b	1,946,082.
c	Fair market value of all other assets (see instructions)	1c	
d	**Total** (add lines 1a, b, and c)	1d	5,145,768.
e	Reduction claimed for blockage or other factors reported on lines 1a and 1c (attach detailed explanation) 1e		
2	Acquisition indebtedness applicable to line 1 assets	2	
3	Subtract line 2 from line 1d	3	5,145,768.
4	Cash deemed held for charitable activities. Enter 1 1/2% of line 3 (for greater amount, see instructions)	4	77,187.
5	**Net value of noncharitable-use assets.** Subtract line 4 from line 3. Enter here and on Part V, line 4	5	5,068,581.
6	**Minimum investment return.** Enter 5% of line 5	6	253,429.

Part XI Distributable Amount (see instructions) (Section 4942(j)(3) and (j)(5) private operating foundations and certain foreign organizations check here ▶ ☐ and do not complete this part.)

1	Minimum investment return from Part X, line 6			1	253,429.
2a	Tax on investment income for 2011 from Part VI, line 5	2a	2,203.		
b	Income tax for 2011. (This does not include the tax from Part VI.)	2b			
c	Add lines 2a and 2b			2c	2,203.
3	Distributable amount before adjustments. Subtract line 2c from line 1			3	251,226.
4	Recoveries of amounts treated as qualifying distributions			4	
5	Add lines 3 and 4			5	251,226.
6	Deduction from distributable amount (see instructions)			6	
7	**Distributable amount** as adjusted. Subtract line 6 from line 5. Enter here and on Part XIII, line 1			7	251,226.

Part XII Qualifying Distributions (see instructions)

1	Amounts paid (including administrative expenses) to accomplish charitable, etc., purposes:		
a	Expenses, contributions, gifts, etc. - total from Part I, column (d), line 26	1a	1,204,226.
b	Program-related investments - total from Part IX-B	1b	
2	Amounts paid to acquire assets used (or held for use) directly in carrying out charitable, etc., purposes	2	
3	Amounts set aside for specific charitable projects that satisfy the:		
a	Suitability test (prior IRS approval required)	3a	
b	Cash distribution test (attach the required schedule)	3b	
4	**Qualifying distributions.** Add lines 1a through 3b. Enter here and on Part V, line 8, and Part XIII, line 4	4	1,204,226.
5	Foundations that qualify under section 4940(e) for the reduced rate of tax on net investment income. Enter 1% of Part I, line 27b (see instructions)	5	0
6	**Adjusted qualifying distributions.** Subtract line 5 from line 4	6	1,204,226.

Note. The amount on line 6 will be used in Part V, column (b), in subsequent years when calculating whether the foundation qualifies for the section 4940(e) reduction of tax in those years.

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Part XIII Undistributed Income (see instructions)

		(a) Corpus	(b) Years prior to 2010	(c) 2010	(d) 2011
1	Distributable amount for 2011 from Part XI, line 7				251,226.
2	Undistributed income, if any, as of the end of 2011:				
a	Enter amount for 2010 only				
b	Total for prior years: 20 09 ,20 08 ,20 07				
3	Excess distributions carryover, if any, to 2011:				
a	From 2006 ... 3,384,774.				
b	From 2007 ... 3,348,840.				
c	From 2008 ... 1,896,993.				
d	From 2009 ... 2,293,087.				
e	From 2010 ... 1,645,368.				
f	Total of lines 3a through e	12,569,062.			
4	Qualifying distributions for 2011 from Part XII, line 4: ▶ $ 1,204,226.				
a	Applied to 2010, but not more than line 2a				
b	Applied to undistributed income of prior years (Election required - see instructions)				
c	Treated as distributions out of corpus (Election required - see instructions)				
d	Applied to 2011 distributable amount				251,226.
e	Remaining amount distributed out of corpus	953,000.			
5	Excess distributions carryover applied to 2011 *(If an amount appears in column (d), the same amount must be shown in column (a).)*				
6	**Enter the net total of each column as indicated below:**				
a	Corpus. Add lines 3f, 4c, and 4e. Subtract line 5	13,522,062.			
b	Prior years' undistributed income. Subtract line 4b from line 2b				
c	Enter the amount of prior years' undistributed income for which a notice of deficiency has been issued, or on which the section 4942(a) tax has been previously assessed				
d	Subtract line 6c from line 6b. Taxable amount - see instructions				
e	Undistributed income for 2010. Subtract line 4a from line 2a. Taxable amount - see instructions				
f	Undistributed income for 2011. Subtract lines 4d and 5 from line 1. This amount must be distributed in 2012				
7	Amounts treated as distributions out of corpus to satisfy requirements imposed by section 170(b)(1)(F) or 4942(g)(3) (see instructions)				
8	Excess distributions carryover from 2006 not applied on line 5 or line 7 (see instructions)	3,384,774.			
9	**Excess distributions carryover to 2012.** Subtract lines 7 and 8 from line 6a	10,137,288.			
10	Analysis of line 9:				
a	Excess from 2007 ... 3,348,840.				
b	Excess from 2008 ... 1,896,993.				
c	Excess from 2009 ... 2,293,087.				
d	Excess from 2010 ... 1,645,368.				
e	Excess from 2011 ... 953,000.				

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Part XIV Private Operating Foundations (see instructions and Part VII-A, question 9) NOT APPLICABLE

1a If the foundation has received a ruling or determination letter that it is a private operating foundation, and the ruling is effective for 2011, enter the date of the ruling . . . . ▶

b Check box to indicate whether the foundation is a private operating foundation described in section ☐ 4942(j)(3) or ☐ 4942(j)(5)

	Tax year (a) 2011	Prior 3 years (b) 2010	(c) 2009	(d) 2008	(e) Total
2a Enter the lesser of the adjusted net income from Part I or the minimum investment return from Part X for each year listed					
b 85% of line 2a					
c Qualifying distributions from Part XII, line 4 for each year listed					
d Amounts included in line 2c not used directly for active conduct of exempt activities					
e Qualifying distributions made directly for active conduct of exempt activities. Subtract line 2d from line 2c					
3 Complete 3a, b, or c for the alternative test relied upon:					
a "Assets" alternative test - enter:					
(1) Value of all assets					
(2) Value of assets qualifying under section 4942(j)(3)(B)(i)					
b "Endowment" alternative test- enter 2/3 of minimum investment return shown in Part X, line 6 for each year listed					
c "Support" alternative test - enter:					
(1) Total support other than gross investment income (interest, dividends, rents, payments on securities loans (section 512(a)(5)), or royalties)					
(2) Support from general public and 5 or more exempt organizations as provided in section 4942 (j)(3)(B)(iii)					
(3) Largest amount of support from an exempt organization					
(4) Gross investment income					

Part XV Supplementary Information (Complete this part only if the foundation had $5,000 or more in assets at any time during the year - see instructions.)

1 Information Regarding Foundation Managers:

a List any managers of the foundation who have contributed more than 2% of the total contributions received by the foundation before the close of any tax year (but only if they have contributed more than $5,000). (See section 507(d)(2).)

NONE

b List any managers of the foundation who own 10% or more of the stock of a corporation (or an equally large portion of the ownership of a partnership or other entity) of which the foundation has a 10% or greater interest.

NONE

2 Information Regarding Contribution, Grant, Gift, Loan, Scholarship, etc., Programs:

Check here ▶ ☐ if the foundation only makes contributions to preselected charitable organizations and does not accept unsolicited requests for funds. If the foundation makes gifts, grants, etc. (see instructions) to individuals or organizations under other conditions, complete items 2a, b, c, and d.

a The name, address, and telephone number of the person to whom applications should be addressed:

ATTACHMENT 8

b The form in which applications should be submitted and information and materials they should include:

ATTACHMENT 9

c Any submission deadlines:

NONE

d Any restrictions or limitations on awards, such as by geographical areas, charitable fields, kinds of institutions, or other factors:

ATTACHMENT 10

Part XV Supplementary Information (continued)

3 Grants and Contributions Paid During the Year or Approved for Future Payment

Recipient Name and address (home or business)	If recipient is an individual, show any relationship to any foundation manager or substantial contributor	Foundation status of recipient	Purpose of grant or contribution	Amount
a Paid during the year				
ATTACHMENT 11				
Total . . . . ▶ 3a				1,179,180.
b Approved for future payment				
Total . . . . ▶ 3b				

Part XVI-A Analysis of Income-Producing Activities

Enter gross amounts unless otherwise indicated.	Unrelated business income		Excluded by section 512, 513, or 514		(e) Related or exempt function income (See instructions.)
	(a) Business code	(b) Amount	(c) Exclusion code	(d) Amount	
1 Program service revenue:					
a					
b					
c					
d					
e					
f					
g Fees and contracts from government agencies					
2 Membership dues and assessments					
3 Interest on savings and temporary cash investments			14	154.	
4 Dividends and interest from securities			14	71,670.	
5 Net rental income or (loss) from real estate:					
a Debt-financed property					
b Not debt-financed property					
6 Net rental income or (loss) from personal property					
7 Other investment income					
8 Gain or (loss) from sales of assets other than inventory			18	77,445.	
9 Net income or (loss) from special events					
10 Gross profit or (loss) from sales of inventory					
11 Other revenue: a					
b OTHER INCOME			01	2,134.	
c					
d					
e					
12 Subtotal. Add columns (b), (d), and (e)				151,403.	

13 **Total.** Add line 12, columns (b), (d), and (e) . . . 13 151,403.

(See worksheet in line 13 instructions to verify calculations.)

Part XVI-B Relationship of Activities to the Accomplishment of Exempt Purposes

Line No. ▼	Explain below how each activity for which income is reported in column (e) of Part XVI-A contributed importantly to the accomplishment of the foundation's exempt purposes (other than by providing funds for such purposes). (See instructions.)

Part XVII Information Regarding Transfers To and Transactions and Relationships With Noncharitable Exempt Organizations

			Yes	No
1	Did the organization directly or indirectly engage in any of the following with any other organization described in section 501(c) of the Code (other than section 501(c)(3) organizations) or in section 527, relating to political organizations?			
a	Transfers from the reporting foundation to a noncharitable exempt organization of:			
	(1) Cash	1a(1)		X
	(2) Other assets	1a(2)		X
b	Other transactions:			
	(1) Sales of assets to a noncharitable exempt organization	1b(1)		X
	(2) Purchases of assets from a noncharitable exempt organization	1b(2)		X
	(3) Rental of facilities, equipment, or other assets	1b(3)		X
	(4) Reimbursement arrangements	1b(4)		X
	(5) Loans or loan guarantees	1b(5)		X
	(6) Performance of services or membership or fundraising solicitations	1b(6)		X
c	Sharing of facilities, equipment, mailing lists, other assets, or paid employees	1c		X

d If the answer to any of the above is "Yes," complete the following schedule. Column **(b)** should always show the fair market value of the goods, other assets, or services given by the reporting foundation. If the foundation received less than fair market value in any transaction or sharing arrangement, show in column **(d)** the value of the goods, other assets, or services received.

(a) Line no.	(b) Amount involved	(c) Name of noncharitable exempt organization	(d) Description of transfers, transactions, and sharing arrangements
	N/A		N/A

2a Is the foundation directly or indirectly affiliated with, or related to, one or more tax-exempt organizations described in section 501(c) of the Code (other than section 501(c)(3)) or in section 527? ☐ Yes ☒ No

b If "Yes," complete the following schedule.

(a) Name of organization	(b) Type of organization	(c) Description of relationship

Sign Here

Under penalties of perjury, I declare that I have examined this return, including accompanying schedules and statements, and to the best of my knowledge and belief, it is true, correct, and complete. Declaration of preparer (other than taxpayer) is based on all information of which preparer has any knowledge.

Heather Rove | 11-15-12 | Treasurer

Signature of officer or trustee | Date | Title

May the IRS discuss this return with the preparer shown below (see instructions)? ☒ Yes ☐ No

Paid Preparer Use Only

Print/Type preparer's name	Preparer's signature	Date	Check ☐ if self-employed	PTIN
ELIZABETH S. HOGAN	Elizabeth S. Hogan	11/12/12		P00273248

Firm's name ▶ BKD, LLP — Firm's EIN ▶ 44-0160260

Firm's address ▶ 1551 N WATERFRONT PKWY, STE 300 WICHITA, KS 67206-6601 — Phone no. 316-265-2811

Form **990-PF** (2011)

Form 8868 (Rev. 1-2012) Page 2

• If you are filing for an **Additional (Not Automatic) 3-Month Extension, complete only Part II** and check this box . . . . ▶ [X]

Note. Only complete Part II if you have already been granted an automatic 3-month extension on a previously filed Form 8868.

• If you are filing for an **Automatic 3-Month Extension, complete only Part I** (on page 1).

Part II **Additional (Not Automatic) 3-Month Extension of Time.** Only file the original (no copies needed).

Enter filer's identifying number, see instructions

Type or print	Name of exempt organization or other filer, see instructions. CLAUDE R. LAMBE CHARITABLE FOUNDATION	Employer identification number (EIN) or [X] 48-0935563
File by the due date for filing your return. See instructions.	Number, street, and room or suite no. If a P.O. box, see instructions. P.O. BOX 2256	Social security number (SSN) [ ]
	City, town or post office, state, and ZIP code. For a foreign address, see instructions. WICHITA, KS 67201-2256	

Enter the Return code for the return that this application is for (file a separate application for each return) . . . . [0 4]

Application Is For	Return Code	Application Is For	Return Code
Form 990	01		
Form 990-BL	02	Form 1041-A	08
Form 990-EZ	01	Form 4720	09
Form 990-PF	04	Form 5227	10
Form 990-T (sec. 401(a) or 408(a) trust)	05	Form 6069	11
Form 990-T (trust other than above)	06	Form 8870	12

STOP! Do not complete Part II if you were not already granted an automatic 3-month extension on a previously filed Form 8868.

• The books are in the care of ▶ HEATHER LOVE

Telephone No. ▶ 316 828-8286 FAX No. ▶

• If the organization does not have an office or place of business in the United States, check this box . . . . ▶ [ ]

• If this is for a Group Return, enter the organization's four digit Group Exemption Number (GEN) ________ . If this is for the whole group, check this box . . . . . . ▶ [ ] . If it is for part of the group, check this box . . . . ▶ [ ] and attach a list with the names and EINs of all members the extension is for.

4 I request an additional 3-month extension of time until 11/15 , 20 12 .

5 For calendar year 2011 , or other tax year beginning ________ , 20____ , and ending ________ , 20____ .

6 If the tax year entered in line 5 is for less than 12 months, check reason: [ ] Initial return [ ] Final return [ ] Change in accounting period

7 State in detail why you need the extension ADDITIONAL TIME IS REQUIRED TO ACCUMULATE THE INFORMATION NECESSARY TO FILE A COMPLETE AND ACCURATE RETURN.

8a	If this application is for Form 990-BL, 990-PF, 990-T, 4720, or 6069, enter the tentative tax, less any nonrefundable credits. See instructions.	8a	$ 0
b	If this application is for Form 990-PF, 990-T, 4720, or 6069, enter any refundable credits and estimated tax payments made. Include any prior year overpayment allowed as a credit and any amount paid previously with Form 8868.	8b	$ 0
c	**Balance Due.** Subtract line 8b from line 8a. Include your payment with this form, if required, by using EFTPS (Electronic Federal Tax Payment System). See instructions.	8c	$ 0

Signature and Verification must be completed for Part II only.

Under penalties of perjury, I declare that I have examined this form, including accompanying schedules and statements, and to the best of my knowledge and belief, it is true, correct, and complete, and that I am authorized to prepare this form.

Signature ▶ Title ▶ Date ▶

Form **8868** (Rev. 1-2012)

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990-PF - PART IV
CAPITAL GAINS AND LOSSES FOR TAX ON INVESTMENT INCOME

Kind of Property		Description				P or D	Date acquired	Date sold
Gross sale price less expenses of sale	Depreciation allowed/ allowable	Cost or other basis	FMV as of 12/31/69	Adj. basis as of 12/31/69	Excess of FMV over adj basis		Gain or (loss)	
		ZAZOVE ASSOCIATES, LLC				P	VARIOUS	VARIOUS
1,234,003.		1,156,558.					77,445.	
TOTAL GAIN(LOSS)							77,445.	

ATTACHMENT 1

FORM 990PF, PART I - ACCOUNTING FEES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	NET INVESTMENT INCOME	ADJUSTED NET INCOME	CHARITABLE PURPOSES
ACCOUNTING FEES	24,338.			22,706.
INVESTMENT ACCTG SERVICE FEES	319.	319.		
TOTALS	24,657.	319.		22,706.

ATTACHMENT 2

FORM 990PF, PART I - OTHER PROFESSIONAL FEES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	NET INVESTMENT INCOME	CHARITABLE PURPOSES
INVESTMENT MANAGEMENT FEES	38,818.	38,818.	
TOTALS	38,818.	38,818.	

ATTACHMENT 3

FORM 990PF, PART I - TAXES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	CHARITABLE PURPOSES
FEDERAL EXCISE TAX	2,203.	
TOTALS	2,203.	

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 4

FORM 990PF, PART I - OTHER EXPENSES

DESCRIPTION	REVENUE AND EXPENSES PER BOOKS	CHARITABLE PURPOSES
INSURANCE	983.	983.
SUPPLIES	477.	477.
BANK FEES	80.	80.
TOTALS	1,540.	1,540.

ATTACHMENT 5

FORM 990PF, PART II - OTHER INVESTMENTS

DESCRIPTION	ENDING BOOK VALUE	ENDING FMV
ZAZOVE BOND FUND	2,984,999.	3,126,054.
TOTALS	2,984,999.	3,126,054.

ATTACHMENT 6

FORM 990PF, PART VII-B, LINE 5C-EXPENDITURE RESPONSIBILITY STATEMENT

GRANTEE'S NAME:	ALLEN-LAMBE HOUSE FOUNDATION
GRANTEE'S ADDRESS:	255 N. ROOSEVELT
CITY, STATE & ZIP:	WICHITA, KS 67208
GRANT DATE:	03/02/2011
GRANT AMOUNT:	116,480.
GRANT PURPOSE:	GENERAL PROGRAM SUPPORT FOR EDUCATIONAL FOUNDATION OPERATING A MUSEUM AND STUDY CENTER
AMOUNT EXPENDED:	116,480.
ANY DIVERSION?	NO
DATES OF REPORTS:	FULL & COMPLETE REPORT SUBMITTED MARCH 9, 2012
VERIFICATION DATE:	

RESULTS OF VERIFICATION:

THE GRANTOR HAS NO REASON TO DOUBT THE ACCURACY OR RELIABILITY OF THE REPORT FROM THE GRANTEE; THEREFORE, NO INDEPENDENT VERIFICATION OF THE REPORT WERE MADE.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990PF, PART VIII - LIST OF OFFICERS, DIRECTORS, AND TRUSTEES

ATTACHMENT 7

NAME AND ADDRESS	TITLE AND AVERAGE HOURS PER WEEK DEVOTED TO POSITION	COMPENSATION	CONTRIBUTIONS TO EMPLOYEE BENEFIT PLANS	EXPENSE ACCT AND OTHER ALLOWANCES
RICHARD H FINK 1515 N. COURTHOUSE RD, SUITE 200 ARLINGTON, VA 22201	PRESIDENT/DIRECTOR 1.00	0	0	0
LOGAN MOORE 1515 N. COURTHOUSE RD, SUITE 200 ARLINGTON, VA 22201	SECRETARY 1.00	0	0	0
VONDA HOLLIMAN P.O. BOX 2256 WICHITA, KS 67201	TREASURER 1.00	0	0	0
CHARLES G KOCH P.O. BOX 2256 WICHITA, KS 67201	DIRECTOR .25	0	0	0
ELIZABETH B KOCH P.O. BOX 2256 WICHITA, KS 67201	DIRECTOR .25	0	0	0
ELIZABETH R KOCH P.O. BOX 2256 WICHITA, KS 67201	DIRECTOR .25	0	0	0

490

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990PF, PART VIII - LIST OF OFFICERS, DIRECTORS, AND TRUSTEES

ATTACHMENT 7 (CONT'D)

NAME AND ADDRESS	TITLE AND AVERAGE HOURS PER WEEK DEVOTED TO POSITION	COMPENSATION	CONTRIBUTIONS TO EMPLOYEE BENEFIT PLANS	EXPENSE ACCT AND OTHER ALLOWANCES
CHARLES C KOCH P.O. BOX 2256 WICHITA, KS 67201	DIRECTOR .25	0	0	0
	GRAND TOTALS	0	0	0

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

ATTACHMENT 8

FORM 990PF, PART XV - NAME, ADDRESS AND PHONE FOR APPLICATIONS

GRANT ADMINISTRATOR
1515 N. COURTHOUSE RD., SUITE 200
ARLINGTON, VA 22201
703-875-1600

990PF, PART XV - FORM AND CONTENTS OF SUBMITTED APPLICATIONS

LETTER EXPLAINING PROJECT AND AMOUNT REQUESTED, PLUS A COPY OF THE IRS DETERMINATION LETTER SHOWING EXEMPTION.

ATTACHMENT 10

990PF, PART XV - RESTRICTIONS OR LIMITATIONS ON AWARDS

GRANTS ARE GENERALLY RESTRICTED TO PUBLIC CHARITY ORGANIZATIONS AS DEFINED IN SECTION 501(C)(3) OF THE INTERNAL REVENUE CODE. THE FOUNDATION DOES NOT MAKE GRANTS TO INDIVIDUALS OR FOR-PROFIT CORPORATIONS.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990PF, PART XV - GRANTS AND CONTRIBUTIONS PAID DURING THE YEAR

ATTACHMENT 11

RECIPIENT NAME AND ADDRESS	RELATIONSHIP TO SUBSTANTIAL CONTRIBUTOR AND FOUNDATION STATUS OF RECIPIENT	PURPOSE OF GRANT OR CONTRIBUTION	AMOUNT
ALLEN-LAMBE HOUSE FOUNDATION 255 NORTH ROOSEVELT WICHITA, KS 67208	PRIVATE	GENERAL OPERATING SUPPORT	116,480.
AMERICAN LEGISLATIVE EXCHANGE COUNCIL 1101 VERMONT AVE. NW FI 11 WASHINGTON, DC 20005	PUBLIC	GENERAL OPERATING SUPPORT	150,000.
AYN RAND INSTITUTE 2121 ALTON PARKWAY SUITE 250 IRVINE, CA 92606	PUBLIC	GENERAL OPERATING SUPPORT	50,000.
CENTER FOR INDEPENDENT THOUGHT 1420 WALNUT ST SUITE 1011 PHILADELPHIA, PA 19102	PUBLIC	GENERAL OPERATING SUPPORT	40,000.
COMPETITIVE ENTERPRISE INSTITUTE 1899 L STREET NW FLOOR 12 WASHINGTON, DC 20005	PUBLIC	GENERAL OPERATING SUPPORT	9,200.
COUNCIL FOR NATIONAL POLICY 1411 K. STREET NW, STE. 601 WASHINGTON, DC 20005	PUBLIC	GENERAL OPERATING SUPPORT	25,000.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990PF, PART XV - GRANTS AND CONTRIBUTIONS PAID DURING THE YEAR

ATTACHMENT 11 (CONT'D)

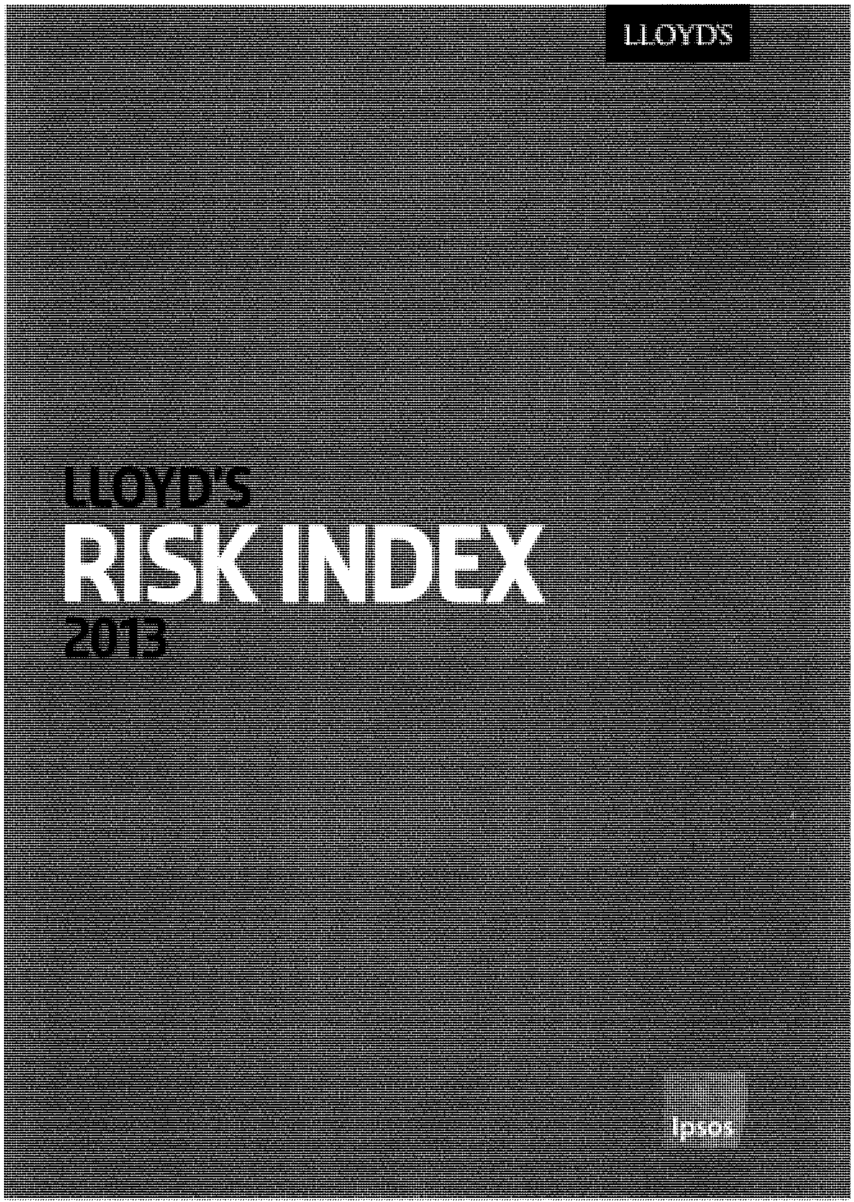
RECIPIENT NAME AND ADDRESS	RELATIONSHIP TO SUBSTANTIAL CONTRIBUTOR AND FOUNDATION STATUS OF RECIPIENT	PURPOSE OF GRANT OR CONTRIBUTION	AMOUNT
FEDERALIST SOCIETY 1015 18TH ST. NW STUITE 425 WASHINGTON, DC 20036	PUBLIC	GENERAL OPERATING SUPPORT	260,000.
FREE CONGRESS FOUNDATION 1423 POWHATAN ST. #2 ALEXANDRIA, VA 22314	PUBLIC	GENERAL OPERATING SUPPORT	25,000.
GEORGE C. MARSHALL INSTITUTE 1601 NORTH KENT ST. SUITE 802 ARLINGTON, VA 22209	PUBLIC	EDUCATIONAL SUPPORT	40,000.
HUDSON INSTITUTE 1015 15TH STREET, NW, 6TH FLOOR WASHINGTON, DC 20005	PUBLIC	GENERAL OPERATING SUPPORT	25,000.
JOSIAH BARTLETT CENTER FOR PUBLIC POLICY 7 SOUTH STATE STREET P.O. BOX 897 CONCORD, NH 03302	PUBLIC	EDUCATIONAL SUPPORT	3,500.
MANHATTAN INSTITUTE FOR POLICY RESEARCH, INC. 52 VANDERBILT AVE. 3RD FLOOR NEW YORK, NY 10017	PUBLIC	GENERAL OPERATING SUPPORT	200,000.

CLAUDE R. LAMBE CHARITABLE FOUNDATION 48-0935563

FORM 990PF, PART XV - GRANTS AND CONTRIBUTIONS PAID DURING THE YEAR

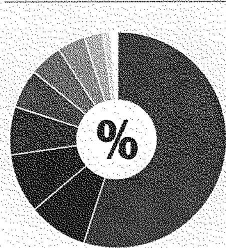
ATTACHMENT 11 (CONT'D)

RECIPIENT NAME AND ADDRESS	RELATIONSHIP TO SUBSTANTIAL CONTRIBUTOR AND FOUNDATION STATUS OF RECIPIENT	PURPOSE OF GRANT OR CONTRIBUTION	AMOUNT
PACIFIC RESEARCH INSTITUTE ONE EMBARCADERO CENTER SUITE 350 SAN FRANCISCO, CA 94111	PUBLIC	EDUCATIONAL SUPPORT	100,000.
REASON FOUNDATION 3415 SOUTH SEPULVEDA SUITE 400 LOS ANGELES, CA 90034	PUBLIC	EDUCATIONAL SUPPORT	75,000.
REASON FOUNDATION 3415 SOUTH SEPULVEDA SUITE 400 LOS ANGELES, CA 90034	PUBLIC	GENERAL OPERATING SUPPORT	50,000.
STATE POLICY NETWORK 2020 N. 14TH ST. STE 250 ARLINGTON, VA 22201	PUBLIC	GENERAL OPERATING SUPPORT	10,000.
		TOTAL CONTRIBUTIONS PAID	1,175,180.


LLOYD'S
LLOYD'S
RISK INDEX
2013
Ipsos

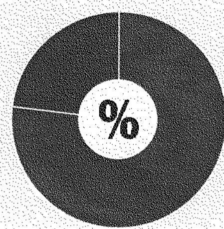
RESPONDENT PROFILES

WHICH OF THE FOLLOWING DESCRIBES YOUR JOB TITLE?



CEO/President/Managing Director	55%
Board Member	9%
Head of Department	9%
CIO/Technology Director	7%
Head of Business Unit	6%
CFO/Treasurer/Comptroller	5%
SVP/VP/Director	4%
Other C-level Executive	3%
Chief Risk Officer	1%
Chief Compliance Officer	1%

WHAT IS YOUR COMPANY'S ANNUAL GLOBAL REVENUE IN US DOLLARS?

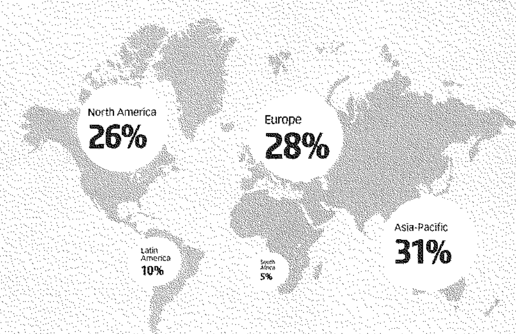


$499m or less	77%
Over $500m	23%

WHAT IS YOUR PRIMARY INDUSTRY?

Aerospace/Defence	1%
Agriculture and agribusiness	3%
Automotive	3%
Chemicals	1%
Construction and real estate	10%
Consumer goods	4%
Education	4%
Energy and natural resources	3%
Entertainment, media and publishing	5%
Financial services	7%
Government/Public sector	2%
Healthcare, pharmaceuticals and biotechnology	4%
IT and technology	8%
Logistics and distribution	2%
Manufacturing	10%
Professional services	20%
Retailing	8%
Telecommunications	1%
Transportation, travel and tourism	4%

IN WHAT REGION ARE YOU PERSONALLY BASED?



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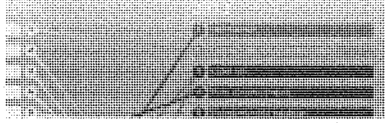
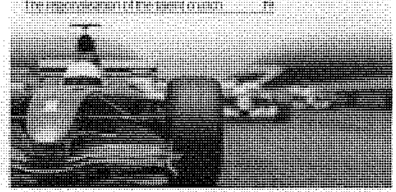
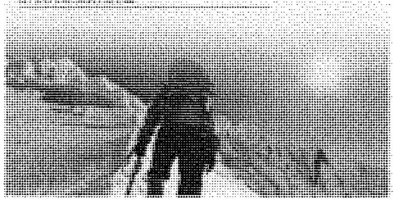


02 THE EVOLUTION OF THE RISK RACE



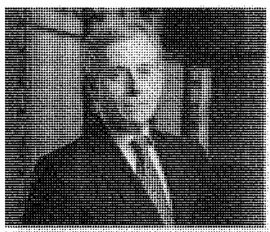
03 THE RISKS LESS TRAVELLED



04 THE VISION 2025 COUNTRIES – THEN AND NOW

CONCLUSION

FOREWORD



"The slowdown in growth has made the world a newly challenging place for the more recently developing nations."

FOREWORD BY DR RICHARD WARD

When the first Lloyd's Risk Index was published in 2009, few thought that the world would not yet be emerging from the economic crisis that gripped it at the time.

Four years on, not only is much of Europe still at a very low economic ebb, previously buoyant growth projections for economies including China and India have been revised downwards.

A global recovery remains stalled, customer demand is in the doldrums and we have had glimpses of social unrest on the streets of the worst hit nations. The 'state of flux' affecting the global economy described in our 2011 Risk Index now appears to have become more entrenched than anyone anticipated.

It is against this backdrop that we asked Ipsos MORI to carry out the third Lloyd's Risk Index, a survey of global business leaders' perceptions of the greatest risks to their businesses and the level to which they believe they feel prepared to deal with them.

The 2013 Lloyd's Risk Index reveals a great deal, but three key themes have emerged:

CORPORATE TAXATION – A NEW GLOBAL PRIORITY

The public scrutiny given to corporate taxation has become increasingly intense over the last two years, with governments and the taxpayer alike demanding greater transparency and changes to legislation. Since 2011, this pressure has clearly been felt by respondents, who now rank the risk of high taxation as their highest overall risk, up from number 13 in 2011. In the US, the priority scores given to this risk are particularly high.

THE TWO-SPEED RECOVERY STALLS

The division between the 'West and the rest' has become far less clear cut than it was when we published the last Lloyd's Risk Index in 2011. Instead of accelerating demand from high growth markets lifting Western economies from stagnation, the impact of decreased demand from Europe and the US has clearly affected developing markets. Particularly striking is the loss of business confidence in Latin American countries, given their relatively recent GDP revisions downwards.

THE EVOLUTION OF RISK MANAGEMENT

The findings from the three Lloyd's Risk Indices show an interesting pattern in terms of risk management. Larger companies are putting a greater priority on strategic and economic risks, as risk management climbs further up their agendas. These corporations have the resources to support dedicated risk management functions and managers. Risk managers at this level often come from an insurance background and belong to risk management membership bodies, such as AIRMIC and FERMA, both of whom Lloyd's works closely with to support professional development of risk managers.

Smaller companies declare themselves to be less prepared with regards to virtually all the risks in the Lloyd's Risk Index, and those in established markets clearly feel better prepared than their counterparts in fast growing economies. Yet smaller balance sheets are more vulnerable to sudden loss than larger ones.

Here is a clear role for the insurance industry; to help smaller companies better understand the risks they face so they can prepare and mitigate against the potential downsides. The industry is at its best as an extra pair of eyes to help businesses protect themselves.

The slowdown in growth has made the world a newly challenging place for the more recently developing nations. It will take expert risk management to help them insulate against the risks from which they are not immune. The timetable for global economic recovery is likely to be much longer than we hoped in the immediate aftermath of the economic crash. In such circumstances, sustainability, rather than growth, will be a priority for many. While consumer demand for many services may remain low for several years to come, the demand for effective risk management and mitigation seems likely to continue to grow.

DR RICHARD WARD
Chief Executive
Lloyd's

EXECUTIVE SUMMARY

> “Businesses appear to have become much more realistic about the degree to which they can mitigate the risks inherent in the wider economic, regulatory and natural environment.”

EXECUTIVE SUMMARY

This is the third biennial Risk Index, commissioned by Lloyd's to assess corporate risk priorities and attitudes among business leaders across the world. The findings are based on a global survey of 588 C-suite and board level executives conducted by Ipsos MORI for Lloyd's during April and May 2013.

Survey respondents were distributed across Asia-Pacific (31%), Europe (28%), North America (26%), Latin America (10%) and South Africa (5%).

77% of respondents represent smaller businesses with an annual turnover of US$499 million or less, and 23% are from larger companies with an annual turnover of US$500 million or more.

We would like to thank all those business leaders who took the time to complete the survey and give us their views. This executive summary looks at some of the overarching themes from the 2013 survey and pinpoints larger shifts from the 2011 Lloyd's Risk Index.

METHODOLOGY

The survey asked respondents about their attitudes to 50 risks across five categories:

> Business and strategic risk.
> Economic, regulatory and market risk.
> Political, crime and security risk.
> Environmental and health risk.
> Natural hazard risk.

Respondents were asked to rate both the overall risk category and a number of specific risks within each of the overall categories for both their corporate risk priorities and for the degree of their business preparedness to manage those risks. A score was calculated for each, with zero being the lowest level of priority or preparedness and ten being the highest.

Some changes have been made to the list of 50 specific risks since the 2011 survey. Full details of these changes can be found at Appendix 1.

This executive summary identifies the priority risk areas in 2013 as well as the biggest changes since 2011. It also summarises regional variations and the different experiences of risk priority and preparedness between smaller and larger businesses.

A REALITY CHECK FOR BUSINESS

As the global economic crisis enters its sixth year, more businesses appear to have become much more realistic about the degree to which they can mitigate the risks inherent in the wider economic, regulatory and natural environment.

In 2011, 70% of respondents claimed they were better prepared to manage risks to their business and operations compared to two years before, 27% felt their preparedness was about the same and just 3% felt they were not as well prepared.

By 2013, only 46% of respondents feel better prepared than they did two years ago, 49% say their preparedness is about the same, while the number of those who feel less well prepared has increased to 5%.

FASTER GROWING ECONOMIES FAST TRACK THEIR PREPAREDNESS

While the overall global findings are that companies have not increased their preparedness at the levels reported between 2009 and 2011, there are significant regional differences in these scores.

While 47% of European respondents and 30% of North American respondents believe they are better prepared to manage their business risks than they were in 2011, businesses in fast growing economies have been much busier when it comes to risk mitigation. 49% of Asia-Pacific respondents and 62% of Latin American respondents feel better prepared than two years ago.

Interestingly, and as seen in 2011, businesses in faster growing regions also give risks in general a higher priority score than those in Europe and the US. In particular, the potential impact of economic, regulatory and market risk has increased the most in Asia-Pacific countries, with the price of material inputs now seen as the number one risk to businesses in this region. Given that businesses in this part of the world are still showing strong growth despite recent slowdown, the priority given to the costs of raw materials reflects this major business overhead. Input costs are particularly critical for fast growing economies – passing on increases in these costs to consumers runs the risk of fuelling inflation, dampening demand or both.

EXECUTIVE SUMMARY
CONTINUED

A GAME OF TWO HALVES

A clear divide is emerging in the evolution of risk management between smaller and larger companies, with further variation determined by whether they operate in an established (North America and Europe) or faster growing market.

Larger companies in faster growing markets are following the evolution of their peers in established markets, recognising the heightened priority of business risks and their relative lack of preparedness to deal with them. Larger companies in established markets are moving increasingly towards a 'more prepared than prioritised' position. They have recognised their vulnerability to risk, made it a greater priority and invested in more comprehensive risk transfer (insurance) and risk management (mitigation) measures.

Chart 1

COMPARED TO TWO YEARS AGO, HOW ARE YOU PREPARED FOR RISKS TO YOUR BUSINESS AND OPERATIONS?

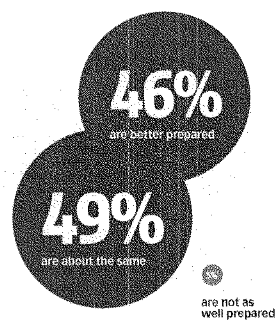


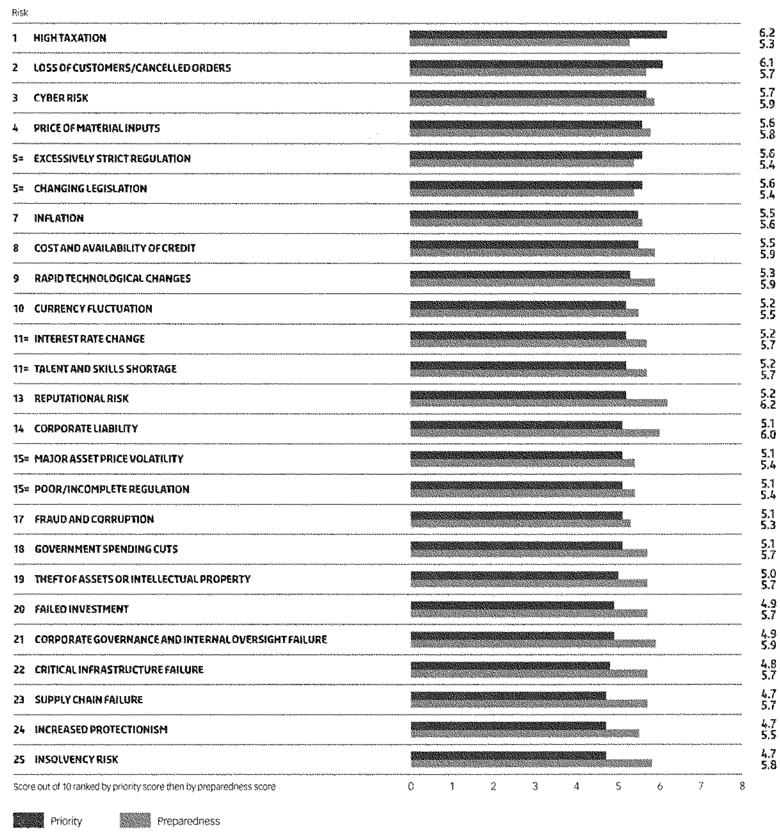
Table 1

OVERALL RISK CATEGORIES – 2013 VERSUS 2011

2013 PRIORITY RANK	OVERALL RISK CATEGORIES – 2013 VERSUS 2011	2013 PRIORITY SCORE	2013 PREPAREDNESS SCORE	2011 Priority Score	2011 Preparedness Score
1	BUSINESS AND STRATEGIC RISK	6.5	6.3	7.3	7.1
2	ECONOMIC, REGULATORY AND MARKET RISK	6.3	6.5	7.2	6.5
3	POLITICAL, CRIME AND SECURITY RISK	5.2	6.0	5.4	6.5
4	ENVIRONMENTAL AND HEALTH RISK	4.8	5.8	5.0	6.1
5	NATURAL HAZARD RISK	4.1	5.5	4.2	5.5

Chart 2

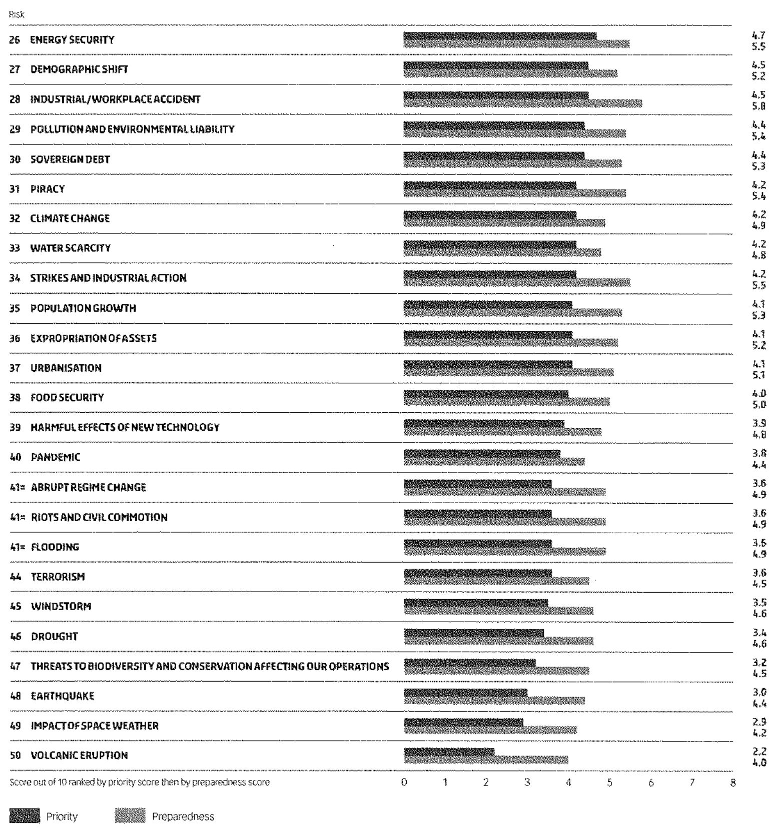
INDIVIDUAL RISKS, PRIORITY AND PREPAREDNESS SCORES 2013



EXECUTIVE SUMMARY
CONTINUED

Chart 2 continued

INDIVIDUAL RISKS, PRIORITY AND PREPAREDNESS SCORES 2013



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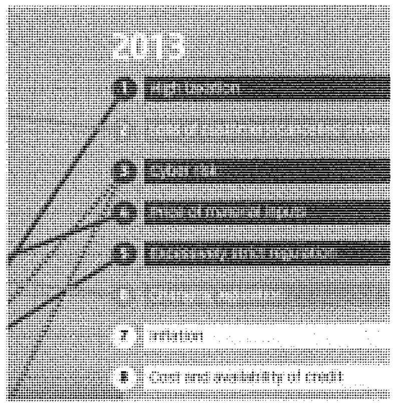


THE TOP FIVE RISKS

THE TOP FIVE RISKS

1. HIGH TAXATION – WHERE ETHICS AND ECONOMICS MEET

Since 2011, the perception of how – and where – global corporations pay their taxes has become an issue of corporate ethics as much as economics.

From the US Senate's investigations into Microsoft and Apple to the grilling given to Google, Starbucks and Amazon by the UK's Public Accounts Committee, the past two years have seen perceptions of corporate tax avoidance become reputational poison.

In the past two years, perception of the issue has changed from that of a domestic problem to one requiring global action. One outcome of the G20 finance ministers' meeting in Moscow in February 2013 was a joint communiqué pledging joined-up action to crack down on tax avoidance by multinationals. More recently, David Cameron issued a letter to all of the UK's overseas territories urging greater transparency on company ownership for tax purposes.

In 2011, the risk of high taxation was one which respondents ranked reasonably highly at 13 out of 50. However, it was also one for which they ranked their preparedness to deal with the risk (5.5) as slightly higher than its priority (5.2). In 2013, this has changed. The risk of high taxation is now the overall biggest risk facing businesses, nudging 'loss of customers/ cancelled orders' off the top spot it held in 2011.

High taxation as a major risk proves consistent across all business types, whether they are in established or fast growing markets and above or below the $500 million threshold. Indeed, the greatest movement in this risk is seen in smaller companies in fast growing markets which in 2013 put this risk at number two, up 16 places since 2011. Interestingly, US businesses feel even more unprepared to deal with this risk than their counterparts in Europe. While both regions put high taxation as their number one risk, US respondents rank their preparedness at number 37= out of 50, compared to European respondents at 21=.

While large multinationals can, in theory, domicile themselves for tax purposes wherever international tax jurisdictions are most favourable, this is likely to be less of an option for smaller businesses. For them, the sooner any moves towards harmonising global tax regulation bear fruit, the more swiftly they can start operating from a level playing field.

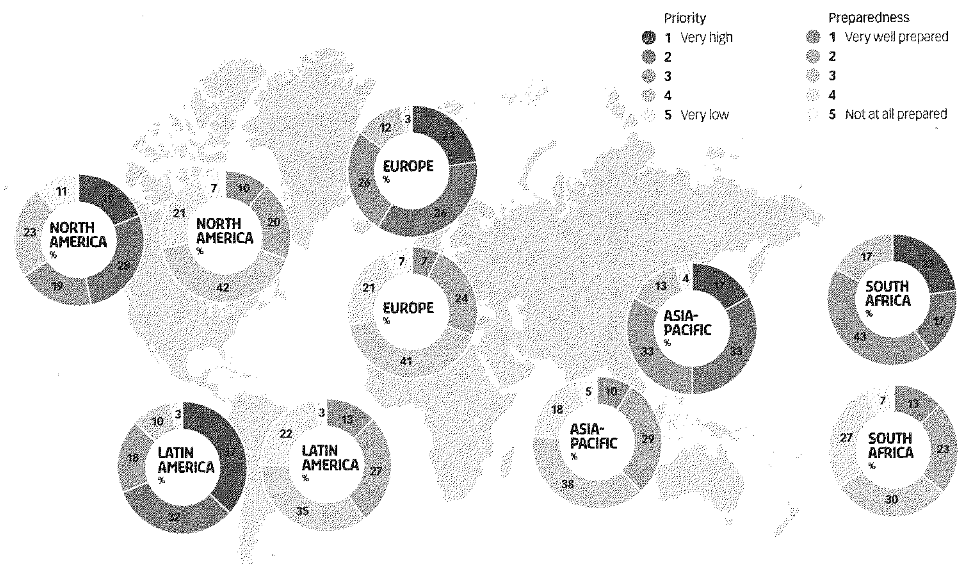
The mood music for corporate taxation has clearly got louder since 2011, but does the increase in volume reflect the reality? KPMG's corporate tax rate table[1] shows that, in fact, not only have corporate income taxes not risen in the past few years, they have actually been either downward or static – despite the financial problems of most major economies. Global corporate tax rates in Asia have declined from an average of 23.1% in 2011 to 22.4% in 2013, in Europe from 20.9% to 20.7% and in North America from 34% to 33%. Globally, the average has fallen from 24.5% in 2011 to 24.1% today.

But while corporate tax rates may have been falling, personal tax rates in some economies, including France, Spain, Israel and Egypt, have shown an upward trend during this period. These particularly affect global businesses competing for international talent, adding another layer to tax considerations when assessing the potential attractiveness of locations and employee costs.

On the increase, too, are indirect taxes. As governments try to ensure their corporate tax regimes remain competitive they tend to shift towards consumption taxes in an effort to maintain revenues. These, in turn, may depress demand in economies struggling with consumer confidence.

The reality for businesses appears to be that government ambiguity about business taxes, whether about extending jurisdictions, amending legislation or changing rates, may actually be more damaging for business confidence than the reality. With the public spotlight increasingly on corporate taxes, the sooner governments provide clarity of intent, the better it may be for business.

HIGH TAXATION – PRIORITY AND PREPAREDNESS BY REGION



THE TOP FIVE RISKS CONTINUED

2. LOSS OF CUSTOMERS – BELT-TIGHTENING BECOMES A GLOBAL PHENOMENON

Apart from the small number of the super-rich in the market for a Mayfair apartment or a Maserati, entrenched global austerity has fundamentally changed the pattern of consumption – and not only in developed economies.

In virtually every region of the world, business leaders feel they are underprepared to deal with the fundamental risk that too few consumers are willing or able to buy their products. Latin America, perhaps reflecting the suddenness of its GDP downgrades, shows the highest gap between priority at 7.7 and preparedness at 6.3, followed closely by Europe with a priority score of 6.4 and a preparedness score of 5.4. Asia-Pacific business leaders show a rough equivalence between priority and preparedness at 6.0 and 5.9 respectively.

Interestingly, only the US entirely bucks the trend, feeling marginally more prepared for the risk than the priority given to the risk itself. It may be that the hat trick of the recent avoidance of the 'fiscal cliff', massive state stimulus and steadily improving employment figures are starting to influence consumer confidence.

Overall, however, belief in a two-speed recovery has been put to the test and found wanting. In 2011, when the risk of losing customers and having orders cancelled took the number one priority slot, many Western pundits were putting their faith in the growing levels of demand for goods and services from the accelerating economies of China, India and Latin America.

Two years ago, GDP forecasts largely bore out this optimism. The International Monetary Fund's (IMF) World Economic Outlook[2] in April 2011 predicted GDP growth for the year at 9.6% for China, 8.2% for India, 4.6% for Mexico and 4.5% for Brazil.

The reality proved somewhat different. While China had a strong 2011 with 9.2% GDP growth, India managed 7.2%, Mexico 4% and Brazil just 2.7%. The predicted 'two-speed recovery' was stalling. 2012 saw this downward trajectory continue, as the impact of the West's lack of demand was finally felt by fast growing economies.

Projections for these economies in 2013 are much less buoyant. The IMF estimates that China will grow by 8%, India by 5.7%, Mexico by 3.4% and Brazil by 3%. In April 2013, the World Trade Organisation followed suit, revising its estimate for global trade growth in 2013 downwards to 3.3% from its earlier forecast of 4.5%. The findings for Latin America, in particular, show a significant drop in confidence about continued consumer spending.

It seems clear that global economic recovery will be a much more gradual process than was envisaged in 2011. In a globalised world, market insecurity about the sustainability of the Eurozone or the latest US employment figures will eventually make their way to high-growth economies, as these results have started to reflect.

However, it is still in these fast growing economies that the impetus for global recovery remains. Businesses need to seek out the niche markets, research the relevance of their products for hard-pressed consumers and – more than ever – actively manage the risks under their control to make sure they are well placed to meet the renaissance in consumer demand when it finally arrives. As challenging economic times look set to continue, sustainability is proving more important than ever to survival.

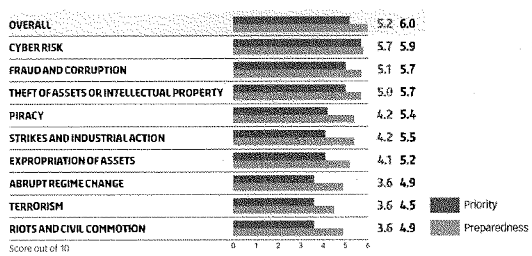
3. THE WORLD CATCHES UP WITH CYBER RISK

THE TOP FIVE RISKS
CONTINUED

CYBER RISK IS TOP OF THE AGENDA FOR OVERALL POLITICAL, CRIME AND SECURITY RISK

Chart 4

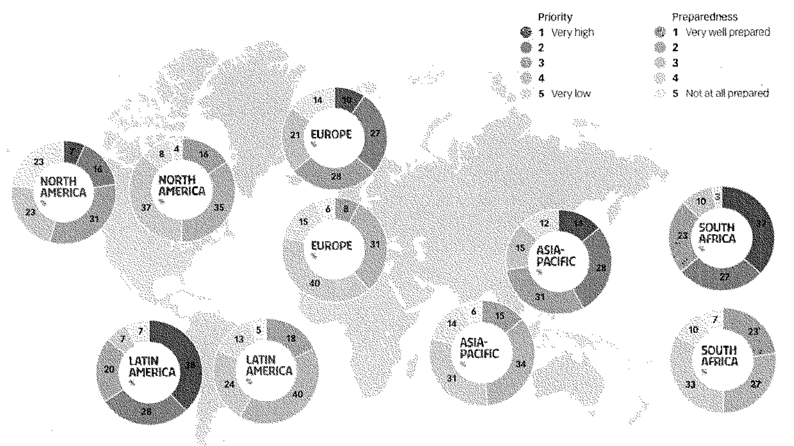
POLITICAL, CRIME AND SECURITY RISK – PRIORITY AND PREPAREDNESS SCORES



> The perception of what motivates cyber attacks is evolving: from financial crime to political and ideological attacks.

Chart 5

POLITICAL, CRIME AND SECURITY RISK – PRIORITY AND PREPAREDNESS BY REGION



4. PRICE OF MATERIAL INPUTS

CASE STUDY: INDIA'S RESOURCES REVOLUTION MOVES NEARER

5. EXCESSIVELY STRICT REGULATION

UK-domiciled financial services have been among the most vocal in warning about the impact of regulation proposed in the wake of the financial crash, but it's an anxiety shared by business leaders across the world. The risk of excessively strict regulation has moved from number ten position overall in 2011 to number five in 2013.

Yet the discrepancy in what has been proposed and what has actually been implemented is significant. In the US, for example, the 'Volcker rule' – at the time of announcement a hugely controversial ban on proprietary trading – was supposed to take effect in July 2012, but is still being drafted by the five separate US agencies responsible for it.[10] At the start of 2013, the US Government Accountability Office announced that fewer than half of the new rules called for by the 2010 Dodd-Frank Act had even been written. In Europe, the deadline for implementation of the Solvency II capital regime for insurers, originally scheduled for October 2012, continues to be extended. At the time of writing, no definite dates for its introduction have been agreed, despite the millions of euros spent by insurance companies and the Lloyd's market in preparing for its implementation.

The EU, led by Germany and France, continues to make the case for a European-wide 'Tobin tax' on financial transactions, while the UK Government remains bitterly opposed to such a move, arguing it would significantly disadvantage London markets. Regulatory protectionism is as much on the agenda today as it was in 2011.

While the media focus in Europe is largely on financial regulation, in other world regions regulatory pressure is increasingly targeting environmental risks. In March 2013, in a fairly damning report into Shell's activities in Alaska, the US Department of the Interior[11] required the company to submit a 'comprehensive and integrated operational plan' for all its future activities in the region. Among them are lessons for any company that relies on contractors for critical aspects of its operations. As the 2012 Lloyd's report, *Arctic Opening: Opportunity and Risk in the High North*,[12] explained, the Arctic region poses unique risks and challenges that sectors from energy to tourism need to manage if they are to make the most of the opportunities the region presents.

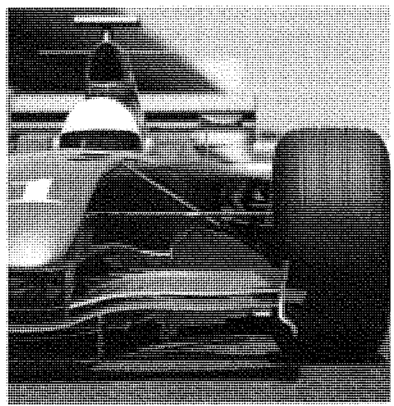
The focus on environmental protection is no longer primarily a 'Western' one. In China, public concerns about pollution are increasing. In February, the Ministry of Environmental Protection (MEP) and the China Insurance Regulatory Commission issued joint guidelines for a pilot of compulsory environmental pollution liability insurance for heavily polluting industries.[13] These include heavy metal producers and petrochemical companies. State approval for operations will increasingly become dependent on such insurance being in place.

Inadequate environmental regulation is challenging China's international operations. Faced with mounting criticism of its environmental record in Africa, where the Sino-African volume of trade reached nearly US$200 billion in 2012, China has produced *Guidelines for Environmental Protection in Foreign Investment and Co-operation* to hold Chinese companies responsible for their impacts overseas.[14] However, adoption remains voluntary and has so far met with limited success. More recently, China's Shuanghui International's move to buy US pork producer Smithfield Foods led to criticism that the potential fall in food safety standards would affect US consumers.[15]

Increasingly, however, the most pressing issue in many large developing markets is not a dearth of regulation but a lack of enforcement. The history and experience of traditional markets indicates that once public pressure and commercial growth reaches a critical mass, enforcement follows. Both domestic businesses and international companies operating in fast growing economies should not assume they will be able to continue to pollute with impunity in the years ahead.

Interestingly, businesses are also worried about the flip side of regulation; 'poor/incomplete regulation' has risen up the Risk Index from 20 in 2011 to 15= today. The consequences of those taking advantage of lax regulation over the last two years are well documented: from the European horsemeat scandal to Chinese melamine-laced baby milk to the Bangladesh Rana Plaza collapse which killed more than 1,000 people. It may be that companies are increasingly recognising that weak regulation can, in practice, be significantly worse for business than no regulation at all.

02



THE EVOLUTION OF THE RISK RACE

THE EVOLUTION OF THE RISK RACE

SIZE – AND GEOGRAPHY – MATTERS

Just as economies evolve, so too do the risk management functions of their businesses. By 2013, a clear pattern is emerging from the findings of our Risk Indices over the past five years, as shown by the scatter charts opposite.

In 2009, with established 'Western' regions reeling from the immediate aftermath of the 2008 financial crash, the distribution of priority and preparedness scores was fairly evenly spread between companies regardless of their size or location.

By 2011, a pattern is emerging. Many of the strategic and economic risks facing larger companies, particularly in established markets, are starting to move higher up as businesses recognise they are a priority and put systems in place to mitigate them. The gap between the priority and preparedness scores against, for example, overall business and strategic risk (priority score: 7.3, preparedness score: 7.1) and overall economic, regulatory and market risks (priority score: 7.2, preparedness score: 6.5) shows that, despite widespread complacency about risks including cyber and cost and availability of credit, awareness of the 'preparedness gap' against key business risks is becoming keener in larger companies.

It is also in 2011 that the link between company size and company location becomes more explicit. The priorities given to risks by smaller companies in faster growing regions are on the rise, while their confidence about their preparedness is waning. This trend towards placing a higher priority score on risks is also shown by their larger peers. Additionally, a pattern is developing with companies in fast growing markets scoring both their business risks higher, and their preparedness to deal with them lower.

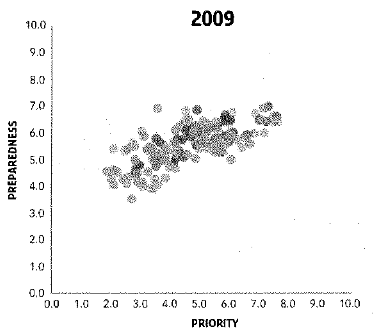
By 2013, this demarcation is even clearer. Companies under US$500 million in faster growing regions are moving towards the bottom right of the graph, where their priority scores are increasingly greater than their preparedness scores, while smaller companies in traditional markets are moving towards the bottom left, believing their preparedness is greater than the priority they give key risks.

Larger companies in fast growing regions are emulating the evolution of their counterparts in established markets, increasingly recognising the heightened priority of business risks and their relative lack of preparedness to deal with them. Larger companies in established markets, however, are moving increasingly towards a 'more prepared than prioritised' position. Having recognised their vulnerability to risk, it appears they have made it a priority and invested in more comprehensive risk transfer (insurance) and risk management (mitigation) measures. For example, both the status and influence of risk managers in larger companies in established markets have risen over the past five years.

These companies appear to be the current leaders in the risk race – it will be interesting to see if larger companies in fast growing economies make the same journey in the next few years.

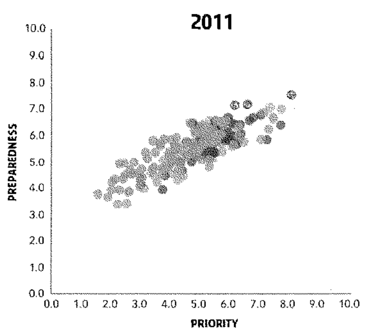
Chart 6

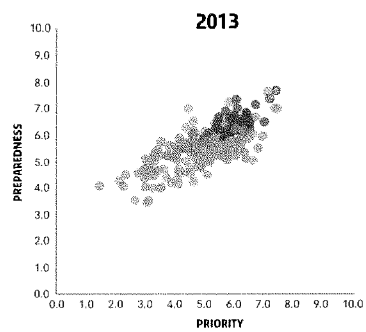
THE LINK BETWEEN COMPANY SIZE AND COMPANY LOCATION



The scatter charts visualise the relationship of preparedness against priority for the years 2009, 2011 and 2013. The individual bubbles represent the aggregated answers of interviewees grouped into four categories for all 50 risks. Over the years a clustering of these groups is emerging and a more proportioned preparedness towards risks.

- **OVER $500M IN ESTABLISHED MARKETS**
- **OVER $500M IN FASTER GROWING MARKETS**
- **$499M OR LESS IN ESTABLISHED MARKETS**
- **$499M OR LESS IN FASTER GROWING MARKETS**





THE EVOLUTION OF THE RISK RACE
CONTINUED

REGULATION, RISK AND REPUTATION – CREATING A VIRTUOUS CYCLE

If the 2008 crash proved one thing about regulation, it was that it isn't always ideally the sole preserve of regulators, who may not always have the required depth of understanding of the sectors they regulate.

Systemic risk was finally recognised as an inherent part of financial services – and a wave of regulatory proposals followed. The Dodd-Frank Wall Street Reform and Consumer Protection Act in the US was followed by similar proposals in the EU, while the UK abolished the Financial Services Authority, giving the Bank of England much greater responsibility for prudential regulatory oversight.

Inherent risk has not, of course, been confined only to the financial services sector. Events from the Deepwater Horizon explosion to the well-publicised slew of cyber breaches affecting governments and companies alike highlighted the crucial role that identifying and managing risk needs to play in organisations today.

Deloitte's seventh Global Risk Management Survey,[16], updated towards the end of 2012, reveals the rise and rise of the Chief Risk Officer (CRO). In 2002, just 65% of institutions surveyed had CROs or their equivalent. By 2012 this had risen to 86%, 86% of whom reported to the board or CEO. In 2008, only 59% of companies surveyed had an enterprise risk management framework in place; in 2012 this figure was 79%.

The Deloitte survey also highlights how the culture of risk management at a senior level can influence the culture of an organisation as a whole. In the final analysis it points out: "An institution's risk profile can be defined by the sum total of business decisions taken every day by employees throughout the organisation."

Any organisation is only as strong as its weakest link, and those who support their CROs to deliver a business-wide risk management culture will find they have created a virtue out of necessity.

THE REGIONALISATION OF THE TALENT CRUNCH

One of the most interesting findings from this year's Risk Index is the reduction in the overall priority given to the talent and skills shortage identified two years ago. In 2011, this risk suddenly rose from its 2009 mid-ranking of 22 to become the number two risk identified by global business leaders. In 2013, it has dropped ten places to number 11= overall. In Germany, for example, a traditional market that is weathering the economic slump much more successfully than its Eurozone partners, the risk has dropped from being business leaders' number 10 priority in 2011 to number 18 in 2013. But, as pointed out in the 2011 Risk Index, Germany is several years into its programme to support succession planning and transfers of businesses, as well as drawing in talent from southern European countries with high levels of unemployed graduates.

It may also be that in the intervening two years since the last Risk Index larger international companies have marshalled their resources to train and upskill key staff, or that an increasingly mobile stratum of senior executives are helping to fill gaps wherever they exist. The appointment of a Canadian as Governor of the Bank of England may, for example, be a reflection of the times. Alternatively, the rise of a talented pool of young specialists in hubs from India to Poland may have matured sufficiently to plug many of the technological and strategic gaps encountered by expanding global businesses.

For the highest-growth economies such as China, however, the lack of suitably skilled staff remains a serious threat to business. As the number one risk for Chinese business leaders in 2011, it has dropped just one place to joint-second in 2013. In Brazil, the risk was placed 13 by companies in 2011; it is now fourth. And yet for faster growing regions as a whole, the risk has dropped from its number one position in 2011 to number seven today – a possible reflection of the way in which the long tail of the global downturn has now reached previously booming economies, reducing the demand for skilled staff.

As swiftly as the talent and skills risk arrived in the Risk Index's Top Five, it has left it. It will be interesting to see where this key strategic risk appears in two years' time, as the forecasted change in economic growth from traditional to high-growth economies becomes further embedded.

CASE STUDY: THE RISE OF SECOND-TIER CITIES

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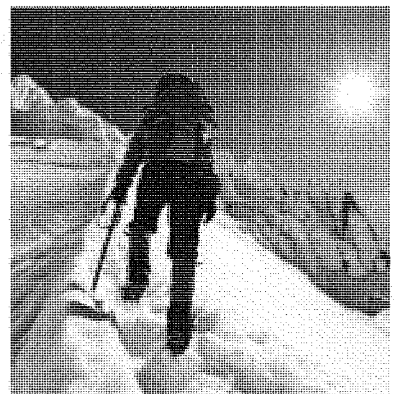
03



THE RISKS LESS TRAVELLED

THE RISKS LESS TRAVELLED

CLIMATE CHANGE – FATIGUE OR FATALISM?

The priority scores respondents give to climate change as a risk have, like those for virtually all other risks, gone up fractionally since 2011, from 4.1 to 4.2. Overall this risk has moved up one place to 32.

According to the World Meteorological Organisation's (WMO) Statement on the Status of the Global Climate,[18] 2012 was the ninth warmest year since records began in 1850, continuing the warming trend begun in 2001. Europe experienced its warmest spring on record, followed by the wettest summer in the UK for 100 years. Drought characterised many regions: Northern Brazil experienced its worst drought in 50 years, while severe drought hit Russia and Siberia and two-thirds of the continental US was in drought by September. In September, Arctic sea ice shrank to its lowest ever recorded level and subsequently contracted 500,000 square kilometres.

Yet, with the sole exception of Latin America, business leaders from all other three major regions of the world continue to score their ability to deal with the risk of climate change more highly than the score they give the risk itself. This difference is most striking for North America, where businesses scored themselves at 5.2 for preparedness, against 3.0 for priority. Only in Latin America do business leaders appear to believe they are underprepared for the threat climate change poses.

In the face of more immediate economic and political risks, the public profile of climate change has declined; it does not dominate the front pages as it once did. Yet the problem itself remains and is likely to be getting worse.

The role of man-made carbon emissions in contributing to climate change is now widely accepted, with an increasing body of evidence that climate change is leading to more extreme weather events. The tensions between high polluting growth economies and low polluting nations which are disproportionately affected by the effects of climate change are unlikely to be resolved any time soon. In the face of a lack of coordinated action by global governments, companies may have to accept they are, for the time being, largely on their own when it comes to taking action to mitigate the ongoing effects of climate change on their businesses – looking at ways to manage its impact on their supply chains may well be a productive place to start.

The role of insurers in helping businesses and communities to mitigate and adapt to the effects of climate change is fundamental and the industry has a crucial role to play in helping customers to manage climate change risks.

At the launch of the Principles for Sustainable Insurance in 2012, Ban Ki-moon underlined the importance of this role: "For years, insurers have been at the forefront of the corporate world in alerting society to the risks of climate change and, more recently, threats such as the loss of biological diversity and the growing pressures on forests, freshwater and other essential ecosystems. Insurers are also increasingly recognizing the need to develop products and services that address the needs of a rapidly changing world, including inclusive insurance that caters to low-income communities, people with HIV/AIDS or disabilities, and ageing populations."[19]

Table 2

ENVIRONMENTAL RISKS – 2013 VERSES 2011 RANKING

ENVIRONMENTAL RISKS	RANKING SHIFT	2013 RANKING	2011 Ranking
DEMOGRAPHIC SHIFT	↑	27	30
INDUSTRIAL/WORKPLACE ACCIDENT	↓	28	27
POLLUTION AND ENVIRONMENTAL LIABILITY	↓	29	24
CLIMATE CHANGE	-	32	32
WATER SCARCITY	↑	33	35
POPULATION GROWTH	↑	35	38
URBANISATION	-	37	37
FOOD SECURITY	↑	38	40
HARMFUL EFFECTS OF NEW TECHNOLOGY	↑	39	41
PANDEMIC	↓	40	33

THE RISKS LESS TRAVELLED
CONTINUED

NATURAL HAZARD – 'THE ABNORMAL IS NOW THE NEW NORMAL'

As in 2011, the priority companies give to natural hazard risks such as flooding, windstorms and drought, is low, and yet awareness of the threat they pose to business is growing. In 2013, 25% of respondents felt the potential impact of natural hazards was greater now than it was two years ago. As in 2011, the risk was felt most keenly by Asia-Pacific respondents, yet natural hazard risk still only ranked in the 40s and business leaders in the region still scored themselves as more prepared for the risk than the priority it posed. 2011 may have been the second costliest year for natural catastrophes for the insurance industry (and the costliest ever for Lloyd's), but in terms of human displacement, 2012 exceeded it. Data from the Internal Displacement Monitoring Centre[20] shows over 32 million people were displaced from their homes by disasters in 2012, double the number left homeless in 2011.

98% of 2012's disasters were weather related: 212,000 people were left homeless by monsoon flooding in North Korea, 530,000 displaced by floods in Niger, 3.5 million in China forced to leave their homes by storms and typhoons and more than 340,000 people displaced by floods in South Sudan. Between them, Superstorm Sandy in the US and Cuba and Super Typhoon Bopha in the Philippines displaced at least 1.1 million and killed at least 1,300 people. The UN Secretary General, Ban Ki-moon, summed up these events with the statement: "The danger signs are all around. The abnormal is now the new normal".[21]

Given the impacts of climate change, we are likely to see increasingly volatile weather patterns and more frequent severe weather events. In areas prone to natural catastrophes, risk mitigation, while important, may only go so far. As infrastructure and industry develop further, businesses and governments must give serious thought to ways in which risk transfer can be used to protect economic growth. The insurance industry needs to continue to provide products which mitigate the financial losses caused by natural hazards and help communities to recover.

This is a reality which too many businesses and governments in disasterprone countries are failing to address.

Towards the end of 2012, Lloyd's and the Centre for Economic and Business Research published the first ever *Lloyd's Global Underinsurance Report*[22] (see Table 4), which quantified the gap between the levels of insurance penetration in 42 countries at various stages of economic development and the annualised cost of natural catastrophes experienced by them. The research showed that 17 high-growth economies had, between them, an annualised US$168 billion insurance deficit, leaving them severely exposed to the long-term costs of catastrophes.

These losses, of course, will not remain static. The report revealed how the pace and extent of global economic development have increased the cost of catastrophes by US$870 billion in real terms since 1980. As fast growing economies develop their infrastructure, transport and industry, and increasing numbers of people live in cities, the impact of natural disasters, both in terms of loss of life and business costs, will inevitably increase.

How these countries chose to transfer their risk is significant. China, for example, which insured just 1.4% of losses from natural catastrophes between 2004 and 2011,'self-insured' losses of US$208 billion in that time; a cost effectively borne by taxpayers. Having analysed five major natural catastrophes, the research found that a one percentage point rise in insurance penetration can reduce the burden on the taxpayer by 22%. In areas prone to natural catastrophes, risk mitigation may only go so far; as infrastructure and industry develop further, businesses and governments will have to give serious thought to ways in which risk transfer can be used to protect economic growth.

Table 3

NATURAL HAZARDS – PRIORITY AND PREPAREDNESS 2013 VERSUS 2011

OVERALL RISKS	2013 PRIORITY SCORE	2013 PREPAREDNESS SCORE	2011 Priority Score	2011 Preparedness Score
FLOODING	3.6	4.9	3.6	5.2
WINDSTORM	3.5	4.6	3.2	4.5
DROUGHT	3.4	4.6	3.0	4.4
THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	3.2	4.5	2.8	4.3
EARTHQUAKE	3.0	4.4	3.3	4.5
IMPACT OF SPACE WEATHER	2.9	4.2	2.6	3.8
VOLCANIC ERUPTION	2.2	4.0	2.4	4.0

Chart 7

NATURAL HAZARDS – PRIORITY AND PREPAREDNESS BY REGION

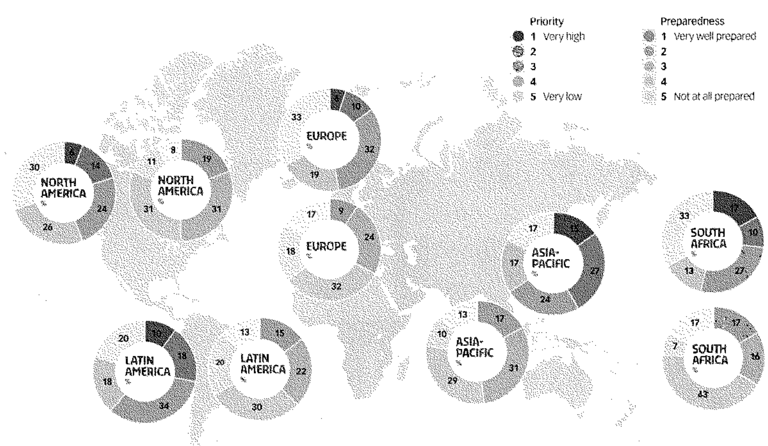
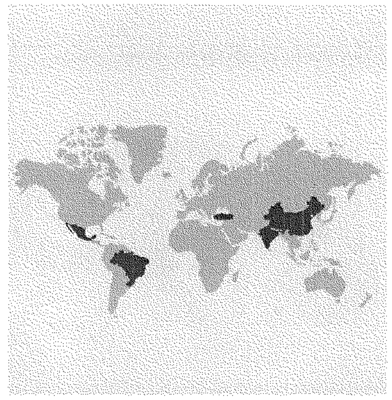


Table 4

INSURANCE CLASSIFICATION OF COUNTRIES (2011) – LLOYD'S GLOBAL UNDERINSURANCE REPORT

TIER 1 (BETTER INSURED)		TIER 2 (MODERATELY INSURED)		TIER 3 (UNDERINSURED)	
COUNTRY	BENCHMARKED INSURANCE LEVEL	COUNTRY	BENCHMARKED INSURANCE LEVEL	COUNTRY	BENCHMARKED INSURANCE LEVEL
NETHERLANDS	8.01	DENMARK	1.36	HONG KONG	-0.03
NEW ZEALAND	3.05	SPAIN	1.05	POLAND	-0.15
SOUTH KOREA	2.55	SOUTH AFRICA	1.02	COLOMBIA	-0.17
UNITED STATES	2.53	TAIWAN	0.97	THAILAND	-0.41
CANADA	2.47	IRELAND	0.75	BRAZIL	-0.51
GERMANY	2.11	ITALY	0.62	MEXICO	-0.67
AUSTRIA	1.67	ARGENTINA	0.44	SAUDI ARABIA	-0.93
UNITED KINGDOM	1.60	ISRAEL	0.44	CHILE	-0.97
AUSTRALIA	1.39	SWEDEN	0.44	CHINA	-1.09
		JAPAN	0.43	NIGERIA	-1.11
		FRANCE	0.39	INDIA	-1.18
		RUSSIA	0.34	TURKEY	-1.31
		NORWAY	0.25	EGYPT	-1.36
		MALAYSIA	0.15	PHILIPPINES	-1.36
		SINGAPORE	0.08	VIETNAM	-1.38
		UAE	0.08	INDONESIA	-1.67
				BANGLADESH	-2.64

04



THE VISION 2025 COUNTRIES – THEN AND NOW

THE VISION 2025 COUNTRIES – THEN AND NOW

In May 2012, Lloyd's launched its new strategy to help the Lloyd's market take advantage of the opportunities presented by the world's fast growing economies – Vision 2025.[23] A detailed analysis of potential opportunities suggested that China, Brazil, Mexico, India and Turkey should be Lloyd's first priorities. In this section, we highlight the top five risk priorities identified by the business leaders surveyed in these countries and summarise the relevant findings from the Lloyd's Global Underinsurance Report for them.

CHINA

THEN

NOW

THE VISION 2025 COUNTRIES – THEN AND NOW
CONTINUED

BRAZIL

THEN

The US was not the only country concerned with currency manipulation in 2011. It was also the number one risk identified by Brazilian business leaders. In September 2011, Brazil presented the World Trade Organisation (WTO) with proposals for WTO members to protect their industries from trade imbalances caused by currency fluctuations. This move came almost immediately after the Brazilian Government raised a tax on cars with a large ratio of imported parts following a surge in Chinese-made car imports.

The number two risk for Brazilian companies in 2011 was fraud and corruption. In the 2011 Transparency International Perception Index 2011, Brazil was ranked 73 out of 182 countries,[25] with the Federation of Industries of São Paulo estimating corruption costs Brazil between 1.4% and 2.3% of its GDP every year.[26]

The number three risk for Brazilian business leaders in 2011 was high taxation. Following the inflationary crises of the 1980s and the 1990s, Brazil prioritised the importance of fiscal stability and inflation control. Despite a reform agenda for personal and corporate tax, much remains unimplemented. As a result, Brazil has corporate tax rates which exceed those of the US, Japan and Canada.

NOW

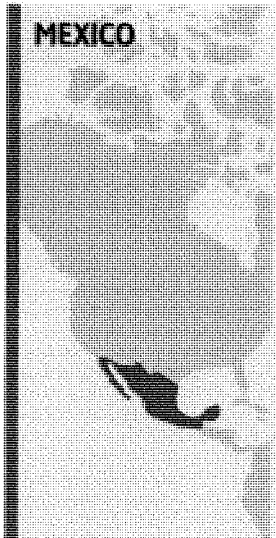
By 2013, with preparation for the forthcoming 2014 World Cup and 2016 Olympics offering global platforms to attract investment, the impact of high taxation has become the number one priority for Brazilian business leaders. With regional competition for exports and FDI heightened by the recent slowdown in Latin American growth, Brazil's GDP projections have suddenly slowed. Uncompetitive corporate tax rates have become the number one priority for Brazilian business leaders, just as they have for their peers in Europe.

As Brazil's growth story slows, the same fear which took first place overall in the 2011 Risk Index, is now being played out in Brazil – the risk of loss of customers and cancelled orders. In 2012, the Brazilian economy grew at its slowest in three years: by just 0.6%. Consumer spending, the driver of growth for many years, slowed right down and, just as in Europe, when consumers started prioritising debt repayment, which for Brazilian households takes around 20% of their income, the impact on consumption was inevitable.

The number three risk to Brazil's businesses in 2013 is critical infrastructure failure, up from 28= in 2011. This is clearly a fixed-time risk for Brazil; with more than US$60 billion of investment in rail, road and airport infrastructure to support the forthcoming World Cup and Olympics, Brazilian business has a lot riding on its successful completion. Given the recent concerns about the preparedness of the Maracana stadium and other facilities under construction, the risk of failing to capitalise on this dual opportunity clearly looms large for Brazilian businesses.

The Lloyd's Global Underinsurance Report shows that Brazil is significantly underinsured against the costs of natural catastrophes, coming 30th out of the 42 countries analysed. Non-life insurance penetration in Brazil as a percentage of GDP stands at 1.5% while the underinsurance gap for Brazil in 2011 was US$12.68 billion (see Table 4).

MEXICO



THEN

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NOW

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CASE STUDY: MEXICO'S WATER CRISIS – WHEN INFRASTRUCTURE ISN'T ENOUGH

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THE VISION 2025 COUNTRIES – THEN AND NOW
CONTINUED

INDIA

THEN

By November 2011, India's inflation rate had exceeded 9% for the 11th successive month, restricting the central bank's ability to keep interest rates on hold to protect India's economy from the global economic crisis. Given that other Asian nations were able to hold or cut interest rates, it's no surprise that the implications for India's global – and regional – competitiveness were reflected in Indian business leaders putting inflationary fears as their number one priority risk. This also explains their number two risk, loss of customers and cancelled orders, as inflation and high interest rates combined to depress demand, both domestically and internationally.

Despite India's young, increasingly educated population, business leaders in 2011 reported the lack of availability of talent and skills was their number three priority. Manpower's 2011 Talent Shortage Results disclosed that 67% of Indian employers reported difficulty in filling roles due to a lack of talent, up sharply from only 16% in 2010.[28] This may have been because, notwithstanding India's inflationary and interest rate woes, India's economy was still growing strongly at around 6%, and the scarcity of skilled employees in sectors such as tourism and construction was proving a visible brake on expansion.

NOW

In 2013, as with other high-growth economies with strong manufacturing industries, such as China and Brazil, India's business leaders are feeling the pinch caused by the escalating cost of energy and many raw materials and the ongoing impact of currency devaluation – the cost of material inputs is their number one business risk.

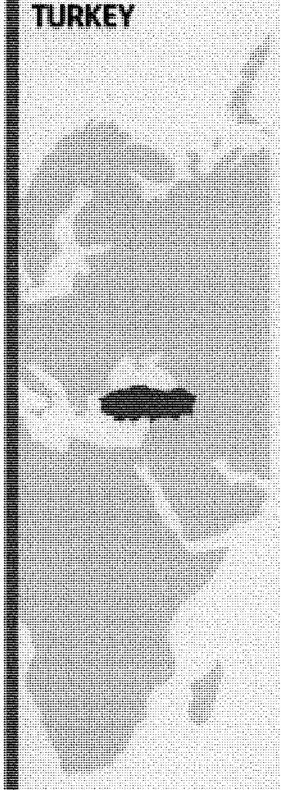
2012 was a year of exceptional volatility for the rupee, a volatility which has continued into 2013 – reflected in currency fluctuation being the number two risk for Indian business leaders. During 2012 it fluctuated by over 18% to become one of the year's poorest performing currencies. While China has benefited from a devalued currency, India is a net importer, with products for export heavily reliant on imports of raw materials.

India's current insecurity about cyber risk is reflected in its number three position. In July 2012, northern India experienced its worst blackout ever. While the report into its cause, published just two weeks later, exonerated cyber breaches, some industry experts remained unconvinced. India's defence sites also came under attack from 'hacktivist' groups Anonymous and Hackers in Algeria in 2012 and, according to CERT-In, well over 14,000 Indian websites were hacked during the year. March 2013 saw the site of the military Defence Research and Development Organisation breached by suspected foreign state-sponsored hackers. The changing trend in hacking motivation in the last few years from publicity to financial gain and political attack has raised its priority both politically and commercially.

In response, in May 2013, India's Cabinet Committee on Security approved a National Cyber Security Policy to strengthen India's cyber security.[29] The policy is aimed at building domestic capacity for a secure computing infrastructure. It also acknowledges the need to create a skilled domestic cyber security workforce, rather than relying on externally sourced solutions. India has pledged to train tens of thousands of students as the future frontline against the commercial and political cyber threats the country faces.

The Lloyd's Global Underinsurance Report shows that India is severely underinsured against the costs of natural catastrophes, coming 36th out of the 42 countries analysed. Non-life insurance penetration in India as a percentage of GDP stands at 0.7%, while the underinsurance gap for India in 2011 was US$19.72 billion (see Table 4).

TURKEY



THE VISION 2025 COUNTRIES – THEN AND NOW
CONTINUED

TURKEY
CONTINUED

While Turkey's young population may be the envy of ageing European countries such as Germany, the implications of demographic change are clearly being felt by our sample who ranked it as their number three business risk. The high birth rate, which has declined only since 2005, has created a young and growing population which is placing pressure on state finances and urban infrastructure and presents a challenge to the state in terms of providing adequate jobs. Low wages and underdeveloped rural areas, where nearly a quarter of the population work in agriculture, are driving more young people to the cities, adding to pressure on housing and education provision. While Turkey's overall unemployment rate stood at just over 9% at the start of 2013, its youth unemployment rate reached over 20% in May. According to the OECD's May 2013 list, Turkey came fourth in the list of the ten most unproductive countries in Western Europe.[32]

Countries all over Europe are recognising the dangers a 'lost generation' of young unemployed present to social stability and future economic prosperity. For a country with the largest youth demographic in Europe, these dangers can only be amplified.

CONCLUSION – A GAME OF TWO HALVES

> The sophistication of companies' risk management function is evolving over time depending on their size, location and stage of economic development.

The past two years have not only failed to provide the 'two-speed' recovery predicted by many economists in 2011, they have also put a brake on the expansion of the higher growth economies which were supposed to save the day.

The findings show a clear effect on the attitude of business leaders to these events. There is now a sense that their companies may have come to the limit of organisational preparedness in the face of what is now a global slowdown, rather than a tale of the 'West and the rest' which was being told in 2011. Yet while there has been a drop of more than a quarter in those reporting that they feel better prepared than they did two years ago, the preparedness scores for many risks still show a questionable level of realism. Despite the significant overall rise in the priority given to cyber risk, for example, the fact that business' overall preparedness score is higher than the priority implies a level of complacency unmatched by the acts.

In the longer term, however, perhaps the most fascinating reflection in this year's Risk Index is how the sophistication of companies' risk management function is evolving over time depending on their size, location and stage of economic development. If larger companies in faster growing economies follow the pattern of their peers in established markets in seeking risk management and risk transfer solutions, the market for those providing them is set to grow significantly. For smaller companies in these markets, even less prepared, the next few years may prove critical.

Businesses providing the expertise, capacity and products to support companies in higher growth economies, including international insurance markets, need to recognise the opportunities available and plan accordingly. The future of global economic power is shifting before their eyes. If they fail to capitalise on these expanding markets now, they will miss the opportunities – the urgency of risk management in fast growing countries cannot be postponed. Given how swiftly the risk management landscape has changed for businesses in traditional markets in the five years since the first Risk Index was published in 2009, these are challenges which the insurance industry needs to meet now.

APPENDIX 1

RISKS CHANGED FROM 2011 SURVEY AND RISKS INCLUDED IN 2013 SURVEY

The 2011 risk definitions 'cyber attacks (malicious)' and 'cyber attacks (non malicious)' combined and became 'cyber risk' in the 2013 survey. The risk 'Corporate governance and internal oversight failure' was added to the 2013 survey.

ESTABLISHED AND FAST-GROWING TERMINOLOGY

'Established' markets refer to those markets in North America and Europe:

> USA
> Canada
> UK
> France
> Germany
> Italy
> Spain
> Turkey

Faster growing markets refer to all other regions:

> China
> India
> Australia
> Singapore
> Japan
> Mexico
> Brazil
> South Africa

RESULTS FROM EARLIER RISK INDICES RANKED IN ORDER OF THEIR PRIORITY AT THAT TIME.

2013 RISKS

1 High taxation
2 Loss of customers/cancelled orders
3 Cyber risk
4 Price of material inputs
5 Excessively strict regulation
6 Changing legislation
7 Inflation
8 Cost and availability of credit
9 Rapid technological changes
10 Currency fluctuation
11 Interest rate change
12 Talent and skills shortage
13 Reputational risk
14 Corporate liability
15 Major asset price volatility
16 Poor/incomplete regulation
17 Government spending cuts
18 Fraud and corruption
19 Theft of assets/Intellectual Property
20 Failed investment
21 Corporate governance and internal oversight failure
22 Critical infrastructure failure
23 Supply chain failure
24 Increased protectionism
25 Insolvency risk
26 Energy security
27 Demographic shift
28 Industrial/workplace accident
29 Pollution and environmental liability
30 Sovereign debt
31 Piracy
32 Climate change
33 Water scarcity
34 Strikes and industrial action
35 Population growth
36 Expropriation of assets
37 Urbanisation
38 Food security
39 Harmful effects of new technology
40 Pandemic
41 Abrupt regime change
42 Terrorism
43 Riots and civil commotion
44 Flooding
45 Windstorm
46 Drought
47 Threats to biodiversity and conservation affecting our operations
48 Earthquake
49 Impact of space weather
50 Volcanic eruption

2011 RISKS

1 Loss of customers/Cancelled orders
2 Talent and skills shortages (including succession risk)
3 Reputational risk
4 Currency fluctuation
5 Changing legislation
6 Cost and availability of credit
7 Price of material inputs
8 Inflation
9 Corporate liability
10 Excessively strict regulation
11 Rapid technological changes
12 Cyber attacks (malicious)
13 High taxation
14 Failed investment
15 Major asset price volatility
16 Theft of assets/Intellectual Property
17 Fraud and corruption
18 Interest rate change
19 Cyber risks (non-malicious)
20 Poor/Incomplete regulation
21 Critical infrastructure failure
22 Government spending cuts
23 Supply chain failure
24 Pollution and environmental liability
25 Sovereign debt
26 Increased protectionism
27 Industrial/workplace accident
28 Energy security
29 Insolvency risk
30 Demographic shift (eg ageing population, youth emigration)
31 Strikes and industrial action
32 Climate change
33 Pandemic
34 Piracy
35 Water scarcity
36 Terrorism
37 Urbanisation
38 Population growth
39 Riots and civil commotion
40 Food security
41 Harmful effects of new technology
42 Flooding
43 Expropriation of assets
44 Earthquake (including tsunami)
45 Abrupt regime change
46 Windstorm (eg hurricane, cyclone, typhoon)
47 Drought
48 Threats to biodiversity
49 Impact of space weather (eg solar flares)
50 Volcanic eruption (including ash)

2009 RISKS

1 Cost and availability of credit
2 Currency fluctuation
3 Insolvency risk
4 Loss of customers
5 Major asset price volatility
6 Cancelled orders
7 Risk of excessively strict regulation
8 Corporate liability
9 Reputational risk
10 Project delivery risk
11 Abrupt interest rate change
12 Risk of poor/incomplete regulation
13 Increasing protectionism
14 Failed investment
15 Fraud and corruption
16 Information security breach
17 Price of material inputs
18 Theft of assets/Intellectual property
19 Rapid technological change
20 Cyber attacks
21 Workforce health
22 Talent and skills shortages
23 Supply chain failure
24 Succession risk
25 Industrial/workplace accident
26 Energy security
27 Piracy
28 Strikes
29 Pollution (caused by business)
30 Flooding
31 Terrorism
32 Currency inconvertibility
33 Climate change (impact on business)
34 Pandemic
35 Expropriation of assets
36 Earthquake
37 Drought
38 Riots and civil commotion
39 Windstorm (eg hurricane or typhoon)
40 Abrupt regime change
41 Wildlife

APPENDIX 2

TOP 50 PRIORITY RISK SCORES IN 2013 BY REGION

Chart 8

TOP 50 PRIORITY RISK SCORES IN 2013 – ASIA-PACIFIC

Risk		Score out of 10
1	PRICE OF MATERIAL INPUTS	6.60
2	HIGH TAXATION	6.13
3=	CURRENCY FLUCTUATION	6.05
3=	INFLATION	6.05
5	LOSS OF CUSTOMERS/CANCELLED ORDERS	6.01
6=	MAJOR ASSET PRICE VOLATILITY	5.91
6=	TALENT AND SKILLS SHORTAGE	5.91
8	CYBER RISK	5.90
9	EXCESSIVELY STRICT REGULATION	5.76
10	INTEREST RATE CHANGE	5.75
11	COST AND AVAILABILITY OF CREDIT	5.72
12	RAPID TECHNOLOGICAL CHANGES	5.70
13=	SUPPLY CHAIN FAILURE	5.61
13=	CHANGING LEGISLATION	5.61
15	CORPORATE GOVERNANCE AND INTERNAL OVERSIGHT FAILURE	5.59
16	CRITICAL INFRASTRUCTURE FAILURE	5.58
17	CORPORATE LIABILITY	5.55
18=	FAILED INVESTMENT	5.52
18=	REPUTATIONAL RISK	5.52
20	INCREASED PROTECTIONISM	5.47
21	INDUSTRIAL/WORKPLACE ACCIDENT	5.46
22=	FRAUD AND CORRUPTION	5.40
22=	POOR/INCOMPLETE REGULATION	5.40
24	GOVERNMENT SPENDING CUTS	5.39
25	ENERGY SECURITY	5.36
26	THEFT OF ASSETS OR INTELLECTUAL PROPERTY	5.32
27	POPULATION GROWTH	5.30
28	DEMOGRAPHIC SHIFT	5.28
29	POLLUTION AND ENVIRONMENTAL LIABILITY	5.25
30=	INSOLVENCY RISK	5.19
30=	FOOD SECURITY	5.19
32	CLIMATE CHANGE	5.18
33	SOVEREIGN DEBT	5.14
34	PANDEMIC	5.11
35	URBANISATION	5.08
36	WATER SCARCITY	5.07
37=	PIRACY	5.00
37=	EXPROPRIATION OF ASSETS	5.00
39	HARMFUL EFFECTS OF NEW TECHNOLOGY	4.96
40	STRIKES AND INDUSTRIAL ACTION	4.54
41	DROUGHT	4.28
42	FLOODING	4.23
43	ABRUPT REGIME CHANGE	4.21
44	THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	4.19
45	EARTHQUAKE	4.16
46	TERRORISM	4.09
47	RIOTS AND CIVIL COMMOTION	3.99
48	WINDSTORM	3.94
49	IMPACT OF SPACE WEATHER	3.85
50	VOLCANIC ERUPTION	3.48

Score out of 10 — 0 1 2 3 4 5 6 7 8

Chart 9

TOP 50 PRIORITY RISK SCORES IN 2013 – EUROPE

Risk		Score out of 10
1	HIGH TAXATION	6.59
2	LOSS OF CUSTOMERS/CANCELLED ORDERS	6.44
3	CHANGING LEGISLATION	5.94
4	COST AND AVAILABILITY OF CREDIT	5.86
5	EXCESSIVELY STRICT REGULATION	5.80
6	CYBER RISK	5.56
7	PRICE OF MATERIAL INPUTS	5.42
8	RAPID TECHNOLOGICAL CHANGES	5.41
9	REPUTATIONAL RISK	5.38
10	CORPORATE LIABILITY	5.29
11	POOR/INCOMPLETE REGULATION	5.24
12	GOVERNMENT SPENDING CUTS	5.21
13	THEFT OF ASSETS OR INTELLECTUAL PROPERTY	5.20
14	FRAUD AND CORRUPTION	5.11
15	INFLATION	5.05
16	TALENT AND SKILLS SHORTAGE	5.03
17	FAILED INVESTMENT	5.02
18	INTEREST RATE CHANGE	4.98
19	INSOLVENCY RISK	4.97
20=	CORPORATE GOVERNANCE AND INTERNAL OVERSIGHT FAILURE	4.89
20=	CURRENCY FLUCTUATION	4.89
22	CRITICAL INFRASTRUCTURE FAILURE	4.83
23	MAJOR ASSET PRICE VOLATILITY	4.82
24	SOVEREIGN DEBT	4.68
25	INCREASED PROTECTIONISM	4.62
26	SUPPLY CHAIN FAILURE	4.52
27	ENERGY SECURITY	4.44
28	DEMOGRAPHIC SHIFT	4.36
29	INDUSTRIAL/WORKPLACE ACCIDENT	4.27
30=	POLLUTION AND ENVIRONMENTAL LIABILITY	4.24
30=	STRIKES AND INDUSTRIAL ACTION	4.24
32	PIRACY	4.02
33=	EXPROPRIATION OF ASSETS	3.80
33=	HARMFUL EFFECTS OF NEW TECHNOLOGY	3.80
35	RIOTS AND CIVIL COMMOTION	3.76
36	URBANISATION	3.67
37	CLIMATE CHANGE	3.64
38	ABRUPT REGIME CHANGE	3.59
39	TERRORISM	3.56
40	FOOD SECURITY	3.52
41	WATER SCARCITY	3.48
42	FLOODING	3.38
43	POPULATION GROWTH	3.33
44	PANDEMIC	3.30
45	WINDSTORM	2.88
46	THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	2.79
47	EARTHQUAKE	2.64
48	IMPACT OF SPACE WEATHER	2.50
49	DROUGHT	2.47
50	VOLCANIC ERUPTION	1.97

Score out of 10: 0 1 2 3 4 5 6 7 8

APPENDIX 2
CONTINUED

Chart 10

TOP 50 PRIORITY RISK SCORES IN 2013 – SOUTH AFRICA

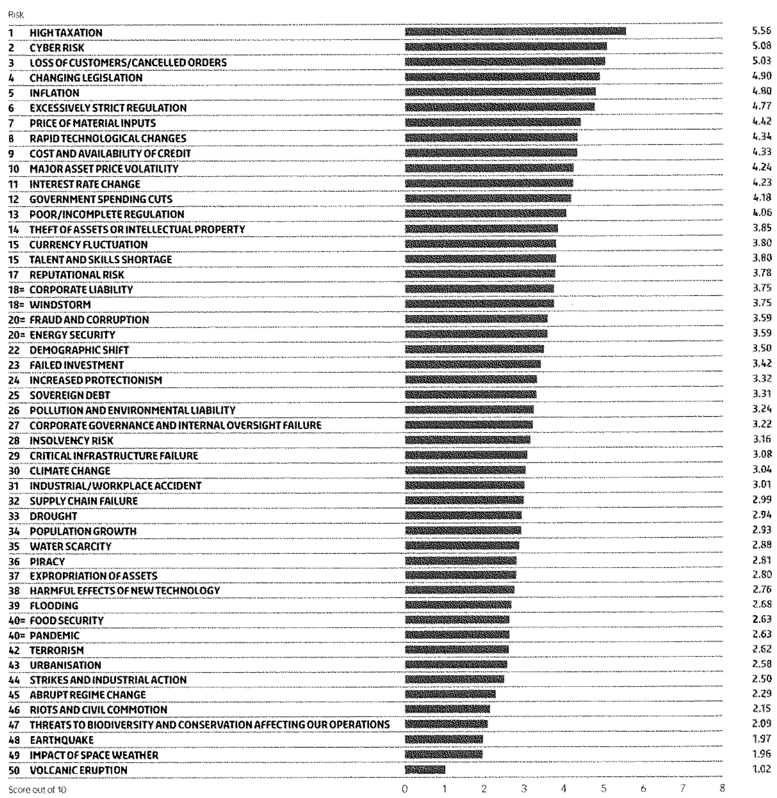
	Risk	Score
1	LOSS OF CUSTOMERS/CANCELLED ORDERS	6.92
2	FRAUD AND CORRUPTION	6.67
3=	CURRENCY FLUCTUATION	6.50
3=	STRIKES AND INDUSTRIAL ACTION	6.50
5	INFLATION	6.42
6=	COST AND AVAILABILITY OF CREDIT	6.33
6=	CYBER RISK	6.33
6=	EXCESSIVELY STRICT REGULATION	6.33
9	INCREASED PROTECTIONISM	6.25
10=	HIGH TAXATION	6.17
10=	PRICE OF MATERIAL INPUTS	6.17
10=	INTEREST RATE CHANGE	6.17
10=	REPUTATIONAL RISK	6.17
14=	RAPID TECHNOLOGICAL CHANGES	6.00
14=	THEFT OF ASSETS OR INTELLECTUAL PROPERTY	6.00
16	SUPPLY CHAIN FAILURE	5.92
17	MAJOR ASSET PRICE VOLATILITY	5.75
18	TALENT AND SKILLS SHORTAGE	5.67
19=	CORPORATE LIABILITY	5.58
19=	CHANGING LEGISLATION	5.58
21	ENERGY SECURITY	5.50
22	FAILED INVESTMENT	5.33
23=	INDUSTRIAL/WORKPLACE ACCIDENT	5.25
23=	DEMOGRAPHIC SHIFT	5.25
23=	GOVERNMENT SPENDING CUTS	5.25
23=	RIOTS AND CIVIL COMMOTION	5.25
27=	CORPORATE GOVERNANCE AND INTERNAL OVERSIGHT FAILURE	5.17
27=	POOR/INCOMPLETE REGULATION	5.17
29	POLLUTION AND ENVIRONMENTAL LIABILITY	5.00
30	EXPROPRIATION OF ASSETS	4.92
31=	CLIMATE CHANGE	4.75
31=	POPULATION GROWTH	4.75
31=	WATER SCARCITY	4.75
34=	INSOLVENCY RISK	4.67
34=	CRITICAL INFRASTRUCTURE FAILURE	4.67
36	ABRUPT REGIME CHANGE	4.58
37	PIRACY	4.50
38	FOOD SECURITY	4.33
39	PANDEMIC	4.17
40	HARMFUL EFFECTS OF NEW TECHNOLOGY	4.08
41=	SOVEREIGN DEBT	4.00
41=	URBANISATION	4.00
43	TERRORISM	3.83
44	FLOODING	3.50
45	DROUGHT	3.42
46	THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	2.92
47	WINDSTORM	2.50
48	IMPACT OF SPACE WEATHER	2.42
49	EARTHQUAKE	1.92
50	VOLCANIC ERUPTION	1.50

Score out of 10

0 1 2 3 4 5 6 7 8

Chart 11

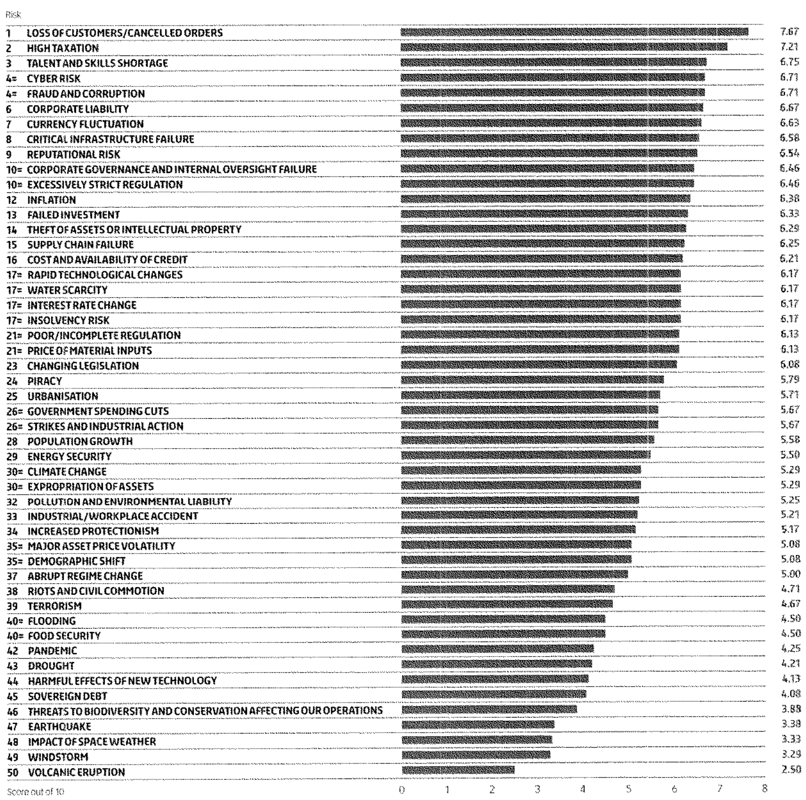
TOP 50 PRIORITY RISK SCORES IN 2013 – NORTH AMERICA



APPENDIX 2
CONTINUED

Chart 12

TOP 50 PRIORITY RISK SCORES IN 2013 – LATIN AMERICA



TOP 50 PREPAREDNESS RISK SCORE IN 2013 BY REGION

Chart 13

TOP 50 PREPAREDNESS SCORES IN 2013 – ASIA-PACIFIC

	Risk	Score out of 10
1	REPUTATIONAL RISK	6.20
2	PRICE OF MATERIAL INPUTS	6.13
3	CYBER RISK	6.06
4	FRAUD AND CORRUPTION	5.94
5	INSOLVENCY RISK	5.93
6=	CORPORATE LIABILITY	5.91
6=	LOSS OF CUSTOMERS/CANCELLED ORDERS	5.91
8	INTEREST RATE CHANGE	5.88
9=	COST AND AVAILABILITY OF CREDIT	5.86
9=	RAPID TECHNOLOGICAL CHANGES	5.86
11	SUPPLY CHAIN FAILURE	5.84
12=	FAILED INVESTMENT	5.81
12=	THEFT OF ASSETS OR INTELLECTUAL PROPERTY	5.81
14=	SOVEREIGN DEBT	5.80
14=	MAJOR ASSET PRICE VOLATILITY	5.80
16=	CORPORATE GOVERNANCE AND INTERNAL OVERSIGHT FAILURE	5.77
16=	TALENT AND SKILLS SHORTAGE	5.77
18=	CRITICAL INFRASTRUCTURE FAILURE	5.70
18=	CURRENCY FLUCTUATION	5.70
20	INCREASED PROTECTIONISM	5.69
21	INFLATION	5.66
22	PIRACY	5.65
23=	EXCESSIVELY STRICT REGULATION	5.64
23=	POOR/INCOMPLETE REGULATION	5.64
25	ENERGY SECURITY	5.61
26	CHANGING LEGISLATION	5.59
27	EXPROPRIATION OF ASSETS	5.55
28	INDUSTRIAL/WORKPLACE ACCIDENT	5.54
29	STRIKES AND INDUSTRIAL ACTION	5.51
30	HIGH TAXATION	5.50
31	POLLUTION AND ENVIRONMENTAL LIABILITY	5.47
32=	CLIMATE CHANGE	5.44
32=	POPULATION GROWTH	5.44
34	DEMOGRAPHIC SHIFT	5.43
35	GOVERNMENT SPENDING CUTS	5.37
36	ABRUPT REGIME CHANGE	5.36
37	FOOD SECURITY	5.28
38	WATER SCARCITY	5.21
39	HARMFUL EFFECTS OF NEW TECHNOLOGY	5.15
40	URBANISATION	5.12
41=	RIOTS AND CIVIL COMMOTION	5.10
41=	PANDEMIC	5.10
43	FLOODING	4.97
44	DROUGHT	4.90
45	TERRORISM	4.88
46	WINDSTORM	4.83
47	THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	4.78
48	EARTHQUAKE	4.74
49	IMPACT OF SPACE WEATHER	4.70
50	VOLCANIC ERUPTION	4.41

Score out of 10

0 1 2 3 4 5 6 7 8

APPENDIX 2
CONTINUED

Chart 14

TOP 50 PREPAREDNESS SCORES IN 2013 – EUROPE

Risk		Score out of 10
1	INDUSTRIAL/WORKPLACE ACCIDENT	5.94
2	CORPORATE GOVERNANCE AND INTERNAL OVERSIGHT FAILURE	5.83
3	CORPORATE LIABILITY	5.82
4	REPUTATIONAL RISK	5.79
5	CYBER RISK	5.74
6	RAPID TECHNOLOGICAL CHANGES	5.64
7	TALENT AND SKILLS SHORTAGE	5.53
8	COST AND AVAILABILITY OF CREDIT	5.48
9	CRITICAL INFRASTRUCTURE FAILURE	5.47
10	SUPPLY CHAIN FAILURE	5.41
11	LOSS OF CUSTOMERS/CANCELLED ORDERS	5.39
12	INFLATION	5.36
13	FAILED INVESTMENT	5.33
14	INTEREST RATE CHANGE	5.32
15	PIRACY	5.26
16=	INSOLVENCY RISK	5.24
16=	PRICE OF MATERIAL INPUTS	5.24
16=	THEFT OF ASSETS OR INTELLECTUAL PROPERTY	5.24
19	FRAUD AND CORRUPTION	5.21
20	GOVERNMENT SPENDING CUTS	5.17
21=	HIGH TAXATION	5.09
21=	ENERGY SECURITY	5.09
21=	CHANGING LEGISLATION	5.09
24=	MAJOR ASSET PRICE VOLATILITY	5.08
24=	POOR/INCOMPLETE REGULATION	5.08
26	INCREASED PROTECTIONISM	5.06
27	EXCESSIVELY STRICT REGULATION	5.00
28	POLLUTION AND ENVIRONMENTAL LIABILITY	4.98
29	STRIKES AND INDUSTRIAL ACTION	4.95
30	CURRENCY FLUCTUATION	4.91
31	SOVEREIGN DEBT	4.73
32	DEMOGRAPHIC SHIFT	4.65
33	URBANISATION	4.64
34	EXPROPRIATION OF ASSETS	4.59
35	POPULATION GROWTH	4.56
36	FOOD SECURITY	4.42
37	HARMFUL EFFECTS OF NEW TECHNOLOGY	4.39
38	RIOTS AND CIVIL COMMOTION	4.29
39	ABRUPT REGIME CHANGE	4.21
40=	FLOODING	4.20
40=	TERRORISM	4.20
42	WATER SCARCITY	4.14
43	CLIMATE CHANGE	4.08
44	WINDSTORM	3.94
45	EARTHQUAKE	3.83
46	THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	3.80
47	PANDEMIC	3.79
48	DROUGHT	3.76
49	IMPACT OF SPACE WEATHER	3.56
50	VOLCANIC ERUPTION	3.52

Score out of 10

0 1 2 3 4 5 6 7 8

Chart 15

TOP 50 PREPAREDNESS SCORES IN 2013 – SOUTH AFRICA

Risk		Score out of 10
1=	CYBER RISK	6.92
1=	THEFT OF ASSETS OR INTELLECTUAL PROPERTY	6.92
3	RAPID TECHNOLOGICAL CHANGES	6.42
4=	REPUTATIONAL RISK	6.33
4=	SUPPLY CHAIN FAILURE	6.33
6=	FRAUD AND CORRUPTION	6.25
6=	CURRENCY FLUCTUATION	6.25
6=	EXPROPRIATION OF ASSETS	6.25
9	CRITICAL INFRASTRUCTURE FAILURE	6.08
10=	STRIKES AND INDUSTRIAL ACTION	6.00
10=	COST AND AVAILABILITY OF CREDIT	6.00
12	LOSS OF CUSTOMERS/CANCELLED ORDERS	5.92
13=	CORPORATE GOVERNANCE AND INTERNAL OVERSIGHT FAILURE	5.83
13=	INDUSTRIAL/WORKPLACE ACCIDENT	5.83
13=	CORPORATE LIABILITY	5.83
13=	POOR/INCOMPLETE REGULATION	5.83
17	INCREASED PROTECTIONISM	5.75
18=	INTEREST RATE CHANGE	5.67
18=	EXCESSIVELY STRICT REGULATION	5.67
20=	DEMOGRAPHIC SHIFT	5.58
20=	TALENT AND SKILLS SHORTAGE	5.58
22=	INFLATION	5.50
22=	INSOLVENCY RISK	5.50
22=	PRICE OF MATERIAL INPUTS	5.50
25=	CHANGING LEGISLATION	5.42
25=	PIRACY	5.42
25=	FAILED INVESTMENT	5.42
25=	RIOTS AND CIVIL COMMOTION	5.42
29=	FOOD SECURITY	5.33
29=	POPULATION GROWTH	5.33
31=	ABRUPT REGIME CHANGE	5.25
31=	HIGH TAXATION	5.25
33	POLLUTION AND ENVIRONMENTAL LIABILITY	5.17
34=	CLIMATE CHANGE	5.08
34=	MAJOR ASSET PRICE VOLATILITY	5.08
34=	TERRORISM	5.08
34=	URBANISATION	5.08
34=	ENERGY SECURITY	5.08
34=	GOVERNMENT SPENDING CUTS	5.08
40	FLOODING	4.83
41	THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	4.75
42=	PANDEMIC	4.67
42=	SOVEREIGN DEBT	4.67
42=	WATER SCARCITY	4.67
45	HARMFUL EFFECTS OF NEW TECHNOLOGY	4.58
46	DROUGHT	4.25
47=	VOLCANIC ERUPTION	3.92
47=	WINDSTORM	3.92
49	EARTHQUAKE	3.58
50	IMPACT OF SPACE WEATHER	3.50

Score out of 10 — 0 1 2 3 4 5 6 7 8

541

APPENDIX 2
CONTINUED

Chart 16

TOP 50 PREPAREDNESS SCORES IN 2013 – NORTH AMERICA

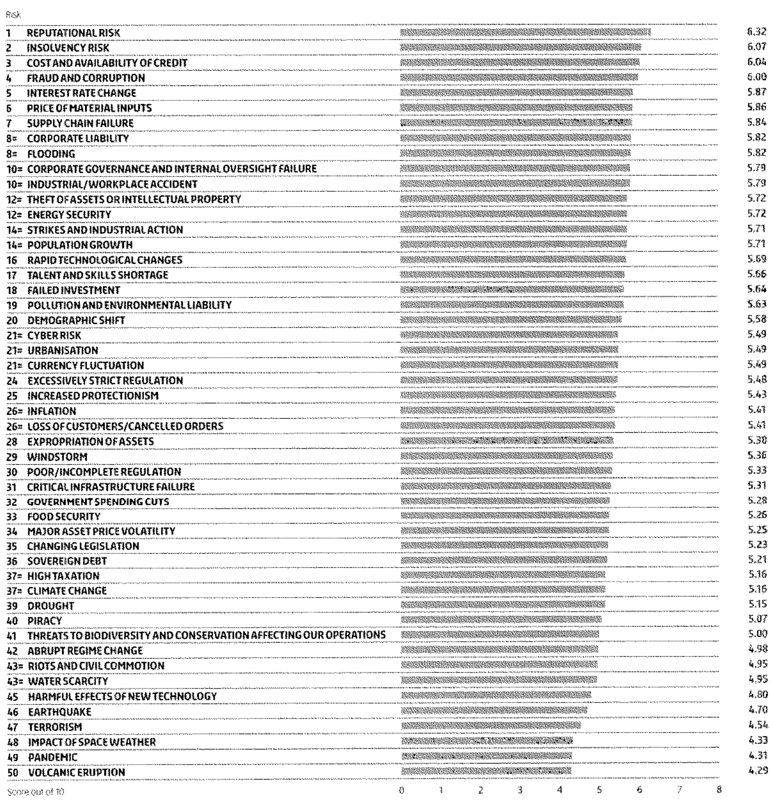


Chart 17

TOP 50 PREPAREDNESS SCORES IN 2013 – LATIN AMERICA

Risk		Score
1=	CORPORATE GOVERNANCE AND INTERNAL OVERSIGHT FAILURE	7.04
1=	CORPORATE LIABILITY	7.04
3	REPUTATIONAL RISK	6.79
4	RAPID TECHNOLOGICAL CHANGES	6.71
5	CRITICAL INFRASTRUCTURE FAILURE	6.58
6	INSOLVENCY RISK	6.50
7=	COST AND AVAILABILITY OF CREDIT	6.38
7=	INFLATION	6.38
7=	CURRENCY FLUCTUATION	6.38
10=	PRICE OF MATERIAL INPUTS	6.33
10=	THEFT OF ASSETS OR INTELLECTUAL PROPERTY	6.33
12=	INDUSTRIAL/WORKPLACE ACCIDENT	6.29
12=	FAILED INVESTMENT	6.29
12=	LOSS OF CUSTOMERS/CANCELLED ORDERS	6.29
15	TALENT AND SKILLS SHORTAGE	6.13
16=	INTEREST RATE CHANGE	6.04
16=	MAJOR ASSET PRICE VOLATILITY	6.04
18	POOR/INCOMPLETE REGULATION	5.88
19=	CYBER RISK	5.83
19=	PIRACY	5.83
19=	ENERGY SECURITY	5.83
22	GOVERNMENT SPENDING CUTS	5.79
23	URBANISATION	5.75
24=	FRAUD AND CORRUPTION	5.71
24=	INCREASED PROTECTIONISM	5.71
24=	SOVEREIGN DEBT	5.71
24=	SUPPLY CHAIN FAILURE	5.71
28	STRIKES AND INDUSTRIAL ACTION	5.67
29=	CHANGING LEGISLATION	5.63
29=	HIGH TAXATION	5.63
29=	EXCESSIVELY STRICT REGULATION	5.63
32=	POPULATION GROWTH	5.58
32=	POLLUTION AND ENVIRONMENTAL LIABILITY	5.58
34=	RIOTS AND CIVIL COMMOTION	5.25
34=	WATER SCARCITY	5.25
36=	DEMOGRAPHIC SHIFT	5.08
36=	FOOD SECURITY	5.08
38	ABRUPT REGIME CHANGE	5.00
39	HARMFUL EFFECTS OF NEW TECHNOLOGY	4.92
40=	EXPROPRIATION OF ASSETS	4.88
40=	CLIMATE CHANGE	4.88
42	DROUGHT	4.71
43	FLOODING	4.67
44	THREATS TO BIODIVERSITY AND CONSERVATION AFFECTING OUR OPERATIONS	4.58
45	EARTHQUAKE	4.54
46	WINDSTORM	4.50
47	PANDEMIC	4.29
48	IMPACT OF SPACE WEATHER	3.96
49	TERRORISM	3.92
50	VOLCANIC ERUPTION	3.67

Score out of 10

0 1 2 3 4 5 6 7 8

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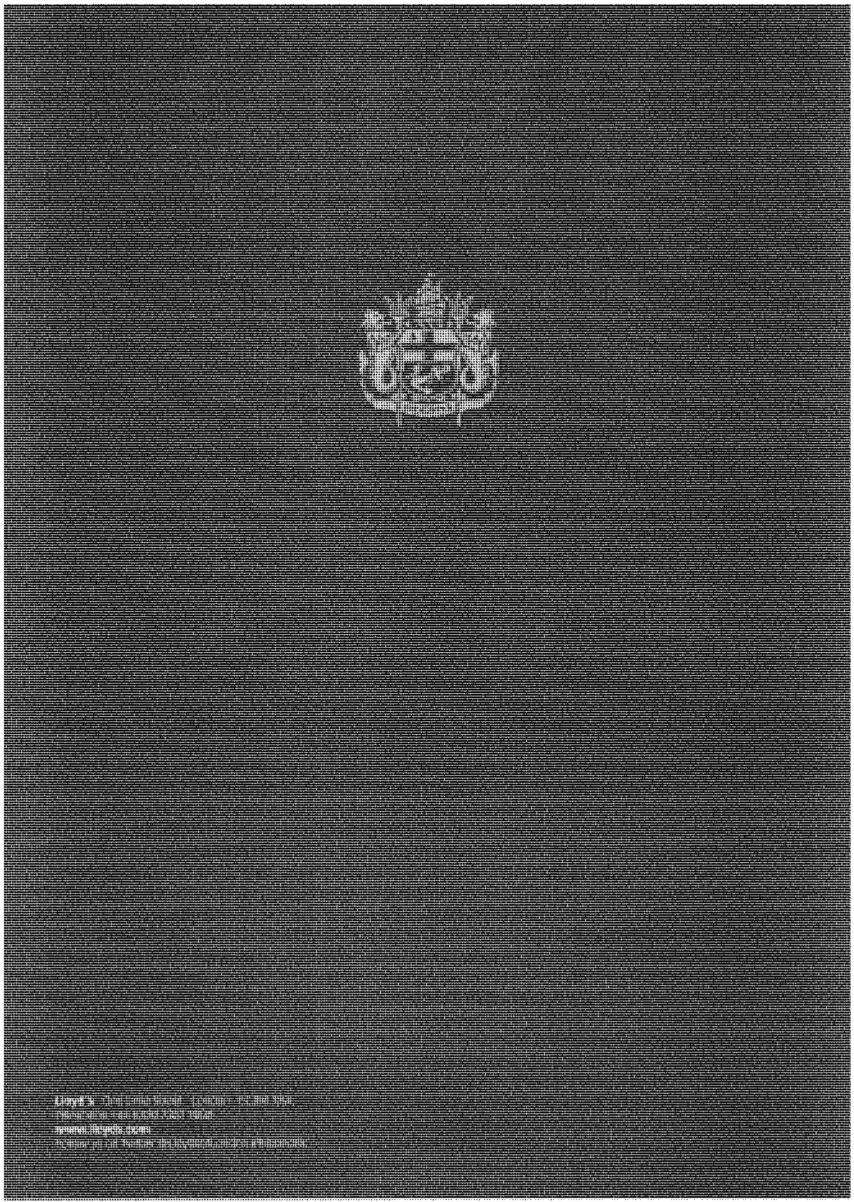

Economic Outcomes of a U.S. Carbon Tax

Full Report

Prepared for National Association of Manufacturers
by NERA Economic Consulting

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Contents

List of Figures

Table of Acronyms

AEO: Annual Energy Outlook
BEV: Battery Electric Vehicle
BTL: Biomass to Liquids
CBO: Congressional Budget Office
CCS: Carbon Capture and Storage
CES: Constant Elasticity of Substitution
CGE: Computable General Equilibrium
CNG: Compressed Natural Gas
CO_2: Carbon Dioxide
DSM: Demand-Side Management
EIA: Energy Information Administration
EPA: U.S. Environmental Protection Agency
EV: Electrified Vehicle
FICA: Federal Insurance Contributions Act
GDP: Gross Domestic Product
GRP: Gross Regional Product
GSP: Gross State Product
GW: Gigawatt
HI: Hospital Insurance
kW: Kilowatt
kWh: Kilowatt-hour
LDV: Light Duty Vehicle
MM: Million
NBER: National Bureau of Economic Research
OECD: Organisation for Economic Co-operation and Development
PHEV: Plug-In Hybrid Electric Vehicle
PIT: Personal Income Tax
REC: Renewable Energy Credit
RPS: Renewable Portfolio Standard
TWh: Terawatt-hour
VMT: Vehicle Miles Traveled

EXECUTIVE SUMMARY

This report evaluates the potential impacts on the U.S. economy from possible future carbon taxes whose revenues would be devoted to a combination of debt and tax rate reduction. The results take into account the varied economic effects of fossil fuel cost increases due to a carbon tax as well as the positive economic effects of the assumption that carbon tax revenues would be used to reduce government debt and Federal taxes.

Objectives and Methodology

We use an economy-wide, computable general equilibrium (CGE) model (NERA's N_{ew}ERA model) to develop estimates of the effects of a carbon tax on the U.S. economic system, including:

1. **U.S. economy.** These effects include economic activity as measured by gross domestic product (GDP), personal income, and various measures of effects on workers. Results are developed for the United States as a whole and for individual sectors and regions (*e.g.*, gross regional product or GRP).
2. **Emissions and energy markets.** These effects include carbon dioxide (CO_2) emissions at the national, regional, and sectoral levels, and outcomes in energy markets, including electricity, natural gas, coal, and oil. We report national and regional results.

Such economic impact results are important so that the economic effects of a specific carbon tax policy can be compared to estimates of the environmental effects of the policy.

The N_{ew}ERA model combines a detailed plant-specific representation of the electricity sector and the related coal sector with representation of the rest of the sectors of the economy. Consumer choices and financial outcomes are also integral to the model projections. This model was designed to assess, on an integrated basis, the effects of major policies on electricity markets, other energy markets, and the overall economy. The model also projects reductions in CO_2 emissions that occur within U.S. borders.[1] N_{ew}ERA performs its analysis with varying regional detail. In this report, we provide results for the United States as a whole and for 11 regions of the U.S. Appendix A provides a detailed description of the N_{ew}ERA model.

Carbon Tax Cases Evaluated

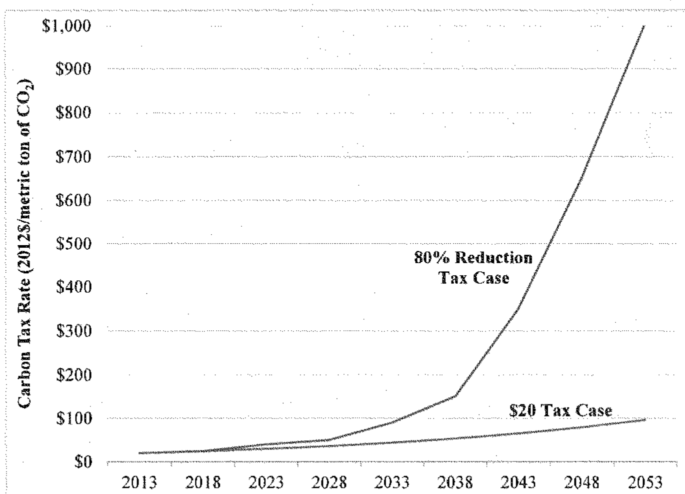
We have developed analyses for a "Baseline" case and two carbon tax cases that are added to the Baseline case's assumptions. All the results that describe changes in economic outcomes due to one of the carbon tax cases are changes relative to the value of that same economic variable in the Baseline case. The specific assumptions of the two carbon tax cases are as follows:

[1] This model does not, however, estimate the potential for the policy to cause increases in emissions outside of U.S. borders, a phenomenon known as "leakage."

1. **\$20 Tax Case:** This case assumes a carbon tax that begins at \$20/metric ton of CO_2 (2012 dollars) in 2013 and increases at 4% per year in real (2012) dollars.
2. **80% Reduction Tax Case:** This case is the same as the \$20 Tax Case up to 2018, at which time it is assumed to be set on a trajectory designed to target progress towards an 80% reduction in CO_2 emissions from 2005 levels by 2053, but with a maximum tax rate set at \$1,000/metric ton.

Both cases presume that the carbon tax would be levied "upstream" on primary fuels in order to cover the vast majority of U.S. carbon emissions. In both cases, the net Federal revenues from the carbon tax are used to reduce the Federal debt and to reduce marginal personal income tax (PIT) rates from their assumed levels in the Baseline. Figure 1 shows the assumed carbon tax rates for the two cases.

Figure 1: Carbon Tax Rates (2012\$/metric ton of CO_2) in the Two Carbon Tax Cases



The \$20 Tax Case is similar to policies suggested recently in reports by the Congressional Research Service and by a group at the Brookings Institution, although they differ in the specific uses of the carbon tax revenues.[2] Similar carbon tax levels to the \$20 Tax Case also have been

[2] J.L. Ramseur, J.A. Leggett and M.F. Sherlock, *Carbon Tax: Deficit Reduction and Other Considerations*, Congressional Research Service report for Congress #7-5700, September 17, 2012; M. Muro and J. Rothwell, "Cut to Invest: Institute a Modest Carbon Tax to Reduce Carbon Emissions, Finance Clean Energy Technology Development, Cut Taxes, and Reduce the Deficit." *Remaking Federalism/Renewing the Economy #7*, Brookings, November 13, 2012.

modeled by other researchers, but again with differing assumptions about how the carbon tax revenues would be recycled.[3]

The 80% Reduction Tax Case is motivated by a recognition that the $20 Tax Case is not projected to produce sufficient carbon emissions reductions to meet the commitments that have been discussed in international negotiations and embedded in prior Congressional legislative proposals for national cap-and-trade programs.[4] This second case represents a scenario in which a carbon tax policy begins with the same rates as the $20 Tax Case but then changes to substantially higher rates in order to target larger emissions reductions by the end of the period.

Baseline debt is also an important assumption in an analysis such as this. The baseline debt is projected initially based on tax rates in place during 2012, combined with current projected expenditure programs; however, the Baseline case also assumes that the debt will not exceed 100% of GDP. In the first modeled year in which the debt would otherwise exceed 100% of GDP (which is 2023 in this study), the 2012 tax rates are replaced by higher tax rates, set at pre-2001 levels. In addition to those tax rate increases, decreases in current projected entitlement spending are also implemented in the Baseline case to maintain a debt/GDP ratio of about 1.0. As discussed in more detail in the main body of this report, a lower national debt-to-GDP ratio is assumed to benefit the economy by lowering interest rates for Federal debt, leading to lower Federal interest payments, which lead to other positive economic impacts. Reductions in PIT rates relative to the Baseline also lead to positive economic impacts because the reductions in tax rates increase incentives to work and invest and also reduce the size of the "tax-interaction effect" associated with the overall cost of the carbon tax.

Effects on the U.S. Economy and U.S. Households

Figure 2 shows the net effects of the two carbon tax cases on the U.S. economy as measured by GDP and U.S. household consumption. (All dollar values in this report are in 2012 dollars.) Under the $20 Tax Case, GDP would be reduced from the Baseline levels by about 0.4% ($60 billion) in 2013 and by about 0.6% ($230 billion) in 2053. The negative impacts of the 80% Reduction Tax Case on GDP are substantially greater in the later time periods, reaching 3.6% (almost $1.4 trillion) by 2053.

[3] S. Rausch and J. Reilly, *Carbon Tax Revenue and the Budget Deficit: A Win-Win-Win Solution?* MIT Joint Program on the Science and Policy of Global Change, Report # 228, August 2012; W. McKibbin, A. Morris, P. Wilcoxen, and Y. Cai, *The Potential Role of a Carbon Tax in U.S. Fiscal Reform*, Climate and Energy Economics Discussion Paper, Brookings, July 24, 2012.

[4] For example, the Waxman-Markey Bill (H.R. 2454) passed by the U.S. House of Representatives in June 2009, would have required greenhouse gas emission reductions of 83% relative to 2005. It should be noted, however, that the Waxman-Markey Bill and other similar legislative proposals allowed for international offsets and had provisions for the banking of allowances.

Figure 2: Macroeconomic Impacts of Carbon Tax Cases

	Present Value	2013	2023	2033	2043	2053
Baseline						
GDP (Billions of 2012$)	$396,400	$14,940	$19,400	$24,680	$31,280	$38,120
$20 Tax Case						
GDP (% Change from Baseline)	-0.5%	-0.4%	-0.5%	-0.5%	-0.5%	-0.6%
Change in Avg. Consumption per Household[5]	-$310	-$20	-$340	-$350	-$440	-$440
80% Reduction Tax Case						
GDP (% Change from Baseline)	-1.2%	-0.4%	-0.5%	-1.0%	-2.5%	-3.6%
Change in Avg. Consumption per Household	-$920	-$80	-$690	-$860	-$1,510	-$2,680

Present value calculated using a 5% real discount rate, which is the rate used in the model.

Under the $20 Tax Case, average household consumption would be reduced by about $340 in 2033 and by about $440 in 2053, with an average present value reduction over the period from 2013 to 2053 of $310 per household. Under the 80% Reduction Tax Case, the average household consumption declines by about $860 in 2033 and by almost $2,700 in 2053, with an average present value reduction of $920 over the entire period.

These results indicate that the net aggregate effects of the two carbon tax cases on the U.S. economy and on U.S. household consumption would be negative. In other words, when considered at an aggregate level, the negative economic effects of both carbon tax cases outweigh their positive economic effects, which include estimates of the gains from using net carbon tax revenues to reduce both the Federal debt and Federal PIT rates. Our analysis of the economy-wide impacts of the policy indicates that although the net carbon tax revenues are positive in all years, their fiscal benefits to the economy are not large enough to outweigh the direct costs that the carbon tax imposes on the economy. We also find that the higher carbon tax case results in larger net negative aggregate impacts.

Figure 3 focuses on several dimensions of projected impacts on income from labor ("worker income") as a result of the carbon tax. The carbon tax leads to lower real wage rates because companies have higher costs and lower labor productivity under a carbon tax, effects that are partially offset by the lower Federal PIT rates that are allowed by the use of carbon tax revenues. Lower real wage rates directly reduce labor income per hour and thus lower workers' incomes even if they continue to work the same number of hours. However, the lower wage rate also decreases the willingness of workers to supply as many hours to the job market. That is, there is

[5] These changes in consumption are relative to an average Baseline household consumption of $94,000. Note that average household consumption is significantly larger than the more commonly-reported figure of median household consumption because of the impact of very high-income households. Also, average household consumption in the U.S. presently exceeds average household income, due to household debt.

an incremental shift towards greater demand for leisure, which implies reduced labor force participation. With fewer hours worked, total labor income declines by a greater percentage than does the wage rate. These are the net effects on labor in the aggregate, and include the positive benefits of increased labor demand in sectors providing energy and other goods and services that have low carbon-intensity.[6]

Figure 3: Labor Impacts of Carbon Tax Cases

	2013	2023	2033	2043	2053
Baseline Job-Equivalents (Thousands)*	138,700	153,100	168,100	183,600	201,000
$20 Tax Case					
Wage Rate (% Change from Baseline)	-0.8%	-1.0%	-0.9%	-1.1%	-1.2%
Labor Income (% Change from Baseline)	-1.0%	-1.1%	-1.1%	-1.2%	-1.4%
Job-Equivalents* (Change from Baseline, Thousands)	-1,510	-2,290	-2,520	-3,210	-3,770
80% Reduction Tax Case					
Wage Rate (% Change from Baseline)	-0.6%	-1.2%	-1.7%	-4.3%	-7.2%
Labor Income (% Change from Baseline)	-0.8%	-1.3%	-1.9%	-5.1%	-8.3%
Job-Equivalents* (Change from Baseline, Thousands)	-1,260	-2,750	-4,370	-11,860	-20,670

* Total job-equivalents equals total labor income change divided by the average annual income per job. This does not represent a projection of numbers of workers that may need to change jobs and/or be unemployed, as some or all of it could be spread across workers who remain employed.

The total reduction in labor income is spread over many workers, most of whom continue to work, but its dollar magnitude can be placed in context by estimating the equivalent number of average jobs that such labor payments would fund under baseline wage rates. To state the labor income changes in terms of such "job-equivalents" in Figure 3, the reduction in labor income is divided by the annual baseline income from the average job. Again, a loss of one job-equivalent does not necessarily mean one fewer employed person—it may be manifested as a combination of fewer people working and less income per worker. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage. Note that the N_{ew}ERA model, like many other similar economic models, does not develop projections of unemployment rates or layoffs associated with reductions in labor income; modeling such largely transitional phenomena would require a different type of modeling methodology.

[6] The Figure 3 shows that the two tax cases have different impacts labor impacts prior to 2023 even though the carbon prices are the same in those years because the model has perfect foresight. Therefore, decisions made in 2013 and 2018 are made with the full awareness that carbon prices are going to be significantly higher in the 80% Reduction Tax Case than in the $20 Tax Case starting in 2023, and this drives different optimal economic decisions in 2013 and 2018.

For the \$20 Tax Case, labor income declines by about 1.0% to 1.4% throughout the period, resulting in job-equivalent losses that range from about 1.5 million job-equivalents in 2013 to about 3.8 million job-equivalents in 2053. Under the 80% Reduction Tax Case, labor income reductions range from about 1% in the early years to more than 8% by the end of the period, resulting in job-equivalent losses ranging from about 1.3 million job-equivalents in 2013 to almost 21 million job-equivalents by 2053.

Effects on Carbon Dioxide Emissions and Energy Markets

Figure 4 summarizes the effects of the two carbon tax cases on CO_2 emissions. For the \$20 Tax Case, CO_2 emissions are projected to be reduced by almost 1,800 million metric tons by 2053; this reduction represents about a 30% reduction relative to the baseline level for 2053 and a 31% reduction relative to the 2005 level (5,988 million metric tons). The 80% Reduction Tax Case would, by design, result in substantially greater emission reductions. By 2053, the carbon tax would reduce CO_2 emissions by about 70% relative to the Baseline and about 71% relative to the 2005 level.[7]

Figure 4: CO_2 Emissions and Reductions of Carbon Tax Cases (Million Metric Tons of CO_2)

	2013	2023	2033	2043	2053
Baseline					
CO_2 Emissions	5,450	5,530	5,650	5,790	5,890
\$20 Tax					
CO_2 Emissions	5,210	4,670	4,590	4,640	4,110
% Reduction from Baseline	*4%*	*16%*	*19%*	*20%*	*30%*
% Reduction from 2005	*13%*	*22%*	*23%*	*23%*	*31%*
80% Reduction					
CO_2 Emissions	5,210	4,400	3,610	2,590	1,760
% Reduction from Baseline	*4%*	*20%*	*36%*	*55%*	*70%*
% Reduction from 2005	*13%*	*27%*	*40%*	*57%*	*71%*

Figure 5 shows energy price projections under the Baseline and the two carbon tax cases (inclusive of the carbon tax on fossil fuels). The price changes relative to the Baseline case's levels reflect two effects: (1) the effect of the carbon tax on fossil fuels, which increases fossil fuel prices by an amount determined by the carbon content of the fuel and the level of the carbon price; and (2) the effect of market adjustments, as fossil fuel users substitute away from the higher-priced fuels (particularly a shift away from coal towards natural gas in the near term). Residential delivered electricity prices increase as a result of the increased costs for fossil fuels due to the carbon tax.

[7] Although this case represents a sequence of carbon tax rates selected to place the U.S. economy on a path towards 80% reduction by 2053, capping the carbon tax rate at \$1,000/ton (2012\$) causes it to fall short of the 80% reduction mark in the last few years of the modeled time period.

Figure 5: Energy Prices of Carbon Tax Cases, Prices Including Carbon Tax (2012$)

	2013	2023	2033	2043	2053
Baseline Prices ($/MMBtu for Coal/Natural Gas, $/gallon for Gasoline, ¢/kWh for Electricity)					
Minemouth Coal	$1.61	$1.79	$2.01	$2.06	$1.76
Wellhead Natural Gas	$3.78	$4.85	$6.09	$8.42	$10.49
Gasoline	$3.51	$4.07	$4.31	$5.02	$5.51
Electricity (Residential)	12.0¢	13.7¢	14.3¢	16.0¢	17.1¢
$20 Tax Case ($/MMBtu for Coal/Natural Gas, $/gallon for Gasoline, ¢/kWh for Electricity)					
Minemouth Coal	$3.39	$4.34	$5.84	$7.84	$10.61
Wellhead Natural Gas	$5.43	$6.43	$8.46	$11.69	$15.14
Gasoline	$3.72	$4.37	$4.74	$5.64	$6.43
Electricity (Residential)	13.4¢	15.4¢	16.7¢	19.3¢	20.5¢
80% Reduction Tax Case ($/MMBtu for Coal/Natural Gas, $/gallon for Gasoline, ¢/kWh for Electricity)					
Minemouth Coal	$3.34	$5.35	$9.84	$34.47	$95.38
Wellhead Natural Gas	$5.42	$7.21	$11.28	$25.77	$62.66
Gasoline	$3.74	$4.43	$5.06	$8.03	$14.57
Electricity (Residential)	13.5¢	16.2¢	18.6¢	25.9¢	24.3¢

Figure 6 shows the effects of the two carbon tax cases on the commodity prices that natural gas and coal producers receive, *i.e.*, excluding the carbon tax. These trends are different for natural gas and coal. Coal prices received by producers decrease in all years in both cases, reflecting the shift away from coal due to the carbon tax. Natural gas prices received by producers increase in the early years (reflecting their lower carbon content relative to coal) but then decrease in the middle years (reflecting the eventual switch away from natural gas to low or zero-emitting fuels). Baseline prices are unchanged (and thus not displayed in Figure 6) since there is no carbon tax in the Baseline.

Figure 6: Energy Commodity Price Effects, Prices Excluding Carbon Tax

	2013	2023	2033	2043	2053
$20 Tax Case (Percentage Changes from Baseline)					
Minemouth Coal	-6.4%	-13%	-14%	-15%	-9.4%
Wellhead Natural Gas	16%	0.3%	0.7%	-2.0%	-4.3%
80% Reduction Tax Case (Percentage Changes from Baseline)					
Minemouth Coal	-9.0%	-11%	-31%	-22%	-15%
Wellhead Natural Gas	16%	4.8%	6.8%	-15%	-8.6%

Figure 7 shows projected impacts on the electricity sector in terms of coal electricity unit retirements and overall electricity demand. As expected, the imposition of a carbon tax increases the quantity of coal unit retirements, with higher tax rates leading to a greater level of retirements. Even the $20 Tax Case is projected to cause three times the amount of coal retirements by 2023 compared to the Baseline. The near-term retirements of the coal units are motivated by the anticipated higher carbon taxes in later years (which make further near-term capital investments to keep such plants operational uneconomical). The extent of the coal unit retirements is exacerbated by relatively low forecasted prices for natural gas. Under the $20 Tax Case, electricity demand declines about 11% below the Baseline level in 2033 and about 12% in 2053; the 80% Reduction Tax Case causes electricity demand to drop by about 17% in 2033 and more than 25% afterward relative to the Baseline.

Figure 7: Electricity Sector Impacts of Carbon Tax Cases

	2013	2023	2033	2043	2053
Baseline					
Coal Retirements (GW)	4	36	37	39	39
U.S. Electricity Demand (TWh)	3,990	4,280	4,640	4,990	5,380
$20 Tax Case					
Coal Retirements (GW)	5	108	112	119	160
U.S. Electricity Demand (TWh)	3,890	3,960	4,150	4,370	4,740
% Change (Relative to Baseline)	*-2.4%*	*-7.7%*	*-11%*	*-12%*	*-12%*
80% Reduction Tax Case					
Coal Retirements (GW)	5	141	213	295	295
U.S. Electricity Demand (TWh)	3,890	3,830	3,840	3,590	4,020
% Change (Relative to Baseline)	*-2.4%*	*-11%*	*-17%*	*-28%*	*-25%*

Conclusions

Our analysis has modeled the economic and energy market impacts of two carbon tax cases, one in which the carbon tax is set at $20 per metric ton of CO_2 in 2013 and increases by 4% per year in real (2012) dollars and one in which the carbon tax rate is the same in the early years but eventually increases to very high levels in efforts to target an 80% reduction in emissions by 2053. Under both cases, the net carbon tax revenues to the Federal government are used to reduce the Federal debt and PIT rates. We use a CGE model of the U.S. economy with regional and sectoral detail to estimate the economic effects of these carbon tax cases.

The model we use includes a methodology for estimating the national economic benefits from using part of the net carbon tax revenues to reduce Federal debt payments and part of the net carbon tax revenues to reduce the marginal tax rates on labor and capital. The combined economic gains from these two uses of net carbon tax revenues—reduced debt and reduced PIT rates—are estimated to be substantial under both carbon tax cases. Nevertheless, our analysis finds that those economic benefits are more than offset by the economic costs that result from the new tax burden of the carbon tax cases. Thus, our results indicate that the net economic impacts of both carbon tax cases are negative, as judged by the summary impact measures for the U.S. as a whole reported above.

The fact that the overall national economic impacts of the two carbon tax cases are negative does not mean that some groups would not gain. Specifically, the national results do not reflect the substantial distributional impacts in which some sectors, regions, and individuals would be adversely affected more than the average, while others would have lower impacts than average and, indeed, some would be better off than in the Baseline. Aggregate economic analyses such as this are sometimes incorrectly criticized for ignoring employment and other economic gains to lower-carbon activities; however, these gains *are* accounted for in this analysis. Employment gains in lower-carbon activities, and in the investments to reduce the economy's carbon-intensity, are embedded in the summary impact measure for labor as a whole; if these gains had not been included, the projected net employment impacts would have been more negative. Information on potential distributional impacts of the carbon tax cases is more apparent in the detailed sectoral and regional results that are provided in the rest of this report.

The results also indicate a trade-off between reducing carbon emissions in the U.S. and the cost to U.S. households. The lower carbon tax case reduces 2053 U.S. carbon emissions by about 31% relative to 2005 levels at an average cost per household over the entire period of about $310. The higher carbon tax case reduces U.S. carbon emissions in 2053 by about 71% relative to 2005 emissions, but the average cost per household is about $920 per household over the period. Thus, the results from these two carbon tax cases suggest that the potential fiscal benefits from the use of carbon tax revenues do not change the major potential trade-offs in carbon policy, which are that emissions reductions have a net cost and that deeper emissions cuts are increasingly costly.

I. INTRODUCTION

This report evaluates the effects of carbon taxes on the U.S. economy and energy sectors. The analyses assume that carbon tax revenues are used both to reduce the Federal debt and to reduce PIT rates.

A. Background

A carbon tax is a tax imposed on CO_2 and possibly other greenhouse gas emissions. Emissions of CO_2 are due largely to the combustion of fossil fuels in electricity production, transportation, heating, and various industrial and commercial processes. To reduce the administrative difficulties of monitoring CO_2 emissions and collecting the tax, the most direct method is to impose the tax "upstream" on producers of fossil fuels—including coal, natural gas, and various petroleum products—rather than "downstream" on the emissions themselves. Thus, a carbon tax would increase the cost of fossil fuels, leading to increases in costs to consumers and businesses as well as other economic impacts.

The increased costs due to a carbon tax would encourage companies to switch to lower-emitting fuels and would lead households and companies to reduce energy use. The net effect of these changes due to the carbon tax would be to reduce CO_2 emission. The greater the carbon tax, the larger these effects would be and thus the greater the reductions in CO_2 emissions would be.

B. Objectives of This Report

The principal overall objective of this report is to provide estimates of the effects of potential carbon taxes on the U.S. economy. That is, we consider the potential effects of a carbon tax on U.S. GDP and other measures of economic activity, compared to a Baseline case that does not have that carbon tax. We use a state-of-the-art integrated energy and economic model, the N_{ew}ERA model, to estimate these complex effects. The N_{ew}ERA model allows us to estimate detailed effects on energy markets as well as impacts on different sectors and different regions of the country.

As described in more detail in Section II, we consider two potential carbon tax cases:

1. **\$20 Tax Case**: This case assumes a carbon tax that begins at \$20/metric ton of CO_2 (2012 dollars) in 2013 and increases at 4% per year in real (2012) dollars.
2. **80% Reduction Tax Case**: This case is the same as the \$20 Tax Case up through 2018, after which time it is assumed to be set on a trajectory designed to target progress towards an 80% reduction in CO_2 emissions from 2005 levels by 2053, but with a maximum tax rate set at \$1,000/metric ton.

These cases were chosen based upon prior studies and proposals. The \$20 Tax Case is similar to a case developed by the Congressional Budget Office (CBO) recently and is similar to other recent studies. The 80% Reduction Tax Case is consistent with the emission reduction objectives expressed in international climate negotiations and in prior Congressional cap-and-trade proposals.

One important determinant of the effects of a carbon tax is use of carbon tax revenue. Our study assumes that net carbon tax revenue would be used for two purposes: (1) to reduce the Federal debt (relative to the Baseline levels projected for each year); and (2) to reduce Federal PIT rates.

C. Outline of the Report

The remainder of the report is organized as follows. Section II provides an overview of the key assumptions associated with the Baseline case and the two carbon tax cases analyzed against that Baseline. It also provides an overview of the N_{ew}ERA model that is used to analyze these cases. Section III presents the results of the analyses. The appendices provide details on the N_{ew}ERA model, modeling assumptions, and detailed regional results.

II. CARBON TAX CASES, BASELINE, AND METHODOLOGY

This section provides an overview of the carbon tax cases evaluated in this report and the methodology we use to evaluate their effects on the economy and on the energy system. The section includes an overview of the $N_{ew}ERA$ model as well as the various assumptions and methodologies we used to model the effects of the carbon tax cases.

A. Carbon Tax Cases

This section summarizes the carbon cases we evaluated, including the carbon tax rates and the assumptions regarding the uses of carbon tax revenues.

1. Carbon Tax Rates

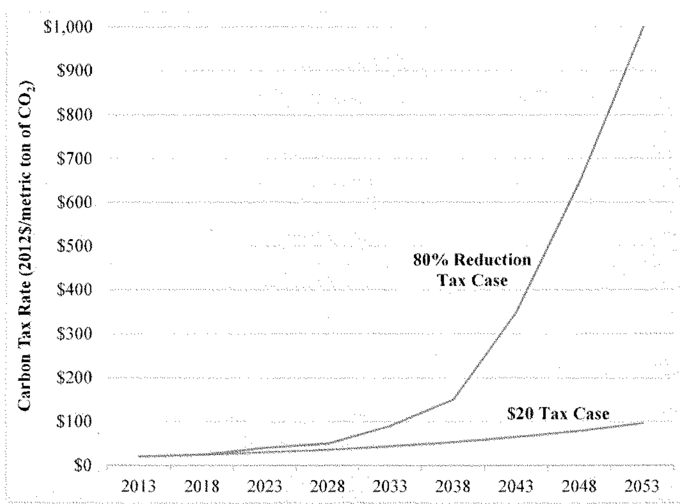
We evaluated two different carbon tax cases that differ substantially in the carbon tax rates over the entire modeling period (2013 to 2053).

1. **\$20 Tax Case**: The first case assumes that a policy is enacted that imposes a \$20 tax per metric ton of CO_2 (in 2012 dollars) starting in 2013. The carbon tax increases over time at a rate of 4% in real terms.
2. **80% Reduction Tax Case**: The second case begins just like the first with the same carbon tax rates up until 2018. This case assumes that the carbon tax rate increases after 2018 to levels needed to put U.S. CO_2 emissions on the path towards an 80% reduction by the end of the model horizon (2053), a target similar to the objectives discussed in international negotiations and included in prior Congressional cap-and-trade proposals.[8] The 80% reduction is not completely achieved by the end of the model horizon because of a constraint that the carbon tax rate not exceed \$1,000 per metric ton of CO_2 (in 2012 dollars).

The carbon taxes for the two cases are shown in Figure 8. The rates are identical in 2013 and 2018, but begin to diverge thereafter as the 80% Reduction Tax Case includes a path towards an 80% reduction in emissions relative to 2005 CO_2 emissions.

[8] For example, the Waxman-Markey Bill (H.R. 2454) passed by the U.S. House of Representatives in June 2009, would require greenhouse gas emission reductions of 83% relative to 2005. It should be noted, however, that the Waxman-Markey Bill and other similar legislative proposals allowed for international offsets and had provisions for the banking of allowances.

Figure 8: Carbon Tax Rates (2012$/metric ton of CO_2)



2. Carbon Tax Revenues

The imposition of the carbon tax results in additional net tax revenues for the Federal government. Gross carbon tax revenues are equal to the carbon tax rate multiplied by the annual emissions of CO_2 resulting from the combustion of fossil fuels such as coal, natural gas, and oil. Net carbon tax revenues reflect lower federal revenues in other areas due to the negative economic impacts of the carbon tax. Under both scenarios, the net revenue from a carbon tax would be used for debt reduction and to lower individual tax rates.

1. **Reduction of Federal Debt**: Until 2023, all of the net carbon tax revenues would be used to lower the Federal debt. After 2023, 50% of the net carbon tax revenues are used to lower the Federal debt, while the other 50% is used to defray increases in income tax rates (see point 2). Lowering the federal debt would lower interest rates for government borrowing, which would reduce the cost to the economy to service the debt.
2. **Reduction of Federal PIT Rates**: In the Baseline, the 2012 capital and labor tax rates are assumed to remain in effect until the debt/GDP ratio exceeds 1.0, at which point the model assumes tax rates would increase to pre-2001 levels.[9] Thus, the higher tax rates come into effect starting in model year 2023. At that time, it is also assumed that 50% of the net carbon tax revenues are used to moderate the amount of increase in Federal PIT

[9] These baseline tax rates include all of the tax cuts enacted from 2001 through 2003 on capital and labor income and the lowered payroll tax rate that was in effect only in 2011 and 2012.

rates that occurs in the Baseline.[10] Reduction of PIT rates relative to their baseline levels reduces the baseline tax distortions which offsets some of the economic costs of the carbon tax.

In the policy scenarios, the flow of goods and services from the government is assumed to be the same as in the Baseline. That is, we do not assume that the new carbon tax revenues will be used to increase government spending or that the carbon policy will be paid for by reduced government services.[11] However, the carbon tax does affect consumption, investment, and labor market decisions, which results in lower Federal revenues from taxes on capital and labor. Thus, benefits of debt and tax rate reduction from use of carbon tax revenues only occur after a sufficient portion of the new carbon tax revenues is used to replace revenue shortfalls from the effect of the carbon tax itself on Federal taxes on capital and labor. Thus, the amounts used for debt and tax rate reduction, as described above, are the *net* amount after offsetting reductions in other Federal revenue projected for each carbon tax case.

B. N_{ew}ERA Model

The N_{ew}ERA model is an economy-wide integrated energy and economic model that includes a detailed representation of the electricity sector. It has been designed to assess, on an integrated basis, the effects of major policies on electricity, other energy markets, and the overall economy. The model performs its analysis with regional detail, accounting for over 30 electricity market regions and 11 regions for other economic activities. Figure 9 provides an overlay of the electricity market region boundaries and the macroeconomic region boundaries. Each colored area on the map denotes a separate electricity market region, and the acronyms that identify each electricity market region are shown in black letters. Note that electricity market regions do not always follow state borders. The macroeconomic region boundaries (which do follow state borders) are denoted by the white lines, and their identifying acronyms are shown in white lettering (and further defined in Figure 10 below). Appendix A provides separate maps of the electricity and macroeconomic regions. This overlay format can be useful to those who wish to understand the mapping between specific electricity market regions (which include the supply conditions that determine electricity costs) and the macroeconomic regions of the analysis (which include the consumers and businesses that have to pay for electricity). As can be seen, it is not a simple one-to-one mapping.

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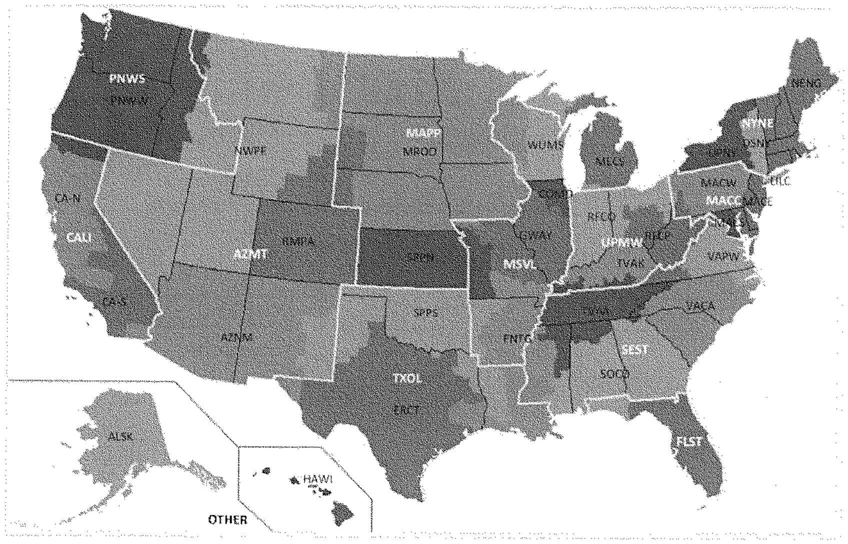
[10] In both of our policy scenarios, even though 50% of net carbon revenues after 2023 are dedicated to lower tax rates, PIT rates would still be higher than the 2012 rates (although lower than their baseline levels).

[11] These assumptions are necessary to ensure that the consumer welfare associated with government services (which is not directly calculated in the model) is identical in both the Baseline and the carbon tax cases. Most prior climate cap-and-trade bills have proposed a variety of new government spending programs, but we are not aware of any specific government spending proposals for carbon tax policies. Moreover, analytical methods to account for their impacts on the economy would need to be developed before they could be incorporated into the analysis. Until specific spending proposals are put forth as part of a specific carbon tax proposal, it is reasonable to avoid the additional analytical effort their analysis would require.

Appendix A also provides a detailed description of the N_{ew}ERA model structure, logic, and other key inputs.

Figure 9: N_{ew}ERA Regional Map



One of the primary drivers of the differences in regional impacts (reported in Section III) is the difference in carbon intensity (metric tons of CO_2 per thousand dollars of economic output), as shown in Figure 10. The differences in carbon intensity are caused by differences in industrial composition (*e.g.*, California has less heavy industry), electricity generation mix (*e.g.*, California and New York/New England have limited coal-fired generation), and relative energy prices (*e.g.*, a $20 carbon tax in California is a smaller percentage increase in energy prices than in many other regions so the tax has a smaller impact in California).

Figure 10: Baseline Carbon Intensity by Region in 2013

Region	Average Emissions Intensity
Upper Midwest (UPMW)	0.23
Texas, Oklahoma, Louisiana (TXOL)	0.17
Mid-America (MAPP)	0.16
Arizona and Mountain States (AZMT)	0.16
Mississippi Valley (MSVL)	0.13
Southeast (SEST)	0.12
Mid-Atlantic (MACC)	0.10
Florida (FLST)	0.09
Pacific Northwest (PNWS)	0.09
California (CALI)	0.07
New York/New England (NYNE)	0.06

The N_{ew}ERA model is a long-term model that includes the assumption that households and firms develop optimum decisions over the modeling period, with perfect foresight. For this analysis, we evaluate the economic implications of the carbon tax cases over the period from 2013 through 2053. The model develops results for every five year period beginning with 2013. Thus the model provides results for 2013, 2018, 2023, 2028, 2033, 2038, 2043, 2048, and 2053. In this report we show the results in ten year increments.

C. Development of Key Modeling Elements

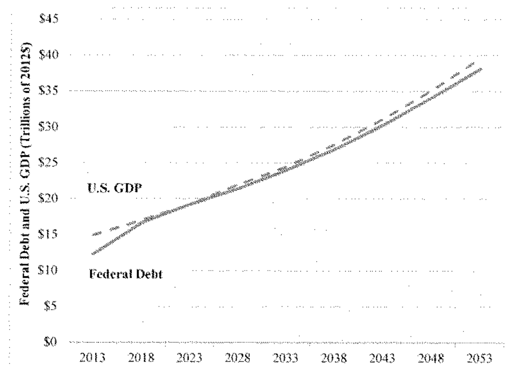
The following sections provide information on the various modeling elements. Appendix B and Appendix C provide additional details on these elements.

1. Developing the Model Baseline

There are many assumptions that define the Baseline case and are also important in determining the ultimate costs and consequences resulting from the scenarios. Wherever possible, we have used publicly-available assumptions from sources like the Energy Information Administration's (EIA's) *Annual Energy Outlook 2012* (AEO 2012), the U.S. Environmental Protection Agency (EPA), and the CBO.

For purposes of this analysis, one of the most important assumptions is the Baseline case's level of Federal debt, which is a function of factors such as government tax revenues and government transfers and expenditures. For the years 2013 through 2022, the Baseline scenario follows the assumptions of the "Extended Alternative Fiscal Scenario" in the CBO 2012 long-term budget outlook.[12] That is, the tax rates in effect in 2012 remain in effect, and spending behavior remains similar to today's pattern. However, for our Baseline we also assume that this pessimistic CBO scenario cannot be sustained indefinitely. We therefore assume that annual deficits will start to be reined in when the Federal debt reaches 100% of GDP, thus slowing growth of the debt so that the Baseline case's debt never exceeds 100% of GDP once it gets to that level. This is accomplished by making two adjustments to the assumptions of the CBO "Extended Alternative Fiscal Scenario." First, Federal tax rates are immediately increased to levels consistent with tax rates in the CBO "Extended Baseline Scenario."[13] This tax rate increase is not, on its own, sufficient to achieve a baseline debt/GDP ratio of 1.0. Thus, the second adjustment to the assumptions of the CBO "Extended Alternative Fiscal Scenario" is to reduce its projections of government expenditures sufficiently to meet the debt/GDP ratio target.[14] The first model year in which these two adjustments are made is 2023. Figure 11 shows the baseline assumption regarding the Federal debt (the blue line), relative to the GDP (the dashed red line).[15]

Figure 11: Baseline Federal Debt



The model accounts for the following categories of Federal taxes: PIT rate on capital, PIT rate on labor, payroll taxes collected for Social Security under the Federal Insurance Contributions Act (FICA) and for Medicare hospital insurance (HI), and the corporate tax rate. The model also

[12] *The 2012 Long-Term Budget Outlook*, June 2012, Congressional Budget Office, available at: http://www.cbo.gov/publication/43288.

[13] "Extended Baseline Scenario" in the CBO report is equivalent to assuming that all of the pre-2001 tax levels come into effect again.

[14] These reductions are not as large as those in the "Extended Baseline Scenario" of the CBO report, which projects a debt/GDP ratio well below 1.0.

[15] To be clear, our baseline tax rates from 2013 until 2022 are all kept at the rates that were prevailing during 2012, and do not include any of the tax rate increases that occurred on January 1, 2013.

includes state PIT and corporate tax rates. More details about the Baseline tax rate assumptions are provided in Appendix B. The model includes all of the tax rates listed above to simulate the magnitude of the overall tax interaction effect with carbon taxes. However, the only rates among these that are reduced in the carbon tax cases due to recycling of carbon tax revenues are the Federal PIT rates (both the capital and labor rates). Further, such reductions only occur in model years from 2023 onwards, when the respective Baseline rates are at their pre-2001 levels. The magnitude of those Federal PIT rate changes relative to the Baseline Federal PIT rates is not an assumption, but a carbon case result that is described in the results section of this report.

Fuel prices are an important input because of the different carbon content of fuels and the opportunities for fuel switching, primarily in the electricity sector. Natural gas and crude oil prices are based on the AEO 2012 Reference Case.[16] Supply curves for coal are based on information from the U.S. EPA.[17] Capital costs and operating characteristics of new electricity generating technologies, electricity demand growth, GDP growth, and non-electricity sector fuel consumption and emissions are also based on assumptions in AEO 2012.

The availability of new low-carbon electricity generating technologies such as nuclear and carbon capture and storage (CCS), with either coal or natural gas, is a baseline assumption that is more relevant in the policy scenario (with the imposition of the carbon tax). NERA imposed realistic adoption rates for these technologies based on historical rates of adoption of nuclear and other developing technologies.

The N_{ew}ERA model includes several alternative transportation fuels for the personal vehicle and commercial trucking sector. The fuels for the personal vehicle market are assumed to be replacements for gasoline, while those for the trucking market are substitutes for diesel. For the gasoline market, we include three different types of ethanol and compressed natural gas (CNG).[18] To reflect the range of possible emission reductions and most likely ethanols we include corn-based ethanol, sugar-based ethanol, and cellulosic ethanol. For the diesel market, we include liquid fuels – soy-based diesel and low-carbon diesel – as well as CNG. Whether or not these fuels replace conventional fuels depends on the relative cost of these fuels compared to their conventional counterparts. In the Baseline, the relative cost of fuels depends on their production and infrastructure costs.

In the tax cases, however, the relative emissions intensity of each fuel matters because a carbon tax raises the cost of each fuel based on the amount of carbon emitted per unit of energy. As the carbon tax increases, the alternative transportation fuels become more cost-effective relative to their conventional fuel counterparts.

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[16] Available at: http://www.eia.gov/forecasts/archive/aeo12/index.cfm.

[17] Appendix 9-4 Coal Supply Curves in EPA Base Case V.4.10.

[18] EVs are another possible technological response. EVs were not included in this analysis due to time constraints. However, previous experience with modeling EVs suggests they would not become economical except in the higher carbon tax case, and only in the later parts of the analysis horizon.

2. Modeling the Carbon Tax Cases

In the tax cases, the only changes were the imposition of the carbon taxes, the uses of net carbon tax revenues, and the effects of changes in the debt on interest rates. All other assumptions remain the same as in the Baseline. However, variables like fuel prices, electricity demand, and GDP growth change in response to the carbon taxes. These changes are presented in the Results section.

3. Modeling Uses of Carbon Tax Revenue

Including an evaluation of the economic impacts of the uses of net carbon revenues from a carbon tax policy is one of the key features of this study's analysis of carbon tax policies. There are many ways that a carbon tax's revenues could be used, and thus returned ("recycled") to the economy. Two primary uses of carbon tax revenues have been important in recent policy discussions: (1) reduce existing tax rates on capital and/or labor (without affecting the debt); and (2) reduce the Federal debt (relative to what it would otherwise be without the carbon tax).

1. Using carbon tax revenues to reduce other taxes seems appealing because existing capital and labor taxes create distortions that reduce the supply of capital and labor and thus reduce overall productive activity. Using carbon tax revenues to reduce these tax rates ("tax swap") would reduce these distortions. Put another way, a carbon tax combined with such a "tax swap" offers the potential to raise the same total Federal revenues but in a manner that could reduce distortions related to supply of capital and labor.[19] However, as discussed in the next section, the carbon tax leads to distortions of its own, including interactions that exacerbate distortions in labor and capital taxes, and thus the combined effect of the "tax swap" on the overall productivity of the economy is the net result of both positive and negative effects.
2. Using carbon tax revenues to reduce the Federal debt relative to its baseline levels is appealing because this could reduce the interest rate for Federal borrowing (see Section 5 below). This effect would reduce interest payments on the Federal debt that remains. Since much of the Federal debt is financed from abroad, reducing federal debt payments would result in additional income to U.S. households. Thus, as with a tax swap, using a carbon tax's revenues for debt reduction could mitigate the net cost of the carbon tax policy.[20]

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[19] In economic analysis circles, the term "double dividend" is used to refer to the fact that reductions in economic distortions from lowered marginal capital and/or labor taxes produce a second return (or "dividend") from a carbon-pricing policy (the first "dividend" being emissions reductions that the policy in intended to motivate). Goulder (1995) distinguished between a "weak" and a "strong" double dividend. If the reduced economic distortions due to the reduction in marginal capital and/or labor taxes would be smaller than the costs of the carbon-pricing policy—including the additional distortions due to the carbon tax—so that the carbon policy still has a net economic cost, this is referred to as a "weak double dividend." If the reduced economic distortions would be larger than the costs of the carbon-pricing policy, this is referred to as a "strong double dividend."

[20] The logic of offsetting economic benefits of deficit reduction is parallel to the concept of a double dividend, but this term has not traditionally been applied to use of carbon revenues to reduce deficits. Whether the benefits of deficit reduction will be greater or less than the direct cost of a carbon-pricing policy is not only uncertain, but we

While there are any number of possible combinations of revenue recycling options that could be paired with a carbon tax policy, this analysis has considered only the single combination summarized above. We make no suggestion that this particular combination is desirable, politically likely, or that it will produce the best overall policy outcomes. It simply reflects a blend of the two policy options currently prominent in discussions of revenue recycling in a possible carbon tax policy. Modeling of other revenue recycling alternatives would be necessary to assess their potential economic impacts.

As described above, this analysis applies the net carbon tax revenue to lowering the Federal debt and lowering Federal PIT rates. The N_{ew}ERA model begins with baseline assumptions regarding Federal deficits over time (and the resulting Federal debt in each future year) as well as Federal PIT rates (see Appendix B). Within the N_{ew}ERA cases, the net carbon tax revenues are estimated, then divided between the two uses as follows: net carbon tax revenues are used entirely for debt reduction from 2013 through 2022, and are evenly split between debt reduction and PIT rate reduction from 2023 onwards. Thus, no tax swap occurs in our policy cases until tax rates are raised above their 2012 levels. Despite the 50% of net carbon revenues that are used to defray tax rate increases from 2023 onwards in the two carbon tax cases, PIT rates remain above their 2012 levels in all those years.

4. Modeling Net Carbon Revenues

In the carbon tax cases, total carbon tax revenues are calculated as the product of the carbon tax rate in a particular year and the resulting emissions of CO_2 from the combustion of fossil fuels. Not all these revenues are available to lower the Federal debt or lower Federal PIT rates, however, because a carbon tax (like any other tax) has a negative impact on economic activity of its own (its "deadweight loss" or impact on economic efficiency) that reduces federal tax payments and thus reduces the net carbon tax proceeds that would be available for revenue recycling. Since the burden of the carbon tax reduces labor earnings and capital earnings, Federal tax revenues from those existing tax bases decline relative to what they are in the Baseline, *even with baseline spending and tax rates*. That is, the carbon tax itself worsens the debt relative to the Baseline (without the carbon tax). Thus, a portion of the gross carbon tax revenues must first be used just to get the debt back to the Baseline's levels.

As PIT rates are reduced from their baseline levels to provide for the carbon policy's tax swap that further affects the revenues from existing taxes. This additional shift in each year's deficit (and hence debt level) relative to that of the Baseline also must be accounted for when determining how much *net* carbon tax revenue is available to reduce debt while providing for a PIT rate reduction of an equal dollar amount in terms of reduced PIT tax collections.[21] These

are not aware of any other modeling studies of the economic impact of using a carbon tax specifically for deficit reduction benefits.

[21] The reduction in PIT rates has two effects on the deficit: (1) direct reductions in tax revenues per dollar of taxable income, and (2) indirect increases in taxable income as a result of increased supply of labor and capital, and a smaller tax interaction effect from the policy. As discussed above in the context of the "weak double dividend,"

complex computations are solved in a simultaneous, general-equilibrium manner in the $N_{ew}ERA$ model's solution.

5. Modeling the Effects of Reductions in Federal Debt on Interest Rates

As discussed above, one of the economic benefits associated with using net carbon tax revenues to reduce the Federal debt is that a lower debt is assumed to lead to a lower interest rate for Federal government borrowing, and therefore, lower debt service payments. We assume that Federal debt is financed by borrowing from foreign entities. Thus, the reduced interest payments in the carbon tax cases represent a windfall of increased wealth to U.S. consumers, which was wealth that was presumed to be sent outside of the U.S. economy in the Baseline.

We have done an extensive literature review of the relationship between government debt and interest rates, as discussed in Appendix C. For purposes of this analysis, we assumed that a change in government debt equal to 1% of GDP would result in a change in the long-term interest rate of 3 basis points. This assumption is largely based on Engen and Hubbard (2005). We rely upon this study for several reasons – their conclusions are grounded in economic theory, backed by empirical results, and consistent with historical experience. The study is relatively recent and includes a comprehensive review of the literature on the relationship between government debt and interest rates. The result that debt has a small positive effect on long-term interest rates seems more plausible than assumptions of either no effect of government debt (which many economists would say is inconsistent with theory) or a large effect (which is arguably inconsistent with historical experience). Note, however, that the effects of changes in the debt-to-GDP ratio on interest rates are subject to considerable debate, as the literature review we provide in Appendix C reveals.

the indirect effect diminishes the size of the deadweight loss of the carbon tax and decreases the deficit, while the direct effect leads to a greater deficit. The net effect of these two effects must also be accounted for—in the general equilibrium context—when determining how much of the gross carbon tax revenues will remain to improve the deficit position relative to the Baseline levels.

III. STUDY RESULTS

The addition of carbon taxes to the Baseline creates additional costs to the U.S. economy. The carbon taxes add to the costs of energy use because the tax is applied to the sale of fossil fuels that emit carbon. Thus, the costs of consuming coal, natural gas, and petroleum products (*e.g.*, gasoline) increase. The increases in energy costs ripple through the economy and result in higher costs of production and less spending on non-energy goods. The economic impacts of these cost increases are at least partially offset by the effects of the manner in which the carbon tax revenues are used, which we assume is for reductions in the Federal debt and PIT rates. Lowering the debt results in lower costs to service the debt, while lowering PIT rates reduces the distortionary impacts of these taxes.

A. Impacts on the U.S. Economy

1. Gross Domestic Product and Its Components

GDP is an economic measure of the entire economy. The components of GDP are consumption, investment, government spending and net exports. Since the level of Federal government expenditures is assumed to remain constant, the changes in GDP are driven by changes in consumption, investment, and net exports. Figure 12 shows the estimated changes in GDP and its components in the two carbon tax cases. GDP declines by approximately 0.5% per year for the $20 Tax Case, while the GDP reduction for the 80% Reduction Tax Case increases from 0.4% in 2013 to nearly 4% by 2053. Both consumption and investment decline as well.

Figure 12: Gross Domestic Product and Components (Percentage Change from Baseline)

	2013	2023	2033	2043	2053
GDP					
Baseline (Billions)	$14,940	$19,400	$24,680	$31,280	$38,120
$20 Tax Case	-0.4%	-0.5%	-0.5%	-0.5%	-0.6%
80% Reduction Tax Case	-0.4%	-0.5%	-1.0%	-2.5%	-3.6%
Consumption					
$20 Tax Case	0.0%	-0.3%	-0.4%	-0.4%	-0.5%
80% Reduction Tax Case	-0.1%	-0.7%	-0.9%	-1.6%	-2.6%
Investment					
$20 Tax Case	-2.7%	-1.0%	-1.2%	-1.3%	-1.5%
80% Reduction Tax Case	-2.0%	-0.4%	-2.3%	-7.4%	-9.4%
Net Exports					
$20 Tax Case	0.6%	0.4%	0.9%	0.9%	0.9%
80% Reduction Tax Case	0.2%	1.1%	1.9%	3.8%	5.0%

One common economic metric of policy costs is the change in consumption per household (sometimes described as change in costs per household). It is important to note that, as with the other measures, the estimated change in consumption per household is a comprehensive figure that includes a large number of influences. This metric incorporates the financial benefits to consumers from the recycling to them of all net carbon tax revenues. It also takes into account the many ways in which consumers and producers can change their behavior to limit financial losses from the increases in energy and other prices due to the carbon tax. That is, this impact measure includes cost-minimizing adjustments to consumers' "market basket" of goods and services purchased and to their lifestyle/behavioral patterns.[22] Similarly, the loss in consumption per household incorporates all the adjustments to inputs and production processes that businesses make to minimize the effects of the carbon tax on the cost of their products or services. These adjustments can lead to non-financial losses and thus the change in consumption per household is not a complete measure of consumer losses. The full effects of the carbon tax include the qualitative effects of all such changes in personal choices and activities as well as the financial costs we report here.

In this study, we report reduced consumption per household as a dollar value relative to current average consumption levels to make it easier for readers to put these estimates into context with current household consumption and income. Figure 13 shows the change in consumption per household for the $20 Tax Case for individual regions and the U.S. as a whole in selected model years and on average as a present value over the model horizon. On average, U.S. household consumption declines by $20 in 2013, a negative impact that increases to $440 by 2053.[23] Regions fare better or worse than the U.S. average primarily due to each region's relative carbon intensity, which is a significant determinant of the increases in costs that consumers in a region will experience as a result of the carbon tax.

Figure 14 includes the change in consumption per household for the 80% Reduction Tax Case. The higher carbon taxes over time produce substantially larger losses in consumption than in the $20 Tax Case in the later years.[24] On average for the 80% Reduction Tax Case, U.S. household consumption declines by $80 in 2013, which increases to almost $2,700 by 2053.

[22] One prominent example at the personal level is use of personal vehicles for transportation services. The carbon tax cases involve people driving fewer miles and buying different types of cars than in the Baseline.

[23] These changes in consumption are relative to an average Baseline national household consumption of $94,000. We estimate that the *median* consumption level is about $65,000, although this is an estimate that is not directly used by N_{ew}ERA.

[24] The two tax cases have different impacts prior to 2023 even though the carbon prices are the same in those years because the model assumes perfect foresight. Therefore, decisions made in 2013 and 2018 are made with the full awareness that carbon prices are going to be significantly higher in the 80% Reduction Tax Case than in the $20 Tax Case starting in 2023, and this drives different optimal economic decisions in 2013 and 2018.

Figure 13: Change in Consumption per Household - $20 Tax Case

Region	Present Value	2013	2023	2033	2043	2053
Arizona and Mountain States	-$950	-$840	-$970	-$950	-$1,010	-$1,040
California	-$60	$310	-$90	-$120	-$250	-$230
Florida	-$30	$270	-$60	-$50	-$150	-$140
Mid-Atlantic	-$400	-$20	-$460	-$470	-$580	-$590
Mid-America	-$450	-$290	-$480	-$450	-$540	-$560
Mississippi Valley	-$300	-$70	-$330	-$330	-$420	-$410
New York/New England	$30	$590	$10	-$20	-$180	-$170
Pacific Northwest	-$200	$30	-$240	-$240	-$300	-$320
Southeast	-$350	-$130	-$400	-$380	-$450	-$450
Texas, Oklahoma, Louisiana	-$290	-$30	-$300	-$310	-$400	-$420
Upper Midwest	-$660	-$530	-$710	-$690	-$730	-$750
U.S.	**-$310**	**-$20**	**-$340**	**-$350**	**-$440**	**-$440**

Present value calculated using a 5% real discount rate.

Figure 14: Change in Consumption per Household – 80% Reduction Tax Case

Region	Present Value	2013	2023	2033	2043	2053
Arizona and Mountain States	-$1,950	-$1,480	-$1,700	-$1,850	-$2,470	-$3,390
California	-$640	$510	-$340	-$590	-$1,490	-$2,890
Florida	-$300	$540	-$110	-$230	-$770	-$1,990
Mid-Atlantic	-$1,120	-$30	-$820	-$1,060	-$1,910	-$3,450
Mid-America	-$1,110	-$520	-$900	-$1,050	-$1,590	-$2,550
Mississippi Valley	-$750	-$70	-$560	-$730	-$1,200	-$2,210
New York/New England	-$530	$950	-$150	-$440	-$1,500	-$3,190
Pacific Northwest	-$890	-$140	-$670	-$820	-$1,440	-$2,540
Southeast	-$810	-$140	-$670	-$760	-$1,200	-$2,220
Texas, Oklahoma, Louisiana	-$1,270	-$610	-$1,040	-$1,180	-$1,810	-$2,800
Upper Midwest	-$1,190	-$710	-$1,070	-$1,160	-$1,510	-$2,350
U.S.	**-$920**	**-$80**	**-$690**	**-$860**	**-$1,510**	**-$2,680**

Present value calculated using a 5% real discount rate.

2. Labor Market

Figure 15 includes labor impacts due to the carbon taxes (and resulting changes in Federal PIT rates). The wage rate declines as the carbon tax rate increases because of lower demand for labor as companies have higher costs and lower output. Labor income is a function of the wage rate and the quantity of hours devoted to labor (as opposed to leisure). Across the cases, labor income experiences declines that are greater than or equal to the declines in the wage rate. A larger decline in the labor income than the wage rate implies that workers are working fewer hours, which is a response to the lower wage rate (smaller incentive to work).

The labor income change in Figure 15 can also be stated in terms of job-equivalents, by dividing the labor income change by the annual income from the average job. A loss of one job-equivalent does not necessarily mean one less employed person—it may be manifested as a combination of fewer people working and less income per person who is working. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage.

Figure 15: Labor Impacts

	2013	2023	2033	2043	2053
$20 Tax Case					
Wage Rate (% Change from Baseline)	-0.8%	-1.0%	-0.9%	-1.1%	-1.2%
Labor Income (% Change from Baseline)	-1.0%	-1.1%	-1.1%	-1.2%	-1.4%
Job-Equivalents* (Change from Baseline, Thousands)	-1,510	-2,290	-2,520	-3,210	-3,770
80% Reduction Tax Case					
Wage Rate (% Change from Baseline)	-0.6%	-1.2%	-1.7%	-4.3%	-7.2%
Labor Income (% Change from Baseline)	-0.8%	-1.3%	-1.9%	-5.1%	-8.3%
Job-Equivalents* (Change from Baseline, Thousands)	-1,260	-2,750	-4,370	-11,860	-20,670

* Total job-equivalents equals total labor income change divided by the average annual income per job. This does not represent a projection of numbers of workers that may need to change jobs and/or be unemployed, as some or all of it could be spread across workers who remain employed.

3. Federal Tax Collections, Deficits and Debt

Our analysis finds that the net carbon tax proceeds available for reducing federal PIT rates and debt reduction are substantially less than the gross projected carbon tax revenues. Figure 16 summarizes the results for the $20 Tax Case and Figure 17 for the more costly 80% Reduction Tax Case. Note that the results presented in these figures are simultaneously determined so that the final amount used to improve each year's deficit (row 3) is equal to the amount by which the scenario's PIT rate reductions decrease the carbon case tax collections (row 5), and they are both also consistent with the general equilibrium conditions that determine the carbon tax's deadweight loss (row 2). Thus, any change in the rule for sharing net carbon revenues between the objectives of debt reduction and tax rate reduction also will change the amount of net carbon revenues available, and cannot be estimated without a separate model run.

Figure 16: Carbon Tax Revenues and Their Disposition in the $20 Tax Case

	2013	2023	2033	2043	2053
(1) Gross Carbon Tax Revenue (Billions)	$104	$138	$201	$301	$395
(2) Reductions in Existing Federal Tax Revenues Due to Deadweight Cost of Carbon Tax (Billions)*	$43	$51	$74	$104	$145
(3) Reduction from Baseline Deficit for that Year (Billions)	$61**	$44	$64	$98	$125
(4) PIT Rate Reduction from "Carbon Tax Swap" (%)	0%**	1.5%	1.7%	2.1%	2.1%
(5) Reduction in Tax Collections Due to PIT Rate Reduction (Billions)	$0**	$44	$64	$98	$125

* Combines effects of reduced taxable income due to deadweight loss of carbon tax and improvements in deadweight loss due to reduced PIT rates shown in row (4). Does not include reductions in PIT revenues due directly to reductions in PIT rates, which are reported in row (5).
** 100% of net carbon tax revenue goes to deficit/debt reduction until baseline tax rates are increased above their prevailing 2012 levels, starting in 2023.

Figure 17: Carbon Tax Revenues and Their Disposition in the 80% Reduction Tax Case

	2013	2023	2033	2043	2053
(1) Gross Carbon Tax Revenue (Billions)	$104	$176	$325	$906	$1,764
(2) Reductions in Existing Federal Tax Revenues Due to Deadweight Cost of Carbon Tax (Billions)*	$42	$57	$112	$429	$910
(3) Reduction from Baseline Deficit in that Year (Billions)	$62**	$60	$107	$239	$427
(4) PIT Rate Reduction from "Carbon Tax Swap" (%)	0%**	2.1%	2.9%	5.3%	7.8%
(5) Reduction in Tax Collections Due to PIT Rate Reduction (Billions)	$0**	$60	$107	$239	$427

* Combines effects of reduced taxable income due to deadweight loss of carbon tax and improvements in deadweight loss due to reduced PIT rates shown in row (4). Does not include reductions in PIT revenues due directly to reductions in PIT rates, which are reported in row (5).
** 100% of net carbon tax revenue goes to deficit/debt reduction until baseline tax rates are increased above their prevailing 2012 levels, starting in 2023.

The tables above summarize the basic components determining the changes in the debt level in each year relative to the respective baseline debt levels. The projected annual deficits and associated debt levels that result are shown in Figure 18. These projections assume the same level of government spending in both carbon tax cases as in the Baseline, and the only difference in deficits and associated debt levels is due to changes in total Federal tax revenues, which is the sum of carbon tax revenues and revenues from all other existing Federal taxes. Relative to its baseline level, the Federal debt in 2053 is reduced by 8% in the $20 Tax Case and by 18% in the 80% Reduction Tax Case. In present value terms, the net economic benefit of a lower debt is tied to changes in the interest rate on Federal debt. In this analysis, the interest rate on Federal debt is assumed to vary with the debt-to-GDP ratio (see Appendix C). While the debt in 2053 is 18% lower in the 80% Reduction Tax Case, the debt-to-GDP ratio is only 14.2% lower, because GDP is estimated to decrease by 4% relative to baseline levels in 2053 (see Figure 12 above). The debt-to-GDP ratio is 7.5% lower by 2053 in the $20 Tax Case.

Figure 18: Federal Deficit and Debt Outcomes of Baseline and Two Carbon Tax Cases (Billions)

	2013	2023	2033	2043	2053
Baseline					
Deficit	$1,020	$330	$520	$720	$830
Debt	$12,280	$19,210	$24,010	$30,320	$38,130
$20 Tax Case					
Deficit	$960	$290	$450	$630	$700
Debt	$12,220	$18,540	$22,800	$28,290	$34,950
80% Reduction Tax Case					
Deficit	$950	$270	$410	$490	$400
Debt	$12,220	$18,510	$22,500	$27,170	$31,290

As noted above, we assume that Federal debt is financed by borrowing from foreign entities and thus the reduced interest payments in the carbon tax cases represent a windfall of increased wealth to U.S. consumers (wealth that was presumed to be sent outside of the U.S. economy in the Baseline). By incorporating this estimate of the financial gain from reduced interest rates into consumer income, the gains flow through to all of the other measures of economic impact reported in this study. By 2053, the lower borrowing cost increases consumer welfare relative to baseline welfare by $76 billion per year in the $20 Tax Case and by $129 billion per year in the 80% Reduction Tax Case.

4. Sectoral Output

Figure 19 shows the estimated changes in energy sector output for the two carbon tax cases. The changes in sectoral output reflect changes both in the quantity of output and changes in the prices/value of output. The value of output declines most markedly in the coal sector. Of the primary fossil fuels, coal has the highest carbon content. It is also primarily used in the electricity sector, where elevated coal prices due to the carbon tax cause generators to switch to natural gas in the short term and to renewable, nuclear and CCS generation in the longer term.

The refined petroleum products sector also sees a large decline in output relative to the Baseline. This is attributable to the higher gasoline prices (because of the carbon tax adder), which leads to declines in vehicle-miles travelled and increases in miles per gallon of the personal transportation fleet. There is also an increasing use of lower-carbon gasoline and diesel alternatives, which reduce demand for conventional gasoline and diesel.

The natural gas sector experiences both increases and decreases over the modeling horizon. In the near term, natural gas gains at the expense of coal in both cases; in the 80% Reduction Case, natural gas then becomes too expensive for the electricity sector leading to declines, which are mitigated around 2050 by increased natural gas usage in the production of lower carbon transportation fuel alternatives. Note that domestic crude oil output does not change substantially because prices are set in global markets. Because imports represent the crude oil that is supplied at the margin, the reduction in refined petroleum output is reflected in reduced crude imports.

Figure 19: Energy Sector Output (Percentage Change from Baseline)

	2013	2023	2033	2043	2053
Coal					
$20 Tax Case	-16%	-44%	-45%	-40%	-55%
80% Reduction Tax Case	-17%	-54%	-87%	-98%	-99%
Crude Oil					
$20 Tax Case	0.5%	-0.2%	0.1%	-0.1%	-0.1%
80% Reduction Tax Case	0.8%	-1.2%	-3.9%	-9.6%	-12%
Natural Gas					
$20 Tax Case	3.1%	0.8%	1.8%	-1.7%	-5.0%
80% Reduction Tax Case	3.1%	4.8%	9.4%	-18%	-6.5%
Refined Petroleum Products					
$20 Tax Case	-0.6%	-2.5%	-6.4%	-9.0%	-11%
80% Reduction Tax Case	-0.6%	-4.4%	-9.9%	-22%	-63%

Figure 20 shows the estimated changes in output for the non-energy side of the economy in the two carbon cases. The measure of sectoral output can be confusing because it is stated in dollar values. If the cost of a product or services increases due to the cost of reducing carbon emissions, the value of output might increase, even if total quantity of physical output has fallen. Although this price-increasing effect is implicit in the model's output projections, the percentage decline in physical output is generally larger, with negative percentage declines in the dollar value of output being projected. The energy-intensive sector is hit relatively hard because it relies on fossil fuels and has higher carbon intensity than most other sectors.

Figure 20: Non-Energy Sector Output (Percentage Change from Baseline)

	2013	2023	2033	2043	2053
Agriculture					
$20 Tax Case	-0.6%	-1.4%	-1.3%	-1.6%	-1.8%
80% Reduction Tax Case	-0.3%	-1.1%	-1.8%	-5.8%	-9.7%
Commercial/Services					
$20 Tax Case	-0.1%	-0.4%	-0.4%	-0.5%	-0.5%
80% Reduction Tax Case	-0.1%	-0.5%	-0.7%	-1.6%	-2.7%
Transportation Services (excluding Personal Transportation)					
$20 Tax Case	-0.3%	-0.8%	-0.8%	-1.0%	-1.1%
80% Reduction Tax Case	-0.2%	-0.9%	-1.4%	-3.6%	-5.9%
Energy-Intensive Manufacturing					
$20 Tax Case	-0.4%	-2.2%	-2.2%	-2.6%	-2.7%
80% Reduction Tax Case	-0.2%	-2.2%	-3.4%	-8.4%	-15%
Non-Energy-Intensive Manufacturing					
$20 Tax Case	-0.7%	-1.0%	-0.9%	-1.1%	-1.3%
80% Reduction Tax Case	-0.3%	-0.5%	-1.0%	-4.6%	-7.7%

5. Economic Welfare

Economic welfare is a concept used by economists that relates to the overall utility that individuals experience from the economy. In N_{ew}ERA, welfare is measured by the sum of the values of household consumption and leisure.

Figure 21 provides information on the effects of the two carbon tax cases on changes in the welfare of U.S. households, expressed as percentage changes relative to the Baseline, with information on regional impacts as well as national impacts. The $20 Tax Case leads to an average U.S. welfare loss over the entire modeling horizon of 0.17% relative to the Baseline, and the 80% Reduction Tax Case produces an average U.S. welfare loss of 0.59%. The regional impacts vary considerably, largely reflecting the wide regional variations in carbon intensity, as shown in Figure 10. Higher carbon intensity leads to larger fossil fuel cost increases, which result in higher price impacts and larger reductions in household consumption.

Figure 21: Regional Percentage Changes in Economic Welfare (2013-2053)

Region	$20 Tax Case	80% Reduction Tax Case
Arizona and Mountain States	-0.57%	-1.29%
California	0.06%	-0.19%
Florida	-0.07%	-0.35%
Mid-Atlantic	-0.12%	-0.45%
Mid-America	-0.32%	-0.89%
Mississippi Valley	-0.23%	-0.67%
New York/New England	0.14%	-0.03%
Pacific Northwest	-0.09%	-0.55%
Southeast	-0.29%	-0.76%
Texas, Oklahoma, Louisiana	-0.23%	-0.94%
Upper Midwest	-0.58%	-1.16%
U.S.	**-0.17%**	**-0.59%**

B. Emissions and Energy Market Impacts

1. Carbon Emissions within U.S. Borders

Figure 22 shows baseline carbon emissions (in millions of metric tons of CO_2), along with emissions for the two carbon tax cases and percentage reductions in emissions relative to the Baseline and the emission level in 2005 (5,988 million metric tons). These results reflect only emissions from activities that occur physically within U.S. borders.[25] Note that in the 80% Reduction Tax Case, the U.S. does not fully achieve an 80% reduction (relative to 2005 levels) by 2053, which reflects just how costly such an outcome would be.

Figure 22: Carbon Emissions (Million Metric Tons of CO_2)

	2013	2023	2033	2043	2053
Baseline					
CO_2 Emissions	5,450	5,530	5,650	5,790	5,890
$20 Tax					
CO_2 Emissions	5,210	4,670	4,590	4,640	4,110
% Reduction from Baseline	*4%*	*16%*	*19%*	*20%*	*30%*
% Reduction from 2005	*13%*	*22%*	*23%*	*23%*	*31%*
80% Reduction					
CO_2 Emissions	5,210	4,400	3,610	2,590	1,760
% Reduction from Baseline	*4%*	*20%*	*36%*	*55%*	*70%*
% Reduction from 2005	*13%*	*27%*	*40%*	*57%*	*71%*

[25] Possible leakage of some of the decreases in U.S. emissions to other countries is not quantified in this analysis.

2. Fossil Fuel Markets

The imposition of a carbon tax leads to higher costs for consuming fossil fuels and reduced consumption of fossil fuels in the long term. In the near term, fuel switching (particularly in the electricity sector) from coal to natural gas, which has a lower carbon content, increases natural gas consumption, but in the long term, natural gas consumption also declines as the carbon taxes increase. Figure 23 shows the fuel consumption for coal, natural gas, and gasoline for the Baseline and the two carbon tax cases, stated in physical units.

Figure 23: Fossil Fuel Consumption (in Quadrillion Btu or Billions of Gallons)

	2013	2023	2033	2043	2053
Coal (Quadrillion Btu)					
Baseline	20	21	22	23	24
$20 Tax Case	17	13	14	16	13
80% Reduction Tax Case	17	11	5	3	5
Natural Gas (Quadrillion Btu)					
Baseline	24	25	26	28	30
$20 Tax Case	25	25	25	26	27
80% Reduction Tax Case	25	26	27	21	21
Gasoline (Billions of Gallons)					
Baseline	130	118	113	111	108
$20 Tax Case	130	115	109	106	101
80% Reduction Tax Case	130	114	106	91	70

The significant declines in coal consumption reflect that coal has the highest carbon content among the fossil fuels. With the majority of coal consumption occurring within the electricity sector, it also suffers from having some of the least costly fuel-switching opportunities (changes in dispatch from existing generating capacity), which allows for the near-term reductions. In the 80% Reduction Tax Case, all coal consumption in the later years is from outside of the electricity sector.

Natural gas consumption increases immediately in both tax cases due to fuel switching from coal to natural gas in the electricity sector. In the later years of the 80% Reduction Tax Case, natural gas becomes too costly to use in large quantities in the electricity sector and is replaced by low- or zero-emitting technologies such as renewables and nuclear. In the carbon tax cases, natural gas demand increases somewhat between 2043 and 2053 because of the deployment of CNG vehicles.

Demand for gasoline decreases over time in the Baseline because of increasing fuel economy standards. The carbon tax provides an incentive to adopt more fuel-efficient vehicles and consumers drive fewer miles due to the higher price of gasoline, which together combine to lower gasoline demand over time in both carbon tax cases.

Figure 24 shows the impacts on the prices of fossil fuels. The upper portion of the figure shows the percentage change in the resource prices for coal and natural gas (i.e., these are the costs of physically producing the commodities, before including the cost of the carbon tax). The lower portion of the figure then shows the total cost of using those fuels, which includes the carbon tax adder that will have to be paid in order to actually use those fuels (whether paid directly by the fuel consumer, or as a cost passed through by the fuel producer who has already paid the tax "upstream" of the point of use).

One can see from the upper portion of the figure that the resource cost declines when demand declines. For example, the carbon tax policy causes coal demand to decline the most (see Figure 23), and the cost of producing coal to meet that lower demand falls. However, that reduction in demand only occurs because the cost of consuming the coal is driven upward by the carbon tax adder. This can be seen in the lower portion of the figure, which shows that the full cost of using coal, when accounting for the carbon adder as well as the resource cost, increases significantly. Coal incurs the largest full cost increase because it has the highest carbon content per unit of energy content, and so its carbon tax adder is the largest among all the fuels.

Figure 24: Fuel Price Impacts (Percentage Change from Baseline)

	2013	2023	2033	2043	2053
			Excluding Carbon Tax		
Minemouth Coal Prices					
$20 Tax Case	-6.4%	-13%	-14%	-15%	-9.4%
80% Reduction Tax Case	-9.0%	-11%	-31%	-22%	-15%
Wellhead Natural Gas Prices					
$20 Tax Case	16%	0.3%	0.7%	-2.0%	-4.3%
80% Reduction Tax Case	16%	4.8%	6.8%	-15%	-8.6%
			Including Carbon Tax		
Minemouth Coal Prices					
$20 Tax Case	110%	143%	191%	281%	503%
80% Reduction Tax Case	107%	199%	390%	1,574%	5,324%
Wellhead Natural Gas Prices					
$20 Tax Case	44%	33%	39%	39%	44%
80% Reduction Tax Case	44%	49%	85%	206%	497%
Gasoline					
$20 Tax Case	6.0%	7.4%	9.9%	12%	17%
80% Reduction Tax Case	6.5%	9.0%	17%	60%	164%

3. Electricity Sector

The electricity sector has the highest carbon intensity and thus the impacts of the carbon tax are large. Figure 25 shows the residential delivered electricity prices in the Baseline and the two tax cases. In the Baseline, residential electricity prices are projected to increase primarily due to increasing fuel prices over time. The addition of a carbon tax in 2013 is an immediate shock to prices, which is tempered slightly by fuel switching from coal-fired generation to natural gas-fired generation. As the carbon tax price increases, so do the impacts on price, although in the later years of the 80% Reduction Tax Case the electricity sector is nearly completely de-carbonized, so the higher carbon prices have a more limited percentage impact.

Figure 25: Residential Delivered Electricity Prices (2012¢/kWh)

	2013	2023	2033	2043	2053
Baseline	12.0¢	13.7¢	14.3¢	16.0¢	17.1¢
$20 Tax Case	13.4¢	15.4¢	16.7¢	19.3¢	20.5¢
Percentage Change from Baseline	*12%*	*12%*	*16%*	*21%*	*20%*
80% Reduction Tax Case	13.5¢	16.2¢	18.6¢	25.9¢	24.3¢
Percentage Change from Baseline	*13%*	*18%*	*30%*	*61%*	*42%*

Figure 26 shows projected physical impacts on the electricity sector in terms of coal electricity unit retirements and overall electricity demand. As expected, the imposition of a carbon tax increases the quantity of coal unit retirements, with higher tax rates leading to a greater level of retirements. Even the $20 Tax Case is projected to cause three times the amount of coal retirements in the near term compared to that projected for the Baseline without any carbon tax. The near-term retirements of the coal units are motivated by the anticipated higher carbon taxes in later years (which make further near-term capital investments to keep such plants operational uneconomical). However, the extent of the coal unit retirement sensitivity is exacerbated by relatively low forecasted prices for natural gas. Under the $20 Tax Case, electricity demand declines about 11% below the Baseline level in 2033 and about 12% in 2053; the 80% Reduction Tax Case causes electricity demand to drop by about 17% in 2033 and more than 25% afterward relative to the Baseline.

Figure 26: Electricity Sector Impacts of Carbon Tax Cases

	2013	2023	2033	2043	2053
Baseline					
Coal Retirements (GW)	4	36	37	39	39
U.S. Electricity Demand (TWh)	3,990	4,280	4,640	4,990	5,380
$20 Tax Case					
Coal Retirements (GW)	5	108	112	119	160
U.S. Electricity Demand (TWh)	3,890	3,960	4,150	4,370	4,740
% Change (Relative to Baseline)	*-2.4%*	*-7.7%*	*-11%*	*-12%*	*-12%*
80% Reduction Tax Case					
Coal Retirements (GW)	5	141	213	295	295
U.S. Electricity Demand (TWh)	3,890	3,830	3,840	3,590	4,020
% Change (Relative to Baseline)	*-2.4%*	*-11%*	*-17%*	*-28%*	*-25%*

4. Alternate Transportation Fuels

To lower carbon taxes in the transportation sector consumers must either consume less transportation fuel or use transportation fuels with lower carbon contents than traditional gasoline and diesel fuel. With respect to fuels, both of the tax cases add significant quantities of advanced biofuels with lower carbon contents than traditional transportation fuels. (The available advanced biofuels are described in Section II.C.1 and in Appendix B.) By 2053, advanced biofuels production doubles from that in the Baseline in the $20 Tax Case. The 80% Reduction Tax Case's advanced biofuels production is more than eight time higher than the Baseline by 2053.

Figure 27: Advanced Biofuels Production (Quadrillion Btu)

	2013	2023	2033	2043	2053
Baseline	0.0	0.0	0.0	1.0	3.1
$20 Tax Case	0.0	0.0	2.1	4.2	6.4
80% Reduction Tax Case	0.0	1.1	3.2	5.3	25.9

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APPENDIX A. N_{EW}ERA MODEL

NERA developed the NewERA model to forecast the impact of policy, regulatory, and economic factors on the energy sectors and the economy. When evaluating policies that have significant impacts on the entire economy, one needs to use a model that captures the effects as they ripple through all sectors of the economy and the associated feedback effects. The NewERA model combines a macroeconomic model with all sectors of the economy (except for the electricity sector) with a detailed electricity sector model. This combination allows for a complete understanding of the economic impacts of different policies on all sectors of the economy.

The macroeconomic model incorporates production and consumption of all goods and services in the economy. The amount of labor, capital, energy, and materials used to produce electricity and coal used in the electricity sector are taken from the electricity sector model. Policy consequences are transmitted throughout the economy as sectors respond until the economy reaches equilibrium. The production and consumption functions employed in the model enable gradual substitution of inputs in response to relative price changes, thus avoiding all-or-nothing solutions.

The main benefit of the integrated framework is that the electricity sector can be modeled in great detail yet through integration the model captures the interactions and feedbacks between all sectors of the economy. Electricity technologies can be well represented according to engineering specifications. The integrated modeling approach also provides consistent price responses since all sectors of the economy are modeled. In addition, under this framework, we are able to model electricity demand response.

There are great uncertainties about how the U.S. natural gas market will evolve, and the NewERA model is designed explicitly to address the key factors affecting future natural gas supply and prices. One of the major uncertainties is the availability of shale gas in the United States. To account for this uncertainty and the subsequent effect it could have on the domestic and international markets, the NewERA model includes resource supply curves for U.S. natural gas that can be altered for sensitivity analysis. The model also accounts for foreign imports and U.S. exports of natural gas, by using a supply (demand) curve for U.S. imports (exports) that represents how the global LNG market price would react to changes in U.S. imports or exports.

The electricity sector model is a detailed model of the electricity and coal sectors. Each of the more than 17,000 electricity generating units in the United States is represented in the model. The model minimizes costs while meeting all specified constraints, such as demand, peak demand, emissions limits, and transmission limits. The model determines investments to undertake and unit dispatch. Because the NewERA model is an integrated model of the entire U.S. economy, electricity demand can respond to changes in prices and supplies. The steam coal sector is represented within the NewERA model by a series of coal supply curves and a coal transportation matrix. The NewERA model represents the domestic and international crude oil and refined petroleum markets.

N_{ew}ERA model outputs include demand and supply of all goods and services, prices of all commodities, and terms of trade effects (including changes in imports and exports). The model outputs also include GRP, consumption, investment, disposable income, and changes in "job-equivalents" based on labor wage income.

Impacts on workers are often considered an important output of policy evaluations. Impacts on workers are complicated to estimate and to explain because they can include several different impacts, including involuntary unemployment, reductions in wage rates for those who continue to work, and voluntary reductions in hours worked due to lower wage rates. No model addresses all of these potential impacts. The N_{ew}ERA model is a long-run equilibrium model based upon full employment, and thus its results relate to the longer-term effects on labor income and voluntary reductions in hours worked rather than involuntary unemployment impacts. It addresses long-run employment impacts, all of which are based on estimates of changes in labor income, also called the "wage bill" or "payments to labor." Labor income impacts consist of two effects: (1) changes in real wage per hour worked; and (2) changes in labor market participation (hours worked) in response to changed real wage rates. The labor income change can also be expressed on a per-household basis, which represents one of the key components of disposal income per household. (The other key components of disposable income are returns on investments or "payments to capital," and income from ownership of natural resources). The labor income change can also be stated in terms of job-equivalents, by dividing the labor income change by the annual income from the average job. A loss of one job-equivalent does not necessarily mean one less employed person—it may be manifested as a combination of fewer people working and less income per person who is working. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage.

A. Overview

NERA's N_{ew}ERA modeling system is an integrated energy and economic model that includes a bottom-up representation of the electricity sector, including all of the unit-level details that are required to accurately evaluate changes in the electricity sector. N_{ew}ERA integrates the electricity sector model with a macroeconomic model that includes all other sectors of the economy (except for the electricity sector) using a top-down representation. The model produces integrated forecasts for future years; the modeling for this study was for the period from 2013 to 2053 with modeling inputs and results for every fifth year in that period. The model produces a standard set of reports that includes the following information.

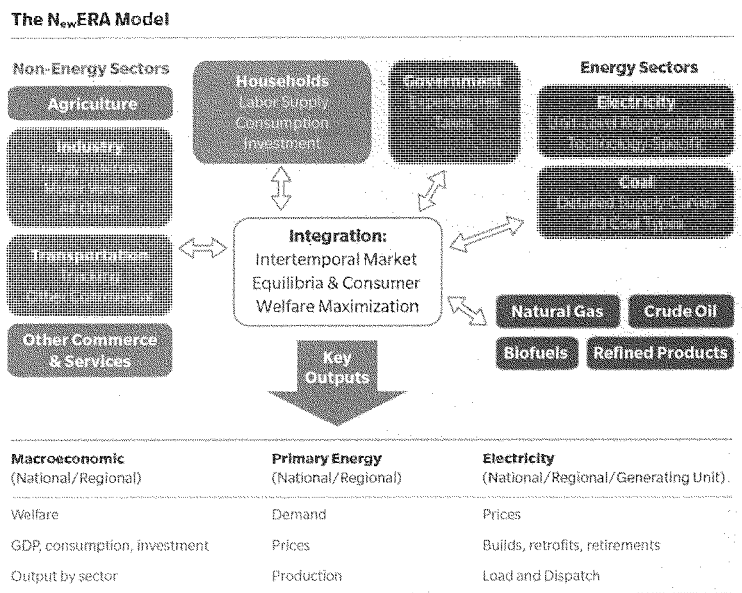
- *Unit-level investments in the electricity sector* – retrofits in response to environmental policies, new builds (full range of new generation technologies represented), retirements based on economics.
- *Prices* – wholesale electricity prices for each of 32 U.S. regions, capacity prices for each U.S. region, delivered electricity prices by sector for each of 11 macroeconomic regions in N_{ew}ERA, Henry Hub natural gas prices and delivered natural gas prices to the

electricity sector for each U.S. region, minemouth coal prices for 24 different types of coal, delivered coal prices by coal unit, refined oil product prices (gasoline and diesel fuel), renewable energy credit (REC) prices for each state/regional renewable portfolio standard (RPS), and emissions prices for all regional and national programs with tradable credits.

- *Macroeconomic results* – GRP for each macroeconomic region and gross state product (GSP) for each state, economic welfare, changes in disposable income, and changes in labor income and real wage rates (used to estimate labor market changes in terms of an equivalent number of jobs).

Figure 28 provides a simplified representation of the key elements of the N_{ew}ERA modeling system.

Figure 28: N_{ew}ERA Modeling System Representation



B. Electricity Sector Model

The electricity sector model that is part of the N_{ew}ERA modeling system is a bottom-up model of the electricity and coal sectors. The model is fully dynamic and includes perfect foresight (under the assumption that future conditions are known). Thus, all decisions within the model are based on minimizing the present value of costs over the entire time horizon of the model while meeting all specified constraints, including demand, peak demand, emissions limits, transmission limits, RPS regulations, fuel availability and costs, and new build limits. The model set-up is intended to mimic (as much as is possible within a model) the approach that electricity sector investors use to make decisions. In determining the least-cost method of satisfying all these constraints, the model endogenously decides:

- What investments to undertake (*e.g.*, addition of retrofits, build new capacity, repower unit, add fuel switching capacity, or retire units);
- How to operate each modeled unit (*e.g.*, when and how much to operate units, which fuels to burn) and what is the optimal generation mix; and
- How demand will respond. The model thus assesses the trade-offs between the amount of demand-side management (DSM) to undertake and the level of electricity usage.

Each unit in the model has certain actions that it can undertake. For example, all units can retire, and many can undergo retrofits. Any publicly-announced actions, such as planned retirements, planned retrofits (for existing units), or new units under construction can be specified. Coal units have more potential actions than other types of units. These include retrofits to reduce emissions of SO_2, NO_X, mercury, and CO_2. The costs, timing, and necessity of retrofits may be specified as scenario inputs or left for the model to endogenously select. Coal units can also switch the type of coal that they burn (with practical unit-specific limitations). Finally, coal units may retire if none of the above actions will allow them to remain profitable, after accounting for their revenues from generation and capacity services.

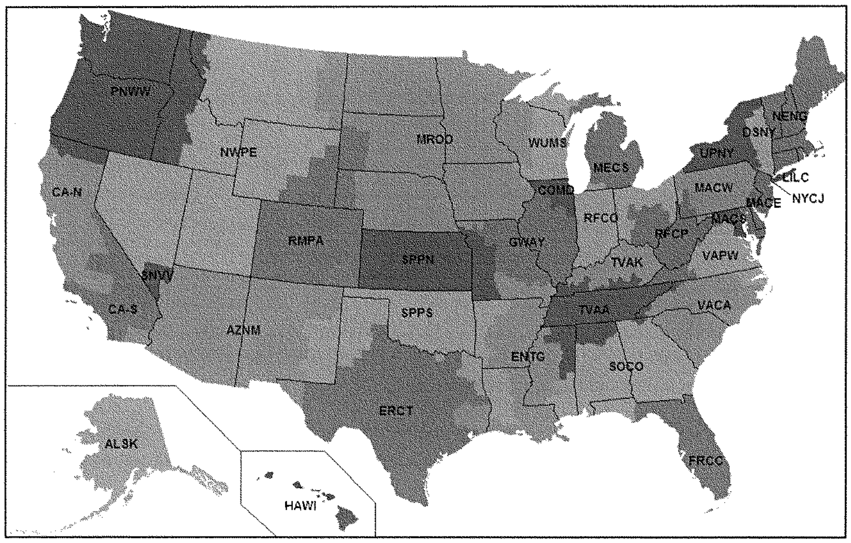
Most of the coal units' actions would be in response to environmental limits that can be added to the model. These include emission caps (for SO_2, NO_X, mercury, and CO_2) that can be applied at the national, regional, state or unit level. We can also specify allowance prices for emissions, emission rates (especially for toxics such as mercury) or heat rate levels that must be met.

Just as with investment decisions, the operation of each unit in a given year depends on the policies in place (*e.g.*, unit-level standards), electricity demand, and operating costs, especially energy prices. The model accounts for all these conditions in deciding when and how much to operate each unit. The model also considers system-wide operational issues such as environmental regulations, limits on the share of generation from intermittent resources, transmission limits, and operational reserve margin requirements in addition to annual reserve margin constraints.

To meet increasing electricity demand and reserve margin requirements over time, the electricity sector must build new generating capacity. Future environmental regulations and forecasted energy prices influence which technologies to build and where. For example, if a national RPS policy is to take effect, some share of new generating capacity will need to come from renewable power. On the other hand, if there is a policy to address emissions, it might elicit a response to retrofit existing fossil-fired units with pollution control technology or enhance existing coal-fired units to burn different types of coals, biomass, or natural gas. Policies calling for improved heat rates may lead to capital expenditure spent on repowering existing units. All of these policies will also likely affect retirement decisions. The N_{ew}ERA electricity sector model endogenously captures all of these different types of decisions.

The model contains 32 U.S. electricity regions (and six Canadian electricity regions). Figure 29 shows the U.S. electricity regions.

Figure 29: N_{ew}ERA Electricity Sector Model – U.S. Regions



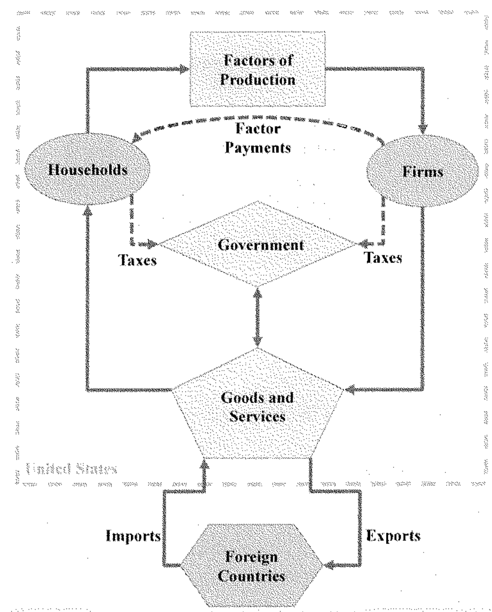
C. Macroeconomic Model

1. Overview

The N_{ew}ERA macroeconomic model is a forward-looking dynamic CGE model of the United States. The model simulates all economic interactions in the U.S. economy, including those among industry, households, and the government. Additional background information on CGE models can be found in Burfisher (2011).

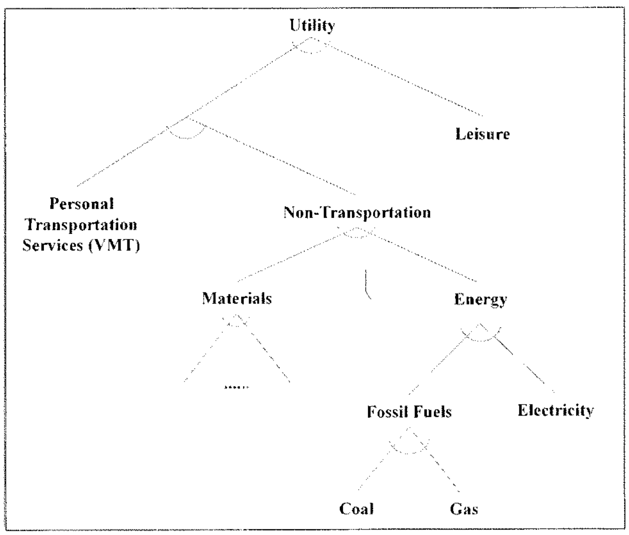
The N_{ew}ERA CGE framework uses the standard theoretical macroeconomic structure to capture the flow of goods and factors of production within the economy. A simplified version of these interdependent macroeconomic flows is shown in Figure 30. The model implicitly assumes "general equilibrium," which implies that all sectors in the economy are in balance and all economic flows are endogenously accounted for within the model. In this model, households supply factors of production, including labor and capital, to firms. Firms provide households with payments for the factors of production in return. Firm output is produced from a combination of productive factors and intermediate inputs of goods and services supplied by other firms. Individual firm final output can be consumed within the United States or exported. The model also accounts for imports into the United States. In addition to consuming goods and services, households can accumulate savings, which they provide to firms for investments in new capital. Government receives taxes from both households and firms, contributes to the production of goods and services, and also purchases goods and services. Although the model assumes equilibrium, a region in the model can run deficits or surpluses in current accounts and capital accounts. In aggregate, all markets clear, meaning that the sum of regional commodities and factors of production must equal their demands, and the income of each household must equal its factor endowments plus any net transfers received.

Figure 30: Interdependent Economic Flows in N_{ew}ERA's Macroeconomic Model



The model uses the standard CGE framework developed by Arrow and Debreu (1954). Behavior of households is represented by a nested Constant Elasticity of Substitution (CES) utility function. The model assumes that households seek to maximize their overall welfare, or utility, across time periods. Households have utility functions that reflect trade-offs between leisure (which reduces the amount of time available for earning income) and an aggregate consumption of goods and services. Households maximize their utility over all time periods subject to an intertemporal budget constraint based on their income from supplying labor, capital, and natural resource to firms. In each time period, household income is used to consume goods and services or to fund investment. Within consumption, households substitute between energy (including electricity, coal, natural gas, and petroleum), personal transportation, and goods and services based on the relative price of these inputs. Figure 31 illustrates the utility function of the households.

Figure 31: Household Consumption Structure in N_{ew}ERA's Macroeconomic Model



On the production side, Figure 32 shows the production structure of the commercial transportation and the trucking sector. Production structure for the rest of the industries is shown in Figure 33. The model assumes all industries maximize profits subject to technological constraints. The inputs to production are energy (including the same four types noted above for household consumption), capital, and labor. Production also uses inputs from intermediate products provided by other firms. The N_{ew}ERA model allows producers to change the technology and the energy source they use to manufacture goods. If, for example, petroleum prices rise, an industry can shift to a cheaper energy source. It can also choose to use more capital or labor in place of petroleum, increasing energy efficiency and maximizing profits with respect to industry constraints.

Figure 32: Commercial Transportation and Trucking Sector Production Structure in N$_{ew}$ERA's Macroeconomic Model

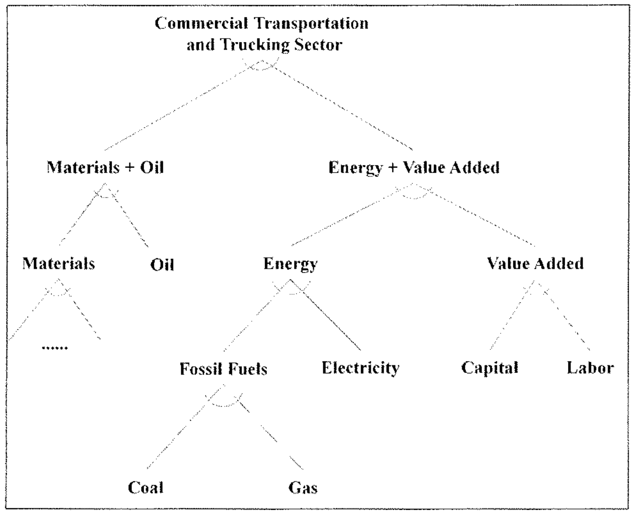
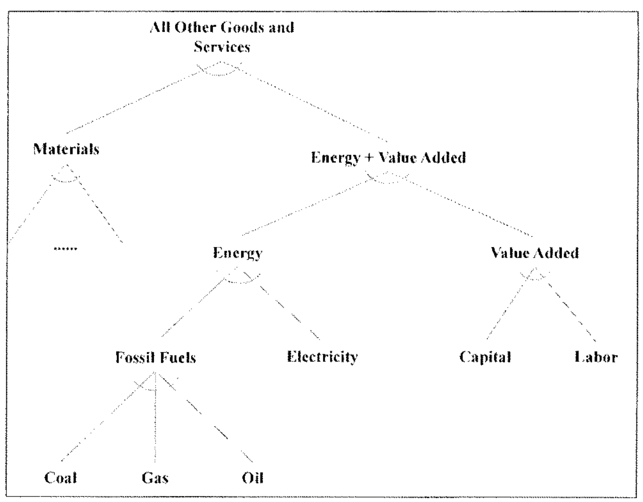


Figure 33: Production Structure for Other Sectors in N$_{ew}$ERA's Macroeconomic Model



All goods and services, except crude oil, are treated as Armington goods, which assume the domestic and foreign goods are differentiated and thus are imperfect substitutes (Armington 1969). The level of imports depends upon the elasticity of substitution between the imported and domestic goods. The Armington elasticity among imported goods is assumed to be twice as large as the elasticity between the domestic and imported goods, characterizing the greater substitutability among imported goods.

Business investment decisions are informed by future policies and outlook. The forward-looking characteristic of the model enables businesses and consumers to determine the optimal savings and investment levels while anticipating future policies with perfect foresight.

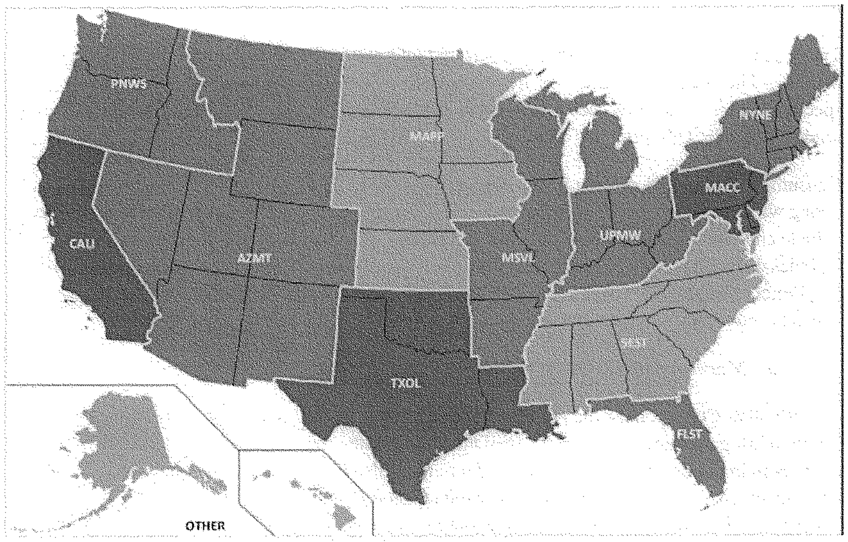
The benchmark year economic interactions are based on the IMPLAN 2008 database, which includes regional detail on economic interactions among 440 different economic sectors. The macroeconomic and energy forecasts that are used to project the benchmark year going forward are calibrated to EIA's AEO 2012.

2. Regional Aggregation

The N_{ew}ERA macroeconomic model typically includes 11 regions: NYNE (New York and New England), MAAC (Mid-Atlantic Coast), UPMW (Upper Midwest), SEST (Southeast), FLST (Florida), MSVL (Mississippi Valley), MAPP (Mid-America), TXOL (Texas, Oklahoma and Louisiana), AZMT (Arizona and Mountain states), CALI (California) and (PNWS) Pacific Northwest. The aggregate model regions are built up from economic data for the 50 U.S. states and the District of Columbia. The 11 standard N_{ew}ERA macroeconomic model regions and the states within each N_{ew}ERA region are shown in Figure 34.

The model's regional representation can also be adjusted to include individual states. This is done when one wishes to evaluate the impacts to a specific state. This is done by creating one additional region, for a total of 12 regions. The state of interest is removed from the region that it is a part of and becomes its own region. Such an approach requires nearly 50 different model runs (California and Florida are already their own region in the standard 11-region model representation) to assess the impacts to each state individually associated with a particular national or regional scale policy analysis.

Figure 34: N$_{ew}$ERA Macroeconomic Model Regions



3. Sectoral Aggregation

The N$_{ew}$ERA model includes a standard set of 12 economic sectors: five energy (coal, natural gas, crude oil, electricity, and refined petroleum products) and seven non-energy sectors (services, manufacturing, energy-intensive,[26] agriculture, commercial transportation excluding trucking, trucking, and motor vehicle manufacturing). These sectors are aggregated up from the 440 IMPLAN sectors. The model has the flexibility to represent sectors at different levels of aggregation, when warranted, to better meet the needs of specific analyses.

4. Natural Gas and Oil Markets

The N$_{ew}$ERA modeling system is designed explicitly to address the key factors affecting future natural gas supply and prices. One of the major uncertainties is the availability of shale gas in the United States. To account for this uncertainty and the subsequent effect it could have on international markets, the N$_{ew}$ERA modeling system has the ability to represent supply curves for conventional natural gas and shale gas for each region of the model. By including each type of natural gas, it is possible to incorporate expert judgments and sensitivity analyses on a variety of

[26] The energy-intensive sector in the N$_{ew}$ERA modeling system includes pulp and paper, chemicals, glass, cement, primary metals, and aluminum.

uncertainties, such as the extent of shale gas reserves, the cost of shale gas production, and the impacts of environmental regulations.

The N_{ew}ERA model represents the domestic and international crude oil and refined petroleum markets. The international markets are represented by flat supply curves with exogenously specified prices. Because crude oil is treated as a homogeneous good, the international price for crude oil sets the U.S. price for crude oil.

Consumption of electricity as a transportation fuel could also affect the natural gas market. Along with alternative transportation fuels (including biofuels), the model also includes different vehicle choices that consumers can employ in response to changes in the fuel prices. The model includes different types of Electrified Vehicles (EVs): Plug-in-Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs).[27] In addition, the model accounts for both passenger vehicles and trucks powered by CNG.

5. Macroeconomic Outputs

As with other CGE models, the N_{ew}ERA macroeconomic model outputs include demand and supply of all goods and services, prices of all commodities, and terms of trade effects (including changes in imports and exports). The model outputs also include GRP, consumption, investment, cost of living or burden on consumers, and changes in "job-equivalents" based on changes in labor wage income. All model outputs are calculated by time, sector, and region.

Impacts on workers are often considered an important output of policy evaluations. Impacts on workers are complicated to estimate and to explain because they can include several different impacts, including involuntary unemployment, reductions in wage rates for those who continue to work, and voluntary reductions in hours worked due to lower wage rates. No model addresses all of these potential impacts. The N_{ew}ERA model is a long-run equilibrium model based upon full employment, and thus its results relate to the longer-term effects on labor income and voluntary reductions in hours worked rather than involuntary unemployment impacts. It addresses long-run employment impacts, all of which are based on estimates of changes in labor income, also called the "wage bill" or "payments to labor." Labor income impacts consist of two effects: (1) changes in real wage per hour worked; and (2) changes in labor market participation (hours worked) in response to changed real wage rates. The labor income change can also be expressed on a per-household basis, which represents one of the key components of disposal income per household. (The other key components of disposable income are returns on investments or "payments to capital," and income from ownership of natural resources). The labor income change can also be stated in terms of job-equivalents, by dividing the labor income change by the annual income from the average job. A loss of one job-equivalent does not

[27] EVs were not included in this analysis due to time constraints. However, previous experience with modeling EVs suggests they would not become economical except in the higher carbon tax case, and only in the later parts of the analysis horizon.

necessarily mean one less employed person—it may be manifested as a combination of fewer people working and less income per person who is working. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage.

D. Integrated N_{ew}ERA Model

The N_{ew}ERA modeling framework fully integrates the macroeconomic model and the electricity sector model so that the final solution is a consistent equilibrium for both models and thus for the entire U.S. economy.

To analyze any policy scenario, the system first solves for a consistent baseline solution; it then iterates between the two models to find the equilibrium solution for the scenario of interest. For the Baseline, the electricity sector model is solved first under initial economic assumptions and forecasts for electricity demand and energy prices. The equilibrium solution provides the baseline electricity prices, demand, and supply by region as well as the consumption of inputs—capital, labor, energy, and materials—by the electricity sector. These solution values are passed to the macroeconomic model.

Using these outputs from the electricity sector model, the macroeconomic model solves the Baseline while constraining the electricity sector to replicate the solution from the electricity sector model and imposing the same energy price forecasts as those used to solve the electricity sector Baseline. In addition to the energy price forecasts, the macroeconomic model's non-electric energy sectors are calibrated to the desired exogenous forecast (*e.g.*, EIA's latest AEO forecast) for energy consumption, energy production, and macroeconomic growth. The macroeconomic model solves for equilibrium prices and quantities in all markets subject to meeting these exogenous forecasts.

After solving the Baseline, the integrated N_{ew}ERA modeling system solves for the scenario. First the electricity sector model reads in the scenario definition. The electricity sector model then solves for the equilibrium level of electricity demand, electricity supply, and inputs used by the electricity sector (*i.e.*, capital, labor, energy, emission permits). The electricity sector model passes these equilibrium solution quantities to the macroeconomic model, which solves for the equilibrium prices and quantities in all markets. The macroeconomic model then passes to the electricity sector model the following (solved for equilibrium prices):

- Electricity prices by region;
- Prices of non-coal fuels used by the electricity sector (*e.g.*, natural gas, oil, and biofuels); and
- Prices of any permits that are tradable between the non-electricity and electricity sectors (*e.g.*, carbon permits under a nationwide greenhouse gas cap-and-trade program).

The electricity sector model then solves for the new electricity sector equilibrium, taking the prices from the macroeconomic model as exogenous inputs. The models iterate—prices being sent from the macroeconomic model to the electricity sector model and quantities being sent from the electricity sector model to the macroeconomic model—until the prices and quantities in the two models differ by less than a fraction of a percent.

This decomposition algorithm allows the N_{ew}ERA model to retain the information in the detailed electricity model, while at the same time accounting for interactions with the rest of the economy. The detailed information on the electricity sector enables the model to represent regulatory policies that are imposed on the electricity sector in terms of their impacts at a unit level.

E. References to the Appendix

Armington, P. 1969. "A Theory of Demand for Products Distinguished by Place of Production." *International Monetary Fund Staff Papers*, XVI: 159-78.

Arrow, K.J., and G. Debreu. 1954. "Existence of Equilibrium for a Competitive Economy." *Econometrica* 22:265-290.

Burfisher, M.E. 2011. *Introduction to Computable General Equilibrium Models*. New York: Cambridge University Press.

APPENDIX B. MODELING ASSUMPTIONS

This appendix includes additional details on the Baseline information used in this study for Federal fiscal information and energy information.

A. Baseline Federal Fiscal Information

Figure 35 provides the assumptions about the Baseline's debt level and the Federal government expenditures. As noted in the main body of the report, this Federal debt has been constructed using tax rate and Federal spending assumptions so that it remains at or below GDP in all years through 2053. The Federal government expenditures were set so that, in combination with the Federal tax rates described below, the debt-to-GDP ratio in the Baseline never exceeds 1.0.

Figure 35: Baseline Federal Debt and Federal Government Expenditures (Billions)

	2013	2023	2033	2043	2053
Federal Debt	$12,280	$19,210	$24,010	$30,320	$38,130
Federal Government Expenditures	$3,420	$3,740	$4,150	$4,190	$3,380

As noted in the main body of the report, the Federal tax rates are initially set at 2012 levels, and remain there through 2022. For that initial period, the tax rates for Federal personal capital and labor income are based on those in the National Bureau of Economic Research's (NBER's) TAXSIM model.[28] The Federal corporate income tax rates are from the Tax Foundation.[29] The PIT and corporate income tax rates are represented by a combination of (1) weighted averages of their marginal rates (taking into account that there are multiple marginal rates across income classes), and (2) a lump-sum transfer that is calculated to ensure that total tax revenues are consistent with the average tax rate actually paid after deductions, *etc.* These rates vary somewhat from state to state, as estimated by the NBER and Tax Foundation, due to differences in state income distributions. For 2013-2022, the Baseline average marginal Federal PIT rate is 25% on labor earnings and 12% to 15% (depending on the state) on capital earnings. The Baseline average marginal corporate income tax rate is 30% to 35%, depending on the state. The model estimates a weighted average of the state-specific levels to obtain the rates it applies in each of the model's multi-state macroeconomic regions. The FICA and HI rates in the initial period of 2013-2022 are set at 12.4% and 2.9%, respectively.[30]

As explained in the main body of the report, the Federal PIT rates are increased in the model year 2023 to the levels that are assumed in the CBO "Extended Baseline Scenario," which are the pre-2001 levels. This is done as one of two steps to hold the Baseline debt at a level that does not exceed GDP in any year (the other step being holding projected government spending to

[28] See http://users.nber.org/~taxsim/ for more information.

[29] See http://taxfoundation.org/ for more information.

[30] See http://www.ssa.gov/oact/progdata/taxRates.html for more information.

the levels shown in Figure 35). To achieve tax revenues equivalent to those of the CBO "Extended Baseline Scenario," baseline Federal PIT rates from 2023 through the end of the model horizon are raised by a factor of about 1.35 from the levels in effect during the model years 2013-2022, and the FICA rate is increased to 14.4%. The corporate income and HI tax rates remain at their initial 2013-2022 rates. (The tax rate increases in the Baseline that occur in 2023 should not be confused with the changes in PIT rates that occur in the carbon tax cases; changes from the Baseline's PIT rates that occur in the carbon tax cases are model results and are reported as percentage changes relative to the baseline rates described here.)

The model also accounts for state personal and corporate income taxes. Like the Federal rates, these are also obtained from NBER's TAXSIM model and the Tax Foundation, respectively. The Baseline rates are the same in all years of the modeled period (they do not change in 2023 as do the Federal rates). The state PIT income tax rates are zero in eight states, and the average marginal rate varies from about 3% to about 8% in the states that do have personal income taxes. The state corporate income tax rates are zero in six states, and the average marginal rate varies from about 3% to about 10% in the states that do have corporate income taxes. As with Federal tax rates, the model estimates a weighted average of state-specific levels to obtain the rates it applies in each of the model's multi-state macroeconomic regions.

B. Baseline Energy Information

Figure 36 reports the prices for natural gas and crude oil that the Baseline is calibrated to. These are national prices, based on AEO 2012. (Coal prices are specific to the type of coal, and are calculated endogenously in the model based on detailed coal supply curves. The results generally match those of AEO 2012.)

Figure 36: Baseline Fuel Prices ($/MMBtu)

	2013	2023	2033	2043	2053
Natural Gas (Wellhead)	$3.78	$4.85	$6.09	$8.42	$10.49
Crude Oil	$90	$112	$125	$149	$165

Figure 37 includes input assumptions for new electricity generating capacity. Capital costs of new generating capacity are based on the assumptions in AEO 2012, including the cost reductions over time (costs remain flat post-2033). The costs of each technology in each electricity region vary from these costs based on regional cost factors. Not included in the figure are costs for geothermal because these are site specific. In 2013, these costs range from $1,756/kilowatt (kW) to $22,350/kW and decline by 10% by 2033.

Figure 37: Electricity Generating Capacity Costs ($/kW)

Generating Technology	2013	2023	2033
Pulverized Coal*	$2,958	$2,840	$2,811
Coal Integrated Gasification Combined Cycle*	$3,347	$3,143	$3,094
Natural Gas Combined Cycle	$1,067	$1,027	$1,017
Natural Gas Combustion Turbine	$745	$704	$695
Onshore Wind	$2,521	$2,501	$2,496
Offshore Wind	$6,180	$4,325	$3,955
Biomass	$3,992	$3,539	$3,434
Solar PV	$4,919	$4,697	$4,427
Coal with CCS	$5,605	$5,109	$4,848
Combined Cycle with CCS	$2,244	$2,043	$1,923
Nuclear	$5,519	$4,834	$4,731

* Neither Pulverized Coal nor Coal Integrated Gasification Combined Cycle are available new options in this analysis as neither technology can currently meet the proposed New Source Performance Standards for Greenhouse Gases for New Electric Generating Units, however, these are the costs assumptions for these technologies that would be assumed if they were available options

Figure 38: Maximum Cumulative New Capacity Allowed (GW)

Generating Technology	2023	2033	2043	2053
Onshore Wind	102	222	342	462
Offshore Wind	14.5	47.5	100.5	173.5
Biomass	34	66	103	149.5
Solar PV	36	76	116	156
Geothermal	27	57	87	117
Coal with CCS	8	40	100	175
Combined Cycle with CCS	8	40	100	175
Nuclear	28	72	126	186

Baseline U.S. electricity demand grows at a 0.75% compound annual growth rate from 2013 through 2053. Different regions exhibit different growth rates.

Figure 39: Baseline Electricity Demand (TWh)

	2013	2023	2033	2043	2053
U.S. Electricity Demand	3,986	4,284	4,637	4,989	5,377

The N$_{ew}$ERA model includes five alternative fuels that can substitute for gasoline and three that can substitute for petroleum-based diesel.[31] Two of the defining characteristics of these fuels are their cost and emissions relative to their petroleum-based counterpart. Figure 40 reports the cost of alternative fuels relative to their petroleum-based counterpart. The cost for CNG includes the infrastructure costs associated with this fuel in the light duty vehicle (LDV) and commercial trucking markets.

Figure 40: Relative Costs of Alternative Fuels, Relative to Petroleum-Based Fuels

Alternative Fuel	2013	2023	2033	2043	2053
Corn Ethanol	1.6	1.5	1.5	1.5	1.5
Sugar Ethanol	1.8	1.7	1.7	1.7	1.7
Cellulosic Ethanol	2.7	2.4	2.3	2.3	2.3
CNG for LDVs	1.7	1.6	1.4	1.3	1.3
Biomass to Liquids (BTL) Gasoline	2.7	2.4	2.3	2.3	2.3
Soybean Diesel	1.8	1.7	1.7	1.7	1.7
CNG for Trucks	1.4	1.2	1.0	1.0	1.0
BTL Diesel	2.7	2.4	2.3	2.3	2.3

Figure 41 reports the emissions of the alternative fuels relative to their petroleum-based counterpart.

Figure 41: Emission Factors of Alternative Fuels, Relative to Petroleum-Based Fuels

Transportation Fuel	Emission Factor
Gasoline	*1.00*
Corn Ethanol	0.84
Sugar Ethanol	0.67
Cellulosic Ethanol	0.26
BTL Gasoline	0.21
CNG for LDVs	0.71
Diesel	*1.00*
Soybean Diesel	0.83
BTL Diesel	0.21
CNG for Trucks	0.72

[31] Additionally, the model has the ability to include EVs as another personal transportation technology option. This feature was not used in this analysis, so it is not documented here.

C. Other Assumptions

Crude oil is a global commodity with prices driven mostly by supply and demand outside of the United States. However, the 80% Reduction Tax Case is projected to have approximately 50% less consumption of crude oil in 2053 than in the Baseline (the $20 Tax Case only reduces crude consumption by 5% in 2053). Such an extensive change in crude oil demand in the United States is likely to reduce global crude oil prices.

To estimate the extent of the U.S. demand drop on global prices we reviewed results from the MIT Joint Program Report, "The Cost of Climate Policy in the United States."[32] We focused on the 167 billion metric tonnes of carbon dioxide equivalent (bmt) case that had similar reductions in U.S. crude oil consumption and applied the same percentage reductions to the crude oil price in our model (see Figure 42). The lowering of crude oil prices has a slight positive impact on the U.S. economy.

Figure 42: Reductions to Global Crude Oil Prices in 80% Tax Reduction Case

	2013	2023	2033	2043	2053
% Change from Baseline Prices	0%	-4%	-7%	-14%	-16%

[32] The text of the report is available at http://globalchange.mit.edu/pubs/abstract.php?publication_id=1965.

APPENDIX C. THE EFFECTS OF CHANGES IN FEDERAL GOVERNMENT DEBT ON INTEREST RATES

This appendix summarizes the literature on the effects of changes in Federal government debt on the economy, focusing on the potential effects of changes in federal debt on the interest rate on federal debt. We begin with an overview of three alternative conceptual approaches that have been developed to characterize the impacts of changes in Federal debt on the economy. We then summarize the rationales and empirical evidence for these approaches. The next section summarizes the results of the empirical study by Engen and Hubbard (2005) that we use as the basis for our estimate of the effects of changes in Federal debt on the interest rate used to determine government interest payments. The final section provides an overview of other potential effects of the federal debt (beyond changes in interest rates) that have been identified in the economic literature.

A. Overview of Conceptual Approaches for Assessing the Economic Effects of Government Debt

This section provides a framework for considering the linkage between the federal debt and macroeconomic variables. The initial effect of using carbon tax revenues to reduce government debt would be to increase public savings by the amount of the increased federal revenues. In terms of national income accounts, pubic savings are linked to private savings and investment through the following accounting identity:

Public Savings + Private Savings = Domestic Investment + Net Foreign Investment

In the identity above, net foreign investment refers to investment by domestic residents in other countries less domestic investment undertaken by foreign residents.

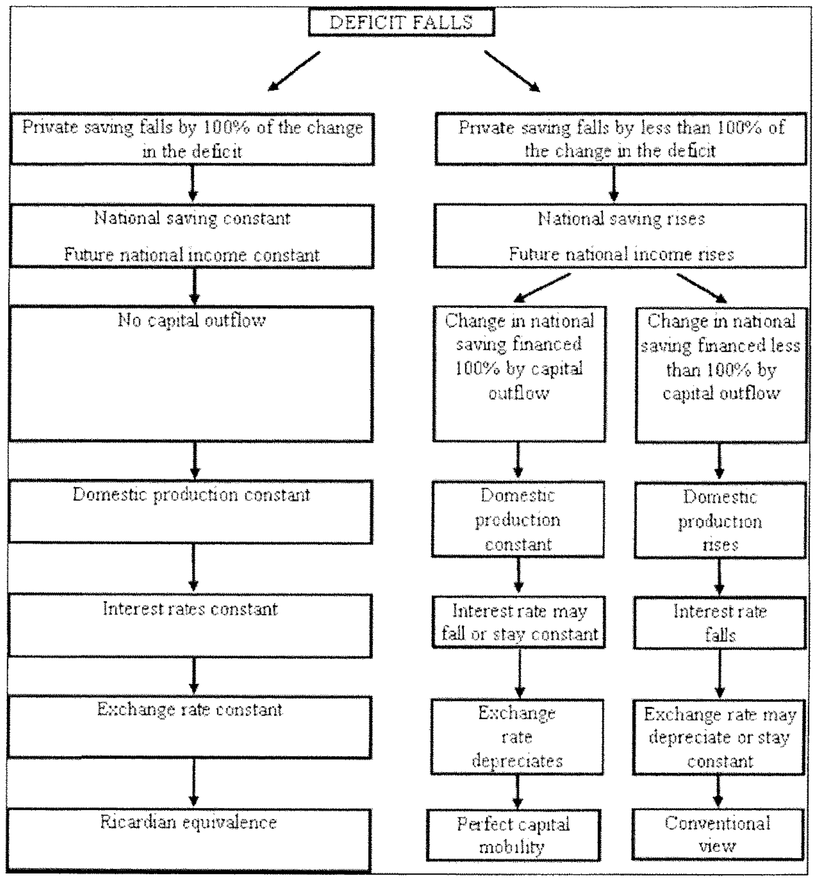
The economic effects of reductions in the Federal debt can be characterized in terms of the potential changes in the other three elements of this accounting identity that could result from the initial increase in public savings.[33] Gale and Orszag (2003) describe three potential outcomes that have been identified in the literature, as summarized below and in Figure 43.

1. **Ricardian equivalence.** This case assumes that an increase in public savings leads to an equal decrease in private savings, leaving total savings (and thus total investment and interest rates) unchanged.
2. **Perfect capital mobility.** This case assumes that an increase in public savings leads to an increase in net foreign investment (*i.e.*, capital inflows from abroad), leaving domestic investment unchanged. This outcome implies that domestic production is unchanged, but the domestic currency will depreciate and interest rates may fall.

[33] This characterization does not include all potential economic effects due to deficit changes. Other potential effects are summarized in the final section of this appendix.

3. **"Conventional view."** This case assumes that an increase in public savings leads to increases in both domestic investment and net foreign investment. This outcome implies that domestic production increases, the domestic currency depreciates and interest rates fall.

Figure 43: Effects of Deficit/Debt Reduction (Adapted from Gale and Orszag, 2003)



B. Theoretical and Empirical Support for Alternative Conceptual Approaches

1. Ricardian Equivalence Approach

One approach identified by Gale and Orszag for assessing the economic effects of government debt is to assume that all households display Ricardian equivalence.

i. The Theory of Equivalence

Budget deficits are reductions in public savings. Households may compensate for an increase in public savings by decreasing their private savings in anticipation of future fiscal policy (*e.g.*, tax decreases).

If all households display Ricardian equivalence (or "Barro-neutrality," which is a related concept), they are sufficiently forward looking that they fully internalize the expected future tax changes implied by changes in the government deficit (Barro (1974)). In other words, private savings would fully adjust to cancel out the changes in public savings, so that no change in interest rates or investment is required for total savings to equal total investment.

As Gale and Orszag note, Ricardian equivalence relies on several strong assumptions, including: 1) fully competitive markets; 2) no borrowing constraints; 3) a transparent tax system and perfect foresight of future fiscal policy; and 4) infinite planning periods of households and governments.

ii. Empirical Evidence on Ricardian Equivalence

Numerous studies of household saving behavior conclude that households respond to budget deficits, but not to the full extent predicted by Barro-neutrality. For example, the CBO (1998) concluded that private saving may offset 20% to 50% of a decline in public savings. Similarly, Elmendorf and Liebman (2000) argue that private saving would offset 25% of an increase in the deficit, and Gale and Potter (2002) estimate that private saving will offset 31% of the decline in public saving caused by the 2001 tax cut.

2. Perfect Capital Mobility Approach

A second approach described by Gale and Orszag (2003) for assessing the impacts of budget deficits assumes that there is an infinitely elastic supply of international capital.

i. The Theory of Perfect International Capital Mobility

The perfect capital mobility approach presumes that net foreign investment adjusts to satisfy the national accounting identity (total savings must equal total investment) and thus domestic investment does not change at all in response to changes in government savings. (Net foreign investment refers to investment by domestic residents in other countries less domestic investment undertaken by foreign residents.)

Under the "perfect capital mobility" approach, budget deficits lead to decreases in net foreign investment, which may lead to decreases in future national income as well, because increased indebtedness to foreigners implies that wealth will flow out of the country in the future (though some portion may eventually re-enter the domestic economy).

In addition, if reduced budget deficits lead to decreased interest rates (either because risk premiums change or because domestic investment is in fact affected by the deficit), domestic investment would become less attractive relative to foreign investment. This would leads to a decrease in the demand for domestic currency, so the domestic currency would depreciate. The depreciation of the domestic currency leads to decreased imports and increased exports, thus decreasing the trade deficit.

ii. Empirical Evidence on Perfect Capital Mobility

As with Ricardian equivalence, the empirical literature does not support the theory of perfect international capital mobility. Net foreign investment does adjust when there are changes in the Federal debt, but it does not fully counteract these changes so that domestic investment would remain unchanged, as the "perfect capital mobility" approach suggests. In other words, the impacts of Federal debt on net foreign investment are not zero but not sufficient to compensate for the full change in public savings when deficits change.

Gale and Orszag (2003) review the literature and estimate that changes in net foreign investment account for roughly between 25% and 40% of changes in national savings. Similarly, Elmendorf and Mankiw (1999) review the literature and estimate that changes in net foreign investment account for about 25% of changes in national savings. They also note that if returns to wealth are the same everywhere, the effects on national income are the same regardless of the extent to which domestic investment and net foreign investment are affected (Elmendorf and Mankiw, (1999)).

3. "Conventional View" of the Effects of Government Debt

The final approach described by Gale and Orszag (2003) for assessing the effects of government debt is referred to as the "conventional view" because it receives the most support in the literature.

i. Economic Theory of the "Conventional View"

The "conventional view" of the effects of government debt is that all three other elements (private savings, domestic investment, and net foreign investment) all adjust with changes in government debt. This view implies that domestic interest rates are affected by changes in the deficit through two potential mechanisms (which are fundamentally equivalent). First, budget deficits represent a decrease in national savings, and firms competing over this smaller pool of funds will need to offer higher rates. Second, budget deficits lead to an increase in the supply of government bonds. To persuade investors to hold more bonds, the government must offer a higher rate (so the price falls). If deficits are decreased, the changes are in the opposite directions, resulting in lower interest rates.

Lower interest rates lead to increased domestic private investment (which is referred to as the "crowding out" effect) and thus a larger long-term capital stock. A change in the capital stock has long-term impacts on the economy, and can lead to changes in technological progress and productivity (see Romer (1987) and DeLong and Summers (1991)).

On the other hand, economists have noted that in certain circumstances deficits can also cause domestic investment to increase when the deficits are used for government infrastructure. Government investment in certain public goods (*e.g.*, highways, airports, sewers) complements private capital and thus "crowds in" private investment (despite any increase in interest rates) because the marginal productivity of private capital rises (see, for example, Aschauer (1989), Eisner (1989), Heng (1997)).

ii. Empirical Evidence on the "Conventional View" of Government Debt

Empirical estimates of the change in domestic private investment due to budget deficits have been inconclusive. These studies range from finding that deficits cause large decreases in investment (*e.g.*, Auerbach and Kotlikoff (1987) find that the decrease in capital stock is roughly the same as any increase in debt, so there is "one-to-one crowding out") to net increases in investment (as noted above, Aschauer (1989), Eisner (1989), and Heng (1997) find that investment is actually "crowded in").

4. Critiques of the Gale and Orszag Conceptual Approaches

The three conceptual approaches described by Gale and Orszag (2003) of the effects of changes in Federal debt on the economy represent a range of potential outcomes that have been identified in the literature. However, it should be noted that other economists reject the Gale and Orszag premise that the major economic effects of deficits stem from the savings/investment accounting identity.

For example, Keynesian economists argue that the primary effects of deficit spending are impacts on real GDP. They argue that the Gale and Orszag approach is valid only in unrealistic models that always assume full employment. Further, investment can rise even if there is a lower investment share of GDP (Galbraith (2005)).

Other economists argue that the treatments of investment and interest rates are incomplete because they do not account for inevitable monetary policy responses to changes in deficits. When deficits occur, monetary authorities (*i.e.*, the central bank) purchase government debt to expand the money supply and keep prices and interest rates relatively constant (Engen and Hubbard (2005)). The recent experience of the United States provides support for this critique. Government debt has increased by an unprecedented amount (over 30% of 2007 levels), but long-term interest rates have actually fallen over this same period to near-record lows.

C. Empirical Estimate of Change in Interest Rates

Many studies that have estimated the relationships between deficits and debt and interest rates. We rely upon a study by Engen and Hubbard (2005) as the basis for the estimate we use of the relationship between federal debt (expressed as a ratio of GDP) and the interest rate.

1. Engen and Hubbard Study

Engen and Hubbard (2005) summarize the literature and provide their own estimates of the effect of changes in government debt on the interest rate. The authors caution that "both economic theory and empirical analysis of the relationship between debt and interest rates have proved inconclusive," and that comparing results across studies is hindered by "different definitions of government debt and interest rates, econometric approaches, sources of data, and rhetoric." The paper also notes that empirical estimates differ markedly based on whether the debt or the deficit is studied (Engen and Hubbard (2005), p. 4).

Engen and Hubbard indicates a small positive relationship between the debt and interest rates that is roughly consistent across its various theoretical and empirical calculations. Specifically, these authors conclude that an increase in federal debt equal to 1% of GDP would increase the long-term interest rate by about 3 basis points.

Recent work by Laubach (2009) has supported the conclusions of Engen and Hubbard. This paper finds a 3 to 4 basis point effect of a 1% increase in the projected debt-to-GDP ratio.

2. Other Empirical Studies and Literature Reviews

Many of the other empirical studies involve estimates of the effects of change in the deficit rather than the debt on interest rates. Barth *et al.* (1991) found that of 42 studies conducted through 1989, 17 found a significant positive effect of deficits on interest rates, 6 found mixed effects, and 19 found predominately insignificant or negative effects. A review by Gale and Orszag (2003) uses the studies collected by Barth *et al.* (1991) and others and finds that when studies without one particular independent variable (a proxy for the expectation of future deficits) are excluded, nearly all the remaining studies find a positive relationship between the deficit and interest rates. From this truncated sample, they postulate an average increase of 40 to 60 basis points in long-term interest rates from a 1% expansion of the *projected* deficit.

Similarly, Gale and Orszag (2004) conduct their own empirical analyses and conclude that "the estimated effect on forward long-term rates from a 1-percent-of-GDP shift in projected primary budget variables ranges between 40 and 67 basis points, depending on the specification and whether the fiscal variable is the primary deficit or revenue and primary outlays separately" (p. 32). They note that the impact on interest rates is notably smaller when the economy is in a recession (p. 30).

Brook (2003) conducted a literature review for the Organisation for Economic Co-operation and Development (OECD) and concludes that "most empirical work conducted in the past ten years estimates the impact on U.S. real long-term interest rates of a sustained 1 percentage point decrease in the U.S. fiscal position to be in the range of 20-40 basis points."

Various structural macroeconomic models have also been used to estimate the effects of government debt/deficits on interest rates. Gale and Orszag (2003) show that using these models, 10-year bond yields change between 5 and 220 basis points after increasing the *deficit* by 1% of GDP.

D. Other Potential Economic Impacts of Government Debt

A comprehensive review of the effects of government debt on the economy would also include an evaluation of various factors outside the scope of the three Gale and Orszag (2003) approaches described above. The following are other effects that have been identified in the literature.

1. Risk Premiums and the Size of the Federal Debt

The interest rate on debt reflects the expectation of repayment and the fear of default or devaluation. An increase in debt may lead to an increased fear of default, in which case risk premiums should rise. The country also becomes more susceptible to a crisis of international confidence and the depreciation of the currency (see Marris (1985) and Krugman (1991)). According to Trumen (2001), "The largest international risk with respect to paying down the debt is that a failure to carry it through undermines international confidence in US economic and financial policies."

Krishnamurthy and Vissing-Jorgensen (2010) estimate the discount at which U.S. government debt trades (in comparison to corporate bonds) due to its safety and liquidity. They find that this discount is influenced by both the debt-to-GDP ratio and the amount of foreign holdings. Historically, an average "convenience" yield for the period from 1926 to 2008 was 72 basis points, 46 of which were driven by liquidity, and 26 which were due to safety. This result suggests a reduced deficit (debt-GDP ratio) will drive up the liquidity premium and drive down the interest rate.

2. Impacts of the Federal Debt on Inflation

Budget deficits can lead to increased inflation because of expectations of future actions by the central bank. Paul Volcker told Congress in 1985 "... the actual and prospective size of the budget deficit ... heightens skepticism about our ability to control the money supply and contain inflation." Alan Greenspan said in 1995 that he expected "... a substantial reduction in the long-term prospective deficit of the United States will significantly lower very long-term inflation expectations *vis-a-vis* other countries." Sargent (1983) explains that inflation can fall sharply in such a country when government borrowing is reduced and the central bank commits not to finance future deficits (Elmendorf and Mankiw (1998)).

3. Future Distortionary Taxes and Federal Debt

An increase in budget deficits may imply that taxes need to be raised in the future to service the debt. Because taxes are generally distortionary, these future tax increases will lead to losses in economic efficiency.

If taxes are higher in the future, the loss in economic efficiency due to the distortionary taxes will be larger than it would be for an increase in taxes today if the marginal efficiency loss increases with the tax rates, as economic theory predicts.

Of course, if lump sum taxes are implemented, this effect disappears because these taxes are not distortionary. In addition, if GDP growth is higher than the long-run government interest rate, the government may be able to continue to rollover its debt forever (Ball and Mankiw, 1995).

4. Policy Uncertainty and Federal Debt

Policy uncertainty increases if deficits are accumulated at an unsustainable pace. This uncertainty can be a hindrance to economic performance because it makes long-term planning difficult. As Gale and Orszag (2003) note,

> *Long-term deficits create significant uncertainty... After all, the government cannot continue to run deficits so large that the public debt grows faster than output... What specific taxes will be raised? What specific spending programs will be reduced? Will the government be forced to resort to extreme measures, such as printing money to finance deficits?*

5. Internatioual Leadership and the Federal Debt

There have also been suggestions in the literature that a nation's borrowing status corresponds with its ability to provide leadership. For example, Friedman (1988) asserted:

> *World power and influence have historically accrued to creditor countries. It is not coincidental that America emerged as a world power simultaneously with our transition from a debtor nation ... to a creditor supplying investment capital to the rest of the world.* (p. 13)

6. Distributional Impacts of the Federal Debt

The accumulation of federal debt does not necessarily increase or reduce welfare, but it has clear distributional impacts across types of individuals and periods in time. The winners from budget deficits are current taxpayers and future owners of capital (because the marginal product of capital rises), whereas the losers are future taxpayers and future workers (because real wages fall) (Ball and Mankiw, 1995).

E. Summary

Theoretical and empirical studies have led some economists to assert that there is no relationship between government debt and interest rates and still others to conclude that there is a strong positive relationship. Nevertheless, if a single parameter must be selected to govern this relationship, it should be grounded in economy theory, backed by empirical results, and not at odds with historical experience.

We use the Engen and Hubbard (2005) study for our empirical estimate of the relationship between changes in Federal government debt and changes in the interest rate; the resulting changes in the interest rate are used to calculate the effects on Federal debt payments. Engen and Hubbard (2005) find that a change in government debt equal to 1% of GDP results in a change in long-term interest rates of roughly 3 basis points. The study is a relatively recent and comprehensive review of the literature that is solely devoted to the relationship between government debt and interest rates. The result of debt having a small positive effect on long-term interest rates is arguably more plausible than claims of either no effect of government debt (which many economics would say is inconsistent with economic theory) or a large effect of debt (which is arguably inconsistent with recent historical experience of large increases in Federal debt corresponding with decreases in interest rates).

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APPENDIX D. REGIONAL RESULTS

This appendix includes additional regional results for each of the 11 macroeconomic regions in the N_{ew}ERA model. The initial figures contain results across regions. The subsequent figures include a set of results for each of the 11 regions.

Figure 44: Gross Regional Product (Percentage Change from Baseline)

Region	Present Value	2013	2023	2033	2043	2053
$20 Tax Case						
Arizona and Mountain States	-1.3%	-1.5%	-1.2%	-1.2%	-1.3%	-1.4%
California	-0.4%	-0.3%	-0.4%	-0.5%	-0.5%	-0.6%
Florida	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%	-0.2%
Mid-Atlantic	-0.6%	-0.5%	-0.5%	-0.6%	-0.7%	-0.8%
Mid-America	-0.5%	-0.7%	-0.4%	-0.4%	-0.6%	-0.7%
Mississippi Valley	-0.5%	-0.5%	-0.4%	-0.4%	-0.5%	-0.6%
New York/New England	-0.4%	0.0%	-0.4%	-0.5%	-0.6%	-0.6%
Pacific Northwest	-0.4%	-0.5%	-0.4%	-0.4%	-0.3%	-0.3%
Southeast	-0.4%	-0.6%	-0.4%	-0.4%	-0.3%	-0.3%
Texas, Oklahoma, Louisiana	-0.1%	0.4%	-0.2%	-0.1%	-0.3%	-0.6%
Upper Midwest	-0.7%	-0.9%	-0.6%	-0.6%	-0.6%	-0.6%
U.S.	**-0.5%**	**-0.4%**	**-0.5%**	**-0.5%**	**-0.5%**	**-0.6%**
80% Reduction Tax Case						
Arizona and Mountain States	-2.6%	-2.2%	-1.5%	-2.3%	-4.3%	-5.1%
California	-1.2%	-0.1%	-0.4%	-1.0%	-2.7%	-4.1%
Florida	-0.5%	0.2%	-0.1%	-0.4%	-1.4%	-2.2%
Mid-Atlantic	-1.4%	-0.5%	-0.6%	-1.2%	-2.9%	-4.3%
Mid-America	-1.3%	-0.9%	-0.4%	-1.1%	-2.6%	-3.4%
Mississippi Valley	-1.0%	-0.4%	-0.3%	-0.8%	-2.2%	-3.2%
New York/New England	-1.1%	0.3%	-0.4%	-1.0%	-2.7%	-4.0%
Pacific Northwest	-1.2%	-0.5%	-0.5%	-1.0%	-2.5%	-3.4%
Southeast	-0.8%	-0.6%	-0.4%	-0.7%	-1.6%	-2.2%
Texas, Oklahoma, Louisiana	-1.3%	0.0%	-0.4%	-1.0%	-3.1%	-4.2%
Upper Midwest	-1.1%	-1.1%	-0.6%	-0.8%	-1.8%	-2.6%
U.S.	**-1.2%**	**-0.4%**	**-0.5%**	**-1.0%**	**-2.5%**	**-3.6%**

Present value calculated using a 5% real discount rate.

Figure 45: Delivered Residential Electricity Prices (Percentage Change from Baseline)

Region	2013	2023	2033	2043	2053
$20 Tax Case					
Arizona and Mountain States	12%	12%	15%	23%	19%
California	7.7%	11%	12%	14%	16%
Florida	10%	10%	17%	18%	19%
Mid-Atlantic	15%	10%	17%	22%	19%
Mid-America	9.3%	15%	20%	22%	18%
Mississippi Valley	14%	15%	19%	20%	21%
New York/New England	9.4%	7.7%	9.6%	12%	15%
Pacific Northwest	10%	12%	15%	22%	18%
Southeast	14%	10%	18%	22%	22%
Texas, Oklahoma, Louisiana	10%	14%	17%	24%	20%
Upper Midwest	13%	12%	17%	24%	21%
U.S.	**12%**	**12%**	**16%**	**21%**	**20%**
80% Reduction Tax Case					
Arizona and Mountain States	11%	20%	29%	60%	41%
California	11%	12%	21%	46%	31%
Florida	10%	16%	34%	65%	44%
Mid-Atlantic	17%	19%	34%	65%	46%
Mid-America	9.2%	25%	31%	54%	35%
Mississippi Valley	13%	24%	27%	61%	43%
New York/New England	9.1%	9.8%	19%	48%	33%
Pacific Northwest	11%	15%	29%	59%	35%
Southeast	16%	17%	36%	71%	51%
Texas, Oklahoma, Louisiana	10%	17%	29%	62%	43%
Upper Midwest	15%	20%	34%	66%	42%
U.S.	**13%**	**18%**	**30%**	**61%**	**42%**

Figure 46: Electricity Demand (Percentage Change from Baseline)

Region	2013	2023	2033	2043	2053
$20 Tax Case					
Arizona and Mountain States	-2.7%	-8.3%	-9.9%	-14%	-12%
California	-1.2%	-6.4%	-8.0%	-8.9%	-10%
Florida	-2.0%	-6.5%	-11%	-11%	-12%
Mid-Atlantic	-2.3%	-5.8%	-10%	-12%	-11%
Mid-America	-2.9%	-12%	-14%	-14%	-12%
Mississippi Valley	-3.3%	-10%	-13%	-13%	-13%
New York/New England	-1.8%	-5.0%	-6.6%	-8.5%	-10%
Pacific Northwest	-2.2%	-8.0%	-9.7%	-13%	-11%
Southeast	-2.5%	-6.6%	-11%	-13%	-12%
Texas, Oklahoma, Louisiana	-2.3%	-8.6%	-11%	-14%	-12%
Upper Midwest	-2.5%	-7.6%	-11%	-14%	-12%
U.S.	**-2.4%**	**-7.7%**	**-11%**	**-12%**	**-12%**
80% Reduction Tax Case					
Arizona and Mountain States	-2.7%	-12%	-17%	-28%	-25%
California	-1.7%	-7.3%	-13%	-23%	-21%
Florida	-1.9%	-9.6%	-19%	-29%	-23%
Mid-Atlantic	-2.4%	-9.6%	-18%	-28%	-25%
Mid-America	-2.8%	-17%	-19%	-28%	-25%
Mississippi Valley	-3.1%	-15%	-17%	-29%	-27%
New York/New England	-1.7%	-6.2%	-12%	-25%	-22%
Pacific Northwest	-2.2%	-9.8%	-16%	-27%	-23%
Southeast	-2.6%	-9.6%	-19%	-29%	-26%
Texas, Oklahoma, Louisiana	-2.4%	-10%	-17%	-29%	-27%
Upper Midwest	-2.6%	-11%	-18%	-29%	-26%
U.S.	**-2.4%**	**-11%**	**-17%**	**-28%**	**-25%**

Figure 47: Coal Use in Electricity (Change from Baseline, in Quadrillion Btu)

Region	2013	2023	2033	2043	2053
$20 Tax Case					
Arizona and Mountain States	-0.3	-0.8	-0.7	-0.6	-1.0
California	0.0	0.0	0.0	0.0	0.0
Florida	-0.1	-0.5	-0.6	-0.5	-0.7
Mid-Atlantic	-0.3	-0.9	-0.9	-0.9	-1.0
Mid-America	-0.2	-0.6	-0.6	-0.6	-0.8
Mississippi Valley	-0.6	-1.4	-1.5	-1.4	-1.8
New York/New England	-0.1	-0.2	-0.3	-0.2	-0.3
Pacific Northwest	-0.1	0.0	0.0	0.0	-0.1
Southeast	-0.6	-2.0	-2.4	-2.4	-3.0
Texas, Oklahoma, Louisiana	-0.2	-0.8	-0.9	-0.8	-1.4
Upper Midwest	-0.4	-0.8	-0.9	-0.8	-1.8
U.S.	**-2.8**	**-8.2**	**-9.0**	**-8.2**	**-11.8**
80% Reduction Tax Case					
Arizona and Mountain States	-0.3	-1.1	-1.9	-2.2	-2.2
California	0.0	0.0	0.0	0.0	0.0
Florida	-0.1	-0.5	-0.7	-0.8	-0.8
Mid-Atlantic	-0.2	-1.1	-1.4	-1.6	-1.6
Mid-America	-0.3	-0.8	-1.5	-1.8	-1.8
Mississippi Valley	-0.6	-2.1	-2.9	-3.2	-3.2
New York/New England	-0.1	-0.2	-0.3	-0.3	-0.3
Pacific Northwest	-0.1	0.0	-0.1	-0.1	-0.1
Southeast	-0.6	-2.4	-3.7	-4.0	-4.0
Texas, Oklahoma, Louisiana	-0.2	-1.2	-2.1	-2.2	-2.2
Upper Midwest	-0.4	-1.1	-3.4	-4.3	-4.3
U.S.	**-2.7**	**-10.6**	**-18.0**	**-20.4**	**-20.5**

Figure 48: Natural Gas Use in Electricity (Change from Baseline, in Quadrillion Btu)

Region	2013	2023	2033	2043	2053
$20 Tax Case					
Arizona and Mountain States	0.1	0.1	-0.1	0.0	-0.8
California	0.0	0.0	0.1	-0.2	-0.1
Florida	0.0	0.1	0.0	0.0	0.0
Mid-Atlantic	0.1	0.1	0.0	0.0	0.0
Mid-America	0.0	0.1	0.1	0.1	0.2
Mississippi Valley	0.2	0.4	0.3	0.1	0.2
New York/New England	0.1	0.0	0.0	-0.1	-0.4
Pacific Northwest	0.0	0.0	0.0	-0.3	-0.3
Southeast	0.3	0.5	0.5	0.0	-0.2
Texas, Oklahoma, Louisiana	0.2	0.3	-0.2	-0.6	-0.3
Upper Midwest	0.1	0.0	0.0	-0.1	-0.3
U.S.	**1.2**	**1.8**	**0.7**	**-1.1**	**-2.0**
80% Reduction Tax Case					
Arizona and Mountain States	0.1	0.2	0.5	-0.4	-0.4
California	0.0	0.0	0.0	-1.1	-0.9
Florida	0.0	0.1	0.0	-0.4	-0.3
Mid-Atlantic	0.1	0.1	0.1	-0.3	-0.2
Mid-America	0.0	0.2	0.6	0.8	0.9
Mississippi Valley	0.2	0.6	0.7	0.3	0.6
New York/New England	0.1	0.1	0.0	-0.6	-0.9
Pacific Northwest	0.0	0.0	0.0	-0.6	-0.6
Southeast	0.3	0.8	0.9	-0.5	-0.8
Texas, Oklahoma, Louisiana	0.2	0.6	0.8	-0.2	0.0
Upper Midwest	0.1	0.1	0.1	0.2	0.3
U.S.	**1.2**	**2.7**	**3.6**	**-2.8**	**-2.2**

Figure 49: Regional Results for Arizona and Mountain States

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012\$/metric ton of CO_2)					
\$20 Tax	\$20	\$30	\$44	\$65	\$96
80% Reduction	\$20	\$40	\$90	\$350	\$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
\$20 Tax	410	370	360	380	320
80% Reduction	410	340	270	160	120
Carbon Tax Costs (Billions of 2012\$)					
\$20 Tax	\$8	\$11	\$16	\$25	\$31
80% Reduction	\$8	\$14	\$24	\$56	\$120

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
\$20 Tax	-1.5%	-1.2%	-1.2%	-1.3%	-1.4%
80% Reduction	-2.2%	-1.5%	-2.3%	-4.3%	-5.1%
Consumption (% Change from Baseline)					
\$20 Tax	-1.0%	-1.1%	-1.1%	-1.2%	-1.2%
80% Reduction	-1.7%	-1.9%	-2.2%	-2.9%	-3.8%
Change in Consumption per Household (2012\$/Household)					
\$20 Tax	-\$840	-\$970	-\$950	-\$1,010	-\$1,040
80% Reduction	-\$1,480	-\$1,700	-\$1,850	-\$2,470	-\$3,390
Investment (% Change from Baseline)					
\$20 Tax	-4.6%	-2.0%	-1.3%	-1.6%	-1.4%
80% Reduction	-5.4%	-2.7%	-2.4%	-10%	-9.4%

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
\$20 Tax	44%	33%	39%	39%	45%
80% Reduction	44%	49%	86%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
\$20 Tax	12%	12%	15%	23%	19%
80% Reduction	11%	20%	29%	60%	41%
Gasoline Prices (% Change from Baseline)					
\$20 Tax	6.4%	7.7%	10%	13%	17%
80% Reduction	7.4%	9.3%	18%	60%	164%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	2.2	2.4	2.3	2.3	2.4
\$20 Tax	1.9	1.5	1.6	1.8	1.5
80% Reduction	1.9	1.3	0.4	0.2	0.3
Natural Gas Consumption (Quadrillion Btu)					
Baseline	1.6	1.8	2.0	2.0	2.5
\$20 Tax	1.7	1.8	1.8	2.0	1.7
80% Reduction	1.7	1.9	2.4	1.3	1.7
Gasoline (Billions of Gallons)					
Baseline	8.0	7.3	7.0	6.9	6.7
\$20 Tax	8.0	7.1	6.7	6.5	6.2
80% Reduction	7.9	7.0	6.5	5.5	4.2

Regional Results for Arizona and Mountain States

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.7	9.1	9.3	9.3	11
80% Reduction	0.7	13	15	27	27
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.7%	-8.3%	-9.9%	-14%	-12%
80% Reduction	-2.7%	-12%	-17%	-28%	-25%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-1.6%	-1.5%	-1.4%	-1.6%	-1.7%
80% Reduction	-2.0%	-2.0%	-2.5%	-5.6%	-8.5%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-180	-180	-190	-250	-290
80% Reduction	-210	-220	-340	-890	-1,490

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.57%
80% Reduction	-1.29%

Figure 50: Regional Results for California

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012$/metric ton of CO_2)					
$20 Tax	$20	$30	$44	$65	$96
80% Reduction	$20	$40	$90	$350	$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
$20 Tax	370	360	370	390	370
80% Reduction	370	350	340	270	190
Carbon Tax Costs (Billions of 2012$)					
$20 Tax	$7	$11	$16	$25	$36
80% Reduction	$7	$14	$31	$95	$190

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
$20 Tax	-0.3%	-0.4%	-0.5%	-0.5%	-0.6%
80% Reduction	-0.1%	-0.4%	-1.0%	-2.7%	-4.1%
Consumption (% Change from Baseline)					
$20 Tax	0.3%	-0.1%	-0.1%	-0.2%	-0.2%
80% Reduction	0.5%	-0.2%	-0.5%	-1.4%	-2.4%
Change in Consumption per Household (2012$/Household)					
$20 Tax	$310	-$90	-$120	-$250	-$230
80% Reduction	$510	-$340	-$590	-$1,490	-$2,890
Investment (% Change from Baseline)					
$20 Tax	0.2%	-0.7%	-0.2%	-0.9%	-0.9%
80% Reduction	1.7%	-0.9%	-2.2%	-5.4%	-8.2%

Regional Results for California

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
$20 Tax	44%	33%	39%	39%	45%
80% Reduction	44%	49%	86%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
$20 Tax	7.7%	11%	12%	14%	16%
80% Reduction	11%	12%	21%	46%	31%
Gasoline Prices (% Change from Baseline)					
$20 Tax	5.9%	7.4%	10%	13%	17%
80% Reduction	6.2%	9.0%	17%	60%	164%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	0.1	0.1	0.1	0.1	0.3
$20 Tax	0.0	0.0	0.2	0.3	0.4
80% Reduction	0.0	0.1	0.2	0.4	0.6
Natural Gas Consumption (Quadrillion Btu)					
Baseline	2.5	2.6	2.8	3.5	3.8
$20 Tax	2.5	2.5	2.9	3.3	3.6
80% Reduction	2.5	2.5	2.6	2.1	2.3
Gasoline (Billions of Gallons)					
Baseline	14	12	12	12	11
$20 Tax	14	12	11	11	11
80% Reduction	14	12	11	9.5	7.2

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.0	0.0	0.0	0.0	0.0
80% Reduction	0.0	0.0	0.0	0.4	0.4
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-1.2%	-6.4%	-8.0%	-8.9%	-10%
80% Reduction	-1.7%	-7.3%	-13%	-23%	-21%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-0.2%	-0.6%	-0.5%	-0.6%	-0.8%
80% Reduction	0.1%	-0.6%	-1.0%	-3.2%	-6.2%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-50	-190	-190	-250	-320
80% Reduction	0	-200	-330	-1,070	-2,060

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	0.06%
80% Reduction	-0.19%

Figure 51: Regional Results for Florida

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012$/metric ton of CO_2)					
$20 Tax	$20	$30	$44	$65	$96
80% Reduction	$20	$40	$90	$350	$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
$20 Tax	200	180	170	160	130
80% Reduction	200	180	150	100	60
Carbon Tax Costs (Billions of 2012$)					
$20 Tax	$4	$5	$7	$10	$12
80% Reduction	$4	$7	$14	$35	$60

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
$20 Tax	-0.1%	-0.2%	-0.1%	-0.1%	-0.2%
80% Reduction	0.2%	-0.1%	-0.4%	-1.4%	-2.2%
Consumption (% Change from Baseline)					
$20 Tax	0.3%	-0.1%	-0.1%	-0.2%	-0.2%
80% Reduction	0.6%	-0.1%	-0.3%	-1.0%	-2.0%
Change in Consumption per Household (2012$/Household)					
$20 Tax	$270	-$60	-$50	-$150	-$140
80% Reduction	$540	-$110	-$230	-$770	-$1,990
Investment (% Change from Baseline)					
$20 Tax	-1.5%	-2.7%	-2.8%	-1.1%	-1.7%
80% Reduction	0.1%	-3.3%	-1.1%	-3.0%	-5.2%

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
$20 Tax	44%	33%	39%	39%	45%
80% Reduction	44%	49%	86%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
$20 Tax	10%	10%	17%	18%	19%
80% Reduction	10%	16%	34%	65%	44%
Gasoline Prices (% Change from Baseline)					
$20 Tax	6.0%	7.4%	10%	13%	17%
80% Reduction	6.3%	8.9%	17%	61%	167%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	0.3	0.7	0.8	0.8	0.9
$20 Tax	0.2	0.2	0.2	0.4	0.3
80% Reduction	0.2	0.2	0.1	0.1	0.2
Natural Gas Consumption (Quadrillion Btu)					
Baseline	1.4	1.2	1.1	0.7	0.6
$20 Tax	1.4	1.2	1.1	0.8	0.6
80% Reduction	1.4	1.3	1.2	0.4	0.4
Gasoline (Billions of Gallons)					
Baseline	7.4	6.7	6.4	6.3	6.2
$20 Tax	7.4	6.6	6.2	6.0	5.7
80% Reduction	7.4	6.5	6.0	5.1	3.9

Regional Results for Florida

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.0	5.8	5.8	5.8	6.2
80% Reduction	0.0	6.5	10	11	11
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.0%	-6.5%	-11%	-11%	-12%
80% Reduction	-1.9%	-9.6%	-19%	-29%	-23%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-0.5%	-0.7%	-0.7%	-0.8%	-0.9%
80% Reduction	-0.1%	-0.9%	-1.4%	-3.6%	-5.6%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-50	-110	-120	-140	-170
80% Reduction	-10	-130	-210	-550	-900

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.07%
80% Reduction	-0.35%

Figure 52: Regional Results for Mid-Atlantic

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012$/metric ton of CO_2)					
$20 Tax	$20	$30	$44	$65	$96
80% Reduction	$20	$40	$90	$350	$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
$20 Tax	430	370	350	350	320
80% Reduction	440	340	290	220	150
Carbon Tax Costs (Billions of 2012$)					
$20 Tax	$9	$11	$15	$23	$31
80% Reduction	$9	$14	$26	$77	$150

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
$20 Tax	-0.5%	-0.5%	-0.6%	-0.7%	-0.8%
80% Reduction	-0.5%	-0.6%	-1.2%	-2.9%	-4.3%
Consumption (% Change from Baseline)					
$20 Tax	0.0%	-0.4%	-0.4%	-0.5%	-0.5%
80% Reduction	0.0%	-0.7%	-1.0%	-1.8%	-2.9%
Change in Consumption per Household (2012$/Household)					
$20 Tax	-$20	-$460	-$470	-$580	-$590
80% Reduction	-$30	-$820	-$1,060	-$1,910	-$3,450
Investment (% Change from Baseline)					
$20 Tax	-4.1%	-1.3%	-1.0%	-1.7%	-1.0%
80% Reduction	-2.2%	1.8%	-1.7%	-7.1%	-8.6%

Regional Results for Mid-Atlantic

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
$20 Tax	44%	33%	39%	39%	45%
80% Reduction	44%	49%	86%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
$20 Tax	15%	10%	17%	22%	19%
80% Reduction	17%	19%	34%	65%	46%
Gasoline Prices (% Change from Baseline)					
$20 Tax	6.1%	7.6%	10%	13%	17%
80% Reduction	6.6%	9.1%	18%	60%	165%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	1.6	1.8	1.8	1.9	2.0
$20 Tax	1.4	0.8	0.9	1.1	1.0
80% Reduction	1.4	0.7	0.4	0.3	0.5
Natural Gas Consumption (Quadrillion Btu)					
Baseline	1.8	1.9	1.8	1.8	1.7
$20 Tax	2.0	1.9	1.8	1.8	1.7
80% Reduction	1.9	1.9	1.8	1.2	1.1
Gasoline (Billions of Gallons)					
Baseline	13	11	11	11	10
$20 Tax	13	11	10	10	9.7
80% Reduction	13	11	10	8.7	6.7

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.2	9.0	10	10	13
80% Reduction	0.2	11	20	24	24
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.3%	-5.8%	-10%	-12%	-11%
80% Reduction	-2.4%	-9.6%	-18%	-28%	-25%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-0.9%	-0.8%	-0.8%	-0.9%	-1.0%
80% Reduction	-0.7%	-1.1%	-1.6%	-3.9%	-6.7%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-150	-180	-200	-260	-300
80% Reduction	-120	-240	-360	-970	-1,730

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.12%
80% Reduction	-0.45%

Figure 53: Regional Results for Mid-America

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012\$/metric ton of CO_2)					
\$20 Tax	\$20	\$30	\$44	\$65	\$96
80% Reduction	\$20	\$40	\$90	\$350	\$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
\$20 Tax	340	300	310	320	290
80% Reduction	330	280	210	150	110
Carbon Tax Costs (Billions of 2012\$)					
\$20 Tax	\$7	\$9	\$14	\$21	\$28
80% Reduction	\$7	\$11	\$19	\$53	\$110

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
\$20 Tax	-0.7%	-0.4%	-0.4%	-0.6%	-0.7%
80% Reduction	-0.9%	-0.4%	-1.1%	-2.6%	-3.4%
Consumption (% Change from Baseline)					
\$20 Tax	-0.3%	-0.5%	-0.5%	-0.6%	-0.6%
80% Reduction	-0.5%	-0.9%	-1.1%	-1.8%	-2.6%
Change in Consumption per Household (2012\$/Household)					
\$20 Tax	-\$290	-\$480	-\$450	-\$540	-\$560
80% Reduction	-\$520	-\$900	-\$1,050	-\$1,590	-\$2,550
Investment (% Change from Baseline)					
\$20 Tax	-6.0%	-1.1%	-0.3%	-1.2%	-1.7%
80% Reduction	-4.5%	0.7%	-2.3%	-8.5%	-9.0%

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
\$20 Tax	44%	33%	39%	39%	44%
80% Reduction	43%	49%	85%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
\$20 Tax	9.3%	15%	20%	22%	18%
80% Reduction	9.2%	25%	31%	54%	35%
Gasoline Prices (% Change from Baseline)					
\$20 Tax	6.1%	7.4%	9.8%	12%	17%
80% Reduction	6.7%	8.8%	17%	60%	165%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	1.8	1.9	2.0	2.1	2.1
\$20 Tax	1.6	1.3	1.4	1.5	1.3
80% Reduction	1.5	1.1	0.5	0.2	0.3
Natural Gas Consumption (Quadrillion Btu)					
Baseline	1.3	1.3	1.3	1.4	1.5
\$20 Tax	1.3	1.3	1.3	1.5	1.7
80% Reduction	1.3	1.3	1.8	1.9	1.9
Gasoline (Billions of Gallons)					
Baseline	6.9	6.2	5.9	5.9	5.7
\$20 Tax	6.8	6.1	5.7	5.6	5.3
80% Reduction	6.8	6.0	5.6	4.8	3.7

Regional Results for Mid-America

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.0	8.8	8.8	8.8	11
80% Reduction	0.0	12	19	25	25
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.9%	-12%	-14%	-14%	-12%
80% Reduction	-2.8%	-17%	-19%	-28%	-25%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-1.1%	-1.3%	-1.4%	-1.5%	-1.5%
80% Reduction	-1.0%	-1.8%	-2.4%	-5.4%	-8.5%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-100	-150	-170	-210	-230
80% Reduction	-90	-180	-280	-730	-1,250

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.32%
80% Reduction	-0.89%

Figure 54: Regional Results for Mississippi Valley

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012$/metric ton of CO_2)					
$20 Tax	$20	$30	$44	$65	$96
80% Reduction	$20	$40	$90	$350	$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
$20 Tax	650	560	550	550	490
80% Reduction	650	490	410	290	200
Carbon Tax Costs (Billions of 2012$)					
$20 Tax	$13	$17	$24	$36	$47
80% Reduction	$13	$20	$37	$102	$200

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
$20 Tax	-0.5%	-0.4%	-0.4%	-0.5%	-0.6%
80% Reduction	-0.4%	-0.3%	-0.8%	-2.2%	-3.2%
Consumption (% Change from Baseline)					
$20 Tax	-0.1%	-0.3%	-0.4%	-0.4%	-0.5%
80% Reduction	-0.1%	-0.6%	-0.8%	-1.4%	-2.3%
Change in Consumption per Household (2012$/Household)					
$20 Tax	-$70	-$330	-$330	-$420	-$410
80% Reduction	-$70	-$560	-$730	-$1,200	-$2,210
Investment (% Change from Baseline)					
$20 Tax	-7.3%	0.3%	-0.1%	-1.4%	-1.2%
80% Reduction	-6.9%	2.5%	-1.6%	-6.9%	-9.1%

Regional Results for Mississippi Valley

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
$20 Tax	44%	33%	39%	39%	45%
80% Reduction	44%	49%	86%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
$20 Tax	14%	15%	19%	20%	21%
80% Reduction	13%	24%	27%	61%	43%
Gasoline Prices (% Change from Baseline)					
$20 Tax	5.8%	7.3%	9.8%	12%	17%
80% Reduction	6.3%	8.7%	17%	59%	164%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	3.4	3.4	3.5	3.6	3.7
$20 Tax	2.8	1.9	2.0	2.3	1.9
80% Reduction	2.8	1.3	0.7	0.3	0.5
Natural Gas Consumption (Quadrillion Btu)					
Baseline	2.5	2.6	2.7	2.8	2.9
$20 Tax	2.6	2.8	2.8	2.8	2.9
80% Reduction	2.6	2.9	3.1	2.5	2.5
Gasoline (Billions of Gallons)					
Baseline	16	14	14	14	13
$20 Tax	16	14	13	13	12
80% Reduction	16	14	13	11	8.6

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.2	24	24	24	25
80% Reduction	0.2	31	35	48	48
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-3.3%	-10%	-13%	-13%	-13%
80% Reduction	-3.1%	-15%	-17%	-29%	-27%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-0.9%	-1.2%	-1.1%	-1.2%	-1.3%
80% Reduction	-0.6%	-1.5%	-1.9%	-4.8%	-7.7%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-200	-300	-330	-410	-480
80% Reduction	-140	-380	-540	-1,470	-2,550

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.23%
80% Reduction	-0.67%

Figure 55: Regional Results for New York/New England

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012$/metric ton of CO_2)					
$20 Tax	$20	$30	$44	$65	$96
80% Reduction	$20	$40	$90	$350	$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
$20 Tax	320	290	290	290	270
80% Reduction	320	280	270	210	130
Carbon Tax Costs (Billions of 2012$)					
$20 Tax	$6	$9	$13	$19	$26
80% Reduction	$6	$11	$24	$74	$130

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
$20 Tax	0.0%	-0.4%	-0.5%	-0.6%	-0.6%
80% Reduction	0.3%	-0.4%	-1.0%	-2.7%	-4.0%
Consumption (% Change from Baseline)					
$20 Tax	0.5%	0.0%	-0.1%	-0.2%	-0.2%
80% Reduction	0.8%	-0.1%	-0.4%	-1.4%	-2.4%
Change in Consumption per Household (2012$/Household)					
$20 Tax	$590	$10	-$20	-$180	-$170
80% Reduction	$950	-$150	-$440	-$1,500	-$3,190
Investment (% Change from Baseline)					
$20 Tax	3.9%	-2.4%	-1.7%	-1.3%	-1.6%
80% Reduction	5.1%	-2.9%	-2.7%	-4.6%	-7.5%

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
$20 Tax	44%	33%	39%	39%	45%
80% Reduction	44%	49%	86%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
$20 Tax	9.4%	7.7%	9.6%	12%	15%
80% Reduction	9.1%	9.8%	19%	48%	33%
Gasoline Prices (% Change from Baseline)					
$20 Tax	5.9%	7.5%	10%	13%	17%
80% Reduction	6.2%	9.1%	18%	61%	166%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	0.2	0.3	0.4	0.4	0.5
$20 Tax	0.1	0.1	0.1	0.2	0.3
80% Reduction	0.1	0.1	0.1	0.2	0.3
Natural Gas Consumption (Quadrillion Btu)					
Baseline	2.1	2.0	2.1	2.2	2.4
$20 Tax	2.2	2.0	2.1	2.1	2.0
80% Reduction	2.2	2.0	2.0	1.3	1.1
Gasoline (Billions of Gallons)					
Baseline	14	13	12	12	12
$20 Tax	14	12	12	11	11
80% Reduction	14	12	11	9.8	7.4

Regional Results for New York/New England

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.0	2.9	2.9	3.1	3.5
80% Reduction	0.0	2.9	2.9	4.3	4.3
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-1.8%	-5.0%	-6.6%	-8.5%	-10%
80% Reduction	-1.7%	-6.2%	-12%	-25%	-22%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-0.3%	-0.5%	-0.4%	-0.4%	-0.6%
80% Reduction	0.0%	-0.6%	-0.8%	-2.6%	-4.7%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-80	-170	-170	-210	-260
80% Reduction	-10	-190	-300	-870	-1,580

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	0.14%
80% Reduction	-0.03%

Figure 56: Regional Results for Pacific Northwest

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012$/metric ton of CO_2)					
$20 Tax	$20	$30	$44	$65	$96
80% Reduction	$20	$40	$90	$350	$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
$20 Tax	180	160	160	160	150
80% Reduction	180	160	150	120	90
Carbon Tax Costs (Billions of 2012$)					
$20 Tax	$4	$5	$7	$10	$14
80% Reduction	$4	$6	$14	$42	$90

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
$20 Tax	-0.5%	-0.4%	-0.4%	-0.3%	-0.3%
80% Reduction	-0.5%	-0.5%	-1.0%	-2.5%	-3.4%
Consumption (% Change from Baseline)					
$20 Tax	0.0%	-0.2%	-0.3%	-0.3%	-0.3%
80% Reduction	-0.2%	-0.7%	-0.9%	-1.6%	-2.5%
Change in Consumption per Household (2012$/Household)					
$20 Tax	$30	-$240	-$240	-$300	-$320
80% Reduction	-$140	-$670	-$820	-$1,440	-$2,540
Investment (% Change from Baseline)					
$20 Tax	0.5%	-0.6%	-1.2%	-0.6%	-0.8%
80% Reduction	1.8%	-1.1%	-0.9%	-6.6%	-9.1%

Regional Results for Pacific Northwest

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
$20 Tax	44%	33%	39%	39%	45%
80% Reduction	44%	49%	86%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
$20 Tax	10%	12%	15%	22%	18%
80% Reduction	11%	15%	29%	59%	35%
Gasoline Prices (% Change from Baseline)					
$20 Tax	5.9%	7.4%	9.9%	12%	17%
80% Reduction	6.6%	9.0%	17%	60%	164%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	0.2	0.1	0.1	0.1	0.2
$20 Tax	0.1	0.0	0.1	0.2	0.3
80% Reduction	0.1	0.1	0.1	0.2	0.3
Natural Gas Consumption (Quadrillion Btu)					
Baseline	1.0	1.0	1.1	1.4	1.7
$20 Tax	1.0	1.0	1.0	1.1	1.4
80% Reduction	1.0	1.0	1.0	0.7	0.9
Gasoline (Billions of Gallons)					
Baseline	5.2	4.7	4.5	4.4	4.3
$20 Tax	5.2	4.5	4.3	4.2	4.0
80% Reduction	5.1	4.5	4.2	3.6	2.7

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.0	1.9	1.9	1.9	1.9
80% Reduction	0.0	1.9	2.0	2.2	2.2
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.2%	-8.0%	-9.7%	-13%	-11%
80% Reduction	-2.2%	-9.8%	-16%	-27%	-23%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-0.5%	-0.9%	-0.8%	-1.1%	-1.2%
80% Reduction	-0.4%	-1.1%	-1.7%	-4.8%	-8.1%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-50	-100	-110	-160	-190
80% Reduction	-40	-120	-200	-600	-1,080

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.09%
80% Reduction	-0.55%

Figure 57: Regional Results for Southeast

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012\$/metric ton of CO_2)					
\$20 Tax	\$20	\$30	\$44	\$65	\$96
80% Reduction	\$20	\$40	\$90	\$350	\$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
\$20 Tax	720	630	610	600	510
80% Reduction	720	580	470	340	220
Carbon Tax Costs (Billions of 2012\$)					
\$20 Tax	\$14	\$19	\$27	\$39	\$49
80% Reduction	\$14	\$23	\$42	\$119	\$220

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
\$20 Tax	-0.6%	-0.4%	-0.4%	-0.3%	-0.3%
80% Reduction	-0.6%	-0.4%	-0.7%	-1.6%	-2.2%
Consumption (% Change from Baseline)					
\$20 Tax	-0.1%	-0.4%	-0.4%	-0.5%	-0.5%
80% Reduction	-0.2%	-0.7%	-0.9%	-1.5%	-2.3%
Change in Consumption per Household (2012\$/Household)					
\$20 Tax	-\$130	-\$400	-\$380	-\$450	-\$450
80% Reduction	-\$140	-\$670	-\$760	-\$1,200	-\$2,220
Investment (% Change from Baseline)					
\$20 Tax	-6.9%	-0.2%	-2.0%	-1.0%	-1.0%
80% Reduction	-7.3%	1.4%	-1.3%	-5.0%	-8.3%

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
\$20 Tax	44%	33%	39%	39%	44%
80% Reduction	44%	49%	85%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
\$20 Tax	14%	10%	18%	22%	22%
80% Reduction	16%	17%	36%	71%	51%
Gasoline Prices (% Change from Baseline)					
\$20 Tax	6.0%	7.4%	9.9%	12%	17%
80% Reduction	6.5%	8.9%	17%	60%	165%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	3.3	3.8	4.2	4.4	4.6
\$20 Tax	2.7	1.8	1.9	2.1	1.6
80% Reduction	2.7	1.4	0.6	0.5	0.7
Natural Gas Consumption (Quadrillion Btu)					
Baseline	2.4	2.6	2.6	3.1	3.2
\$20 Tax	2.8	2.9	3.1	3.1	3.0
80% Reduction	2.8	3.2	3.4	2.3	2.1
Gasoline (Billions of Gallons)					
Baseline	22	20	19	18	18
\$20 Tax	22	19	18	18	17
80% Reduction	22	19	18	15	12

Regional Results for Southeast

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	1.3	24	26	26	32
80% Reduction	1.3	32	47	54	54
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.5%	-6.6%	-11%	-13%	-12%
80% Reduction	-2.6%	-9.6%	-19%	-29%	-26%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-1.1%	-1.1%	-1.1%	-1.3%	-1.4%
80% Reduction	-1.0%	-1.4%	-2.1%	-5.1%	-7.8%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-280	-340	-400	-510	-600
80% Reduction	-240	-420	-700	-1,850	-3,070

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.29%
80% Reduction	-0.76%

Figure 58: Regional Results for Texas, Oklahoma, Louisiana

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012$/metric ton of CO_2)					
$20 Tax	$20	$30	$44	$65	$96
80% Reduction	$20	$40	$90	$350	$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
$20 Tax	910	830	810	820	740
80% Reduction	910	790	680	500	350
Carbon Tax Costs (Billions of 2012$)					
$20 Tax	$18	$25	$36	$53	$71
80% Reduction	$18	$32	$61	$175	$350

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
$20 Tax	0.4%	-0.2%	-0.1%	-0.3%	-0.6%
80% Reduction	0.0%	-0.4%	-1.0%	-3.1%	-4.2%
Consumption (% Change from Baseline)					
$20 Tax	0.0%	-0.3%	-0.3%	-0.4%	-0.4%
80% Reduction	-0.6%	-1.0%	-1.3%	-1.9%	-2.7%
Change in Consumption per Household (2012$/Household)					
$20 Tax	-$30	-$300	-$310	-$400	-$420
80% Reduction	-$610	-$1,040	-$1,180	-$1,810	-$2,800
Investment (% Change from Baseline)					
$20 Tax	-0.4%	-1.3%	-1.9%	-2.0%	-2.9%
80% Reduction	-0.2%	-2.5%	-4.8%	-14%	-16%

Regional Results for Texas, Oklahoma, Louisiana

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
$20 Tax	44%	33%	39%	39%	44%
80% Reduction	43%	49%	85%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
$20 Tax	10%	14%	17%	24%	20%
80% Reduction	10%	17%	29%	62%	43%
Gasoline Prices (% Change from Baseline)					
$20 Tax	5.8%	7.3%	9.8%	12%	17%
80% Reduction	6.7%	8.9%	17%	60%	164%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	2.3	2.2	2.3	2.4	2.6
$20 Tax	2.1	1.4	1.5	1.8	1.4
80% Reduction	2.1	1.1	0.5	0.5	0.8
Natural Gas Consumption (Quadrillion Btu)					
Baseline	5.3	5.8	6.1	6.5	7.1
$20 Tax	5.4	5.7	5.5	5.7	6.5
80% Reduction	5.4	5.8	6.2	5.1	5.2
Gasoline (Billions of Gallons)					
Baseline	14	13	13	12	12
$20 Tax	14	13	12	12	11
80% Reduction	14	13	12	10	7.7

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	0.0	6.5	6.5	14	23
80% Reduction	0.0	11	17	33	33
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.3%	-8.6%	-11%	-14%	-12%
80% Reduction	-2.4%	-10%	-17%	-29%	-27%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-0.8%	-1.4%	-1.4%	-1.6%	-1.8%
80% Reduction	-1.1%	-1.8%	-2.6%	-6.5%	-11%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-160	-330	-360	-470	-540
80% Reduction	-190	-390	-620	-1,700	-3,000

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.23%
80% Reduction	-0.94%

Figure 59: Regional Results for Upper Midwest

Carbon Tax Rates and Carbon Emissions

	2013	2023	2033	2043	2053
Carbon Tax Rate (2012\$/metric ton of CO_2)					
\$20 Tax	\$20	\$30	\$44	\$65	\$96
80% Reduction	\$20	\$40	\$90	\$350	\$1,000
Carbon Emissions (MM Metric Tons of CO_2)					
\$20 Tax	690	620	620	620	510
80% Reduction	690	600	370	230	160
Carbon Tax Costs (Billions of 2012\$)					
\$20 Tax	\$14	\$18	\$27	\$40	\$49
80% Reduction	\$14	\$24	\$33	\$81	\$160

Gross Regional Product

	2013	2023	2033	2043	2053
GRP (% Change from Baseline)					
\$20 Tax	-0.9%	-0.6%	-0.6%	-0.6%	-0.6%
80% Reduction	-1.1%	-0.6%	-0.8%	-1.8%	-2.6%
Consumption (% Change from Baseline)					
\$20 Tax	-0.6%	-0.8%	-0.8%	-0.9%	-0.9%
80% Reduction	-0.9%	-1.2%	-1.4%	-2.0%	-2.7%
Change in Consumption per Household (2012\$/Household)					
\$20 Tax	-\$530	-\$710	-\$690	-\$730	-\$750
80% Reduction	-\$710	-\$1,070	-\$1.160	-\$1,510	-\$2.350
Investment (% Change from Baseline)					
\$20 Tax	-12%	-0.9%	-1.4%	-0.8%	-2.1%
80% Reduction	-11%	0.8%	-2.4%	-10%	-9.5%

Fuel Price Impacts (Inclusive of Carbon Tax)

	2013	2023	2033	2043	2053
Wellhead Natural Gas Prices (% Change from Baseline)					
\$20 Tax	44%	33%	39%	39%	44%
80% Reduction	44%	49%	85%	210%	500%
Residential Delivered Electricity Prices (% Change from Baseline)					
\$20 Tax	13%	12%	17%	24%	21%
80% Reduction	15%	20%	34%	66%	42%
Gasoline Prices (% Change from Baseline)					
\$20 Tax	6.0%	7.4%	9.9%	12%	17%
80% Reduction	6.6%	8.9%	17%	59%	164%

Fuel Consumption

	2013	2023	2033	2043	2053
Coal Consumption (Quadrillion Btu)					
Baseline	4.7	4.7	4.8	4.9	5.0
\$20 Tax	4.3	3.8	3.9	4.1	3.1
80% Reduction	4.3	3.6	1.4	0.4	0.5
Natural Gas Consumption (Quadrillion Btu)					
Baseline	1.8	2.0	2.0	2.1	2.2
\$20 Tax	1.9	1.9	1.9	1.9	1.8
80% Reduction	1.9	1.9	1.9	1.8	1.8
Gasoline (Billions of Gallons)					
Baseline	10	9.4	9.0	8.8	8.6
\$20 Tax	10	9.1	8.6	8.4	8.0
80% Reduction	10	9.0	8.4	7.2	5.6

Regional Results for Upper Midwest

Electricity Sector Impacts

	2013	2023	2033	2043	2053
Coal Generator Retirements (GW)					
$20 Tax	2.1	16	17	17	33
80% Reduction	2.1	19	45	66	66
Total Electricity Demand (% Change from Baseline)					
$20 Tax	-2.5%	-7.6%	-11%	-14%	-12%
80% Reduction	-2.6%	-11%	-18%	-29%	-26%

Labor Impacts

	2013	2023	2033	2043	2053
Wage Rate (% Change from Baseline)					
$20 Tax	-1.7%	-1.6%	-1.6%	-1.9%	-1.9%
80% Reduction	-1.6%	-2.0%	-2.9%	-6.2%	-9.5%
Job-Equivalents (Change from Baseline in Thousands)					
$20 Tax	-210	-230	-270	-350	-390
80% Reduction	-200	-290	-470	-1,170	-1,960

Welfare

	2013
Welfare (% Change from Baseline)	
$20 Tax	-0.58%
80% Reduction	-1.16%

Global Analysis - Annual 2012

Note: The data presented in this report are preliminary. Ranks and anomalies may change as more complete data are received and processed. Effective September 2012, the GHCN-M version 3.2.0 dataset of monthly mean temperature replaced the GHCN-M version 3.1.0 monthly mean temperature dataset. Beginning with the August 2012 Global monthly State of the Climate Report, released on September 17, 2012, GHCN-M version 3.2.0 is used for NCDC climate monitoring activities, including calculation of global land surface temperature anomalies and trends. For more information about this newest version, please see the GHCN-M version 3.2.0 Technical Report.

*The GHCN-M version 3.1.0 Technical Report was revised on September 5, 2012 to accurately reflect the changes incorporated in that version. Previously that report incorrectly included discussion of changes to the Pairwise Homogeneity Algorithm (PHA). Changes to the PHA are included in version 3.2.0 and described in the version 3.2.0 Technical Report. Please see the Frequently Asked Questions to learn more about this update.

Note: On January 15, 2012, NCDC announced as part of its 2012 Global Climate Report that 2012 was the warmest La Niña year on record. While there are a variety of approaches for defining a La Niña or El Niño year, NCDC's criteria is defined as when the first three months of a calendar year meet the La Niña or El Niño threshold as defined by NOAA Climate Prediction Center's (CPC) Oceanic Niño Index (ONI). The list of historical La Niña years released on January 15 was based on an ONI dataset in force in early 2012 and used a 1971–2000 base period. During the course of the year, CPC introduced an ONI dataset using different base periods for determining anomalies for each year, with the most recent years (1995 to date) utilizing the 1981–2010 base period. Because of long-term warming trends in the equatorial Pacific Ocean, applying this more recent base period allows for better discernment of the temperature patterns needed to identify El Niño and La Niña years. In the most recent version of the dataset, using the newer base period methodology, 2006 and 2009 are now classified as La Niña years. The global average temperature in both 2006 and 2009 was 0.02°C (0.04°F) higher than 2012, making these two years the warmest La Niña years on record. NCDC has updated (via strikeout) our Annual Global Climate report to reflect the most current CPC ONI dataset.

With binary definitions of El Niño or La Niña, small changes in processing the data can affect the classification of weak El Niños or La Niñas. Despite these reclassifications, the general conclusions are similar from previous work: (1) global temperature anomalies for each phase (El Niño, La Niña, and neutral) have been increasing over time and (2) on average, global temperatures during El Niño years are higher than neutral years, which in turn, are higher than La Niña years.

NCDC continually examines its practices and definitions as science, datasets, and the understanding they bring improve. Thus, given the nature of our current method of classifying years as El Niño or La Niña, NCDC plans to re-examine and employ the best available definitions and datasets to robustly characterize the influence of El Niño and LaNiña on annual global temperatures.

Note: Effective September 2012, the GHCN-M version 3.2.0 dataset of monthly mean temperature replaced the GHCN-M version 3.1.0 monthly mean temperature dataset. Beginning with the August 2012 Global monthly State of the Climate Report, released on September 17, 2012, GHCN-M version 3.2.0 is used for NCDC climate monitoring activities, including calculation of global land surface temperature anomalies and trends. For more information about this newest version, please see the GHCN-M version 3.2.0 Technical Report.

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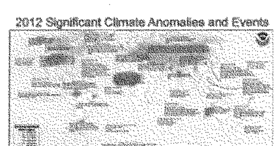


2012 Global Significant Weather and Climate Events

Global Highlights

- The year 2012 was the 10th warmest year since records began in 1880. The annual global combined land and ocean surface temperature was 0.57°C (1.03°F) above the 20th century average of 13.9°C (57.0°F). This marks the 36th consecutive year (since 1976) that the yearly global temperature was above average. Currently, the warmest year on record is 2010, which was 0.66°C (1.19°F) above average. Including 2012, all 12 years to date in the 21st century (2001–2012) rank among the 14 warmest in the 133-year period of record. Only one year during the 20th century—1998—was warmer than 2012.

- Separately, the 2012 global average land surface temperature was 0.90°C (1.62°F) above the 20th century average of 8.5°C (47.3°F) and ranked as the seventh warmest year on record.

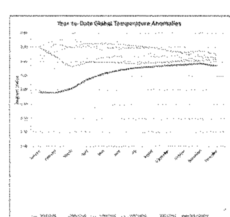
- La Niña, which is defined by cooler-than-normal waters in the eastern and central equatorial Pacific Ocean that affect weather patterns around the globe, was present during the first three months of 2012. The weak-to-moderate La Niña dissipated in the spring and was replaced by ENSO-neutral conditions for the remainder of the year. ~~When compared to previous La Niña years, the 2012 global surface temperature was the warmest observed during such a year; 2011 was the previous warmest La Niña year on record.~~ When compared to previous La Niña years, the 2012 global surface temperature was the third warmest observed during such a year, behind 2006 and 2009, which are currently tied for warmest.

- The 2012 global average ocean temperature was 0.45°C (0.81°F) above the 20th century average of 16.1°C (60.9°F) and ranked as the 10th warmest year on record. ~~It was also the warmest year on record among all La Niña years.~~ The three warmest annual ocean surface temperatures occurred in 2003, 1998, and 2010—all warm phase El Niño years.

- Following the two wettest years on record (2010 and 2011), 2012 saw near average precipitation on balance across the globe. However, as is typical, precipitation varied greatly from region to region.

Global Temperatures

The year 2012 was the 10th warmest year since records began in 1880. The annually-averaged temperature across global land and ocean surfaces was 0.57°C (1.03°F) above the 20th century average. Record to near-record warm land surface temperatures in the Northern Hemisphere from April to September and overall warmer-than-average ocean surface temperatures made the first 11 months of the year the eighth warmest January–November on record. However, extreme cold across much of the Northern Hemisphere land during December helped lower the year-to-date temperature departure from average by 0.02°C (0.04°F) compared with the previous month.



Year-to-date temperatures by month, with 2012 compared to the five warmest years on record

2012 marks the 36th consecutive year (since 1976) that the annual temperature was above the long-term average. Currently, the warmest year on record is 2010, which was 0.66°C (1.19°F) above average. Including 2012, all 12 years to date in the 21st century (2001–2012) rank among the 14 warmest in the 133-year period of record. Only one year during the 20th century—1998—was warmer than 2012. The global annual temperature has increased at an average rate of 0.06°C (0.11°F) per decade since 1880 and at an average rate of 0.16°C (0.28°F) per decade since 1970.

Top 10 Warmest Years (1880–2012)

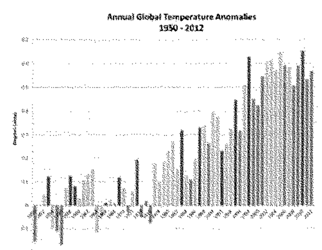
The following table lists the global combined land and ocean annually-averaged temperature rank and anomaly for each of the 10 warmest years on record.

Rank 1 = Warmest Period of Record: 1880–2012	Year	Anomaly °C	Anomaly °F
1	2010	0.66	1.19
2	2005	0.65	1.17
3	1998	0.63	1.13
4	2003	0.62	1.11
5	2002	0.61	1.10
6 (tie)*	2006	0.59	1.07
6 (tie)*	2009	0.59	1.07
6 (tie)*	2007	0.59	1.06
9	2004	0.58	1.04
10	2012	0.57	1.03

*Note: Tie is based on temperature anomaly in °C.

Natural climate patterns that persist for days, months, or even years can affect weather patterns around the world and impact the average global temperature. One such well-known global-scale pattern—the El Niño-Southern Oscillation (ENSO)—is a natural episodic fluctuation in sea surface temperature (El Niño) and the air pressure of the overlying atmosphere (Southern Oscillation) across the equatorial Pacific Ocean. Over a period of months to a few years, ENSO fluctuates between warmer-than-average ocean surface waters (El Niño) and cooler-than-average ocean surface waters (La Niña) in that region.

~~2012 ranked as the warmest "La Niña year", surpassing the previous record set in 2011.~~ 2012 ranked as the third warmest "La Niña year", behind 2006 and 2009, which are currently tied for warmest. Two of the three warmest years on record (2010 and 1998) are "El Niño years". A La Niña (El Niño) year is defined here as occurring when the first three months of a calendar year meet the La Niña (El Niño) criteria as defined by the Climate Prediction Center. The globally-averaged temperature difference between 2010 (warmest year on record) and 2012 (10th warmest year) is 0.09°C (0.16°F).



Global Annual Temperature Anomalies

Separately, the average global land temperature was 0.90°C (1.62°F) above the 20th century average and ranked as the seventh warmest year on record. Because land surfaces generally have low heat capacity, temperature anomalies can vary greatly between months. Over the course of 2012, the average monthly land temperature anomaly ranged from +0.22°C (+0.40°F; December) to +1.39°C (+2.50°F; April), a difference of 1.17°C (2.10°F).

The ocean has a much higher heat capacity than land and thus anomalies tend to vary less over monthly timescales. During the year, the global monthly ocean temperature anomaly ranged from +0.30°C (+0.54°F; January) to +0.55°C (+0.99°F; September), a difference of 0.25°C (0.41°F). For the period January–December, a weakening La Niña during January–March and ensuing ENSO-neutral conditions for the rest of the year contributed to a globally-averaged ocean surface temperature anomaly of 0.45°C (0.81°F) above the 20th century average, tying with 2001 as the 10th warmest year on record. ~~It was also the warmest global ocean temperature anomaly among all La Niña years.~~ It was also tied with 2001 as the third warmest global ocean temperature anomaly among all La Niña years, behind 2006 and 2009. 2003 and 1998—both El Niño years—tie for the warmest years on record for ocean surface, at 0.52°C (0.94°F) above average.

January–November	Anomaly °C	Anomaly °F	Rank (out of 133 years)		Records Year(s)	Records °C	Records °F
Global							
Land	+0.96 ± 0.20	+1.73 ± 0.38	Warmest	5th	2010	+1.12	+2.02
			Coolest	129th	1884	-0.64	-1.15
Ocean	+0.45 ± 0.03	+0.81 ± 0.05	Warmest	9th	1998	+0.53	+0.95
			Coolest	125th	1911	-0.46	-0.83
	Ties: 1997, 2001						
Land and Ocean	+0.59 ± 0.09	+1.06 ± 0.16	Warmest	8th	2010	+0.68	+1.22
			Coolest	126th	1911	-0.46	-0.83
Northern Hemisphere							
Land	+1.06 ± 0.26	+1.91 ± 0.47	Warmest	5th	2007, 2010	+1.24	+2.23
			Coolest	129th	1884	-0.75	-1.35
Ocean	+0.46 ± 0.04	+0.83 ± 0.07	Warmest	8th	2005	+0.56	+1.01
			Coolest	126th	1910	-0.47	-0.85
	Ties: 2002						
Land and Ocean	+0.69 ± 0.14	+1.24 ± 0.25	Warmest	4th	2010	+0.81	+1.46
			Coolest	130th	1912, 1913	-0.47	-0.85
	Ties: 2002						
Southern Hemisphere							
Land	+0.69 ± 0.12	+1.24 ± 0.22	Warmest	8th	2005	+0.90	+1.62
			Coolest	126th	1917	-0.65	-1.17
Ocean	+0.45 ± 0.03	+0.81 ± 0.05	Warmest	11th	1998	+0.55	+0.99
			Coolest	123rd	1911	-0.49	-0.88
Land and Ocean	+0.49 ± 0.06	+0.88 ± 0.11	Warmest	9th	1998	+0.60	+1.08
			Coolest	125th	1911	-0.50	-0.90

The 1901-2000 average combined land and ocean annual temperature is 13.9°C (56.9°F), the annually averaged land temperature for the same period is 8.5°C (47.3°F), and the long-term annually averaged sea surface temperature is 16.1°C (60.9°F).

Top Ten Global Weather/Climate Events for 2012

The following table list the top ten global weather/climate events of 2012. These events are listed according to their overall rank, as voted on by a panel of weather/climate experts. For additional information on these and other significant 2012 climate events, please visit NCDC's Top Ten Global Events webpage.

Rank	Event	When Occurred
1	Arctic Sea Ice Extent	Late Spring Through Fall 2012
2	Agricultural Drought	Summer 2012
3	Hurricane Sandy	October 2012
4	Super Typhoon Bopha/Pablo	December 2012
5	Northern Hemisphere Warmth	Throughout 2012
6	Greenland Ice Sheet & Glacier Calving	July 2012
7	Eurasian Continent Cold Wave	January/February 2012
8	Northeastern Brazil Drought	First Half of 2012
9	African Floods	July - October 2012
10	Antarctic Sea Ice Extent	September 2012

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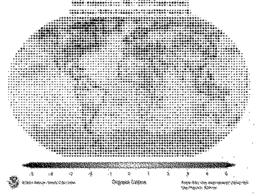
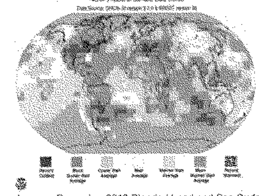
Regional Temperatures

Warmer-than-average temperatures occurred during 2012 for most of the world's surface. The greatest above-average annual temperature anomalies occurred across most of North and South America, central and southern Europe, much of northern and coastal Africa, and western, southern, and far northeastern Asia, with record warmth observed across much of central North America, central South America, parts of southern and eastern Europe, much of the northeastern coastal Atlantic Ocean, part of the southern Arctic Seas, and sections of the mid-latitude Southern oceans. Colder-than-average conditions occurred across most of Alaska, part of the northeastern and east central Pacific Ocean, and the Southern Ocean off the southern tip of South America.


January–December 2012 Blended Land and Sea Surface Temperature Anomalies in degrees Celsius



January–December 2012 Blended Land and Sea Surface Temperature Percentiles

A natural hemispheric-scale climate pattern called the Arctic Oscillation (AO) can be a dominating driver of winter temperatures in the Northern Hemisphere. Its effects were particularly felt from the end of January to mid-February, when the AO was negative. A negative AO is associated with cold polar air that spills southward into the mid-latitudes from the Arctic region and warm air that advects northward from nearer the equator.

Due at least in part to this pattern, frigid temperatures were felt across much of Europe during this time, bringing the worst cold snap to the region in at least the past 26 years. Hundreds of people perished across a dozen countries in central and eastern Europe due to the polar outbreak. Austria's average February temperature was the coldest on record for the month since 1986. Germany also experienced its coldest February since 1986 and 15th coldest since records began in 1881. Spain had its fourth coldest February since its records began in 1961. At the same time, part of Canada was much warmer than average, as temperatures in Ontario, Canada during February "rivaled record values set in 1998", according to Environment Canada. Temperatures across the region ranged from 3.7°C to 6.8°C (6.7°F to 12.2°F) above average. Overall, Canada observed its third warmest winter since national records began in 1948, with the average temperature 3.6°C (6.5°F) above average and virtually no parts of the country colder than average. And in contrast to the winters of 2009/10 and 2010/11, which were colder than average due to the impacts of the negative AO, the contiguous United States was not impacted in the same way by the climate pattern during this period, as it observed its fourth mildest winter since records began in 1895.

In the Southern Hemisphere, with La Niña still in place, Australia reported its 11th coolest average maximum and 15th coolest average minimum austral summer temperature in the country's 63-year period of record.

As winter gave way to spring in the Northern Hemisphere, warmer-than-average temperatures prevailed across much of this region. The contiguous United States had its warmest March on record. Norway also had its warmest March since national records began in 1900. Austria and Germany each had their third warmest March since records began in 1767 and 1881, respectively. The United Kingdom (UK) recorded its warmest March since 1957 and the third warmest since national records began in 1910. Provisionally, Scotland was record warm for the month.

The warmth continued in parts of North America in April, where the contiguous United States had its third warmest April on record. However, in Europe, the UK had its coolest average April temperature since 1989. According to the UK's Met Office, April 2012 was cooler than March 2012, an unusual event that last happened in 1998. It was also cooler than average in Spain, Norway, and Sweden during April.

In the Southern Hemisphere, the lingering effects of La Niña contributed to Australia's third lowest maximum March temperature and fourth lowest minimum autumn (March–May) temperature on record.

For the March–May period, the contiguous United States had its warmest spring on record and to the north, Canada had its ninth warmest such period. Across the Atlantic, Austria observed its seventh warmest spring in its 246-year period of record.

Austria's warmth carried over into June, as the country recorded its highest ever June temperature of 37.7°C (99.9°F) on the 30th in two locations—the capital city of Vienna and in German-Altenburg, Nope. The monthly temperature averaged across Austria was the sixth warmest June on record. However, in other parts of Europe, Norway had its 25th coolest June in its 113-year period of record and the UK had its coolest June since 1991. It was also the coolest July for the UK since 2000. In Australia, the average July maximum temperature was the lowest for that month in the past 30 years. It was a different story in North America, however, as the contiguous United States observed its hottest July (and hottest month ever) on record.

August brought warmer-than-average temperatures to many regions around the world. It was warmer-than-average across New Zealand and temperatures in Australia rebounded from July, with the average maximum temperature ranking as the sixth warmest on record for August. Two separate heat waves brought Spain its second warmest August since 1961, while Austria had its fourth warmest August on record.

The summer (June–August) period in Canada was 1.9°C (3.4°F) above the 1961–1990 average, making this Canada's all-time warmest summer in the 65-year period of record, beating the previous record set in 1998 by 0.2°C (0.4°F). A warmer-than-average August, combined with the record-high July temperatures and a warmer-than-average June brought the contiguous United States its second hottest summer on record.

Following the second warmest summer for Hungary since national records began in 1900, monthly temperatures remained above average across the entire country during September, ranging from about 1.0°–3.5°C (1.8°–6.3°F) above the 1971–2000 average.

Australia had its third warmest maximum September temperatures on record; and monthly-averaged daily, maximum, and minimum temperatures were all above average across Argentina, particularly in the central and northern regions of the country. These warm temperatures contributed to record September warmth across global land and ocean surfaces—the only globally-averaged record warm month of 2012.

A series of low pressure systems that plagued the UK during part of the year kept temperatures below average during October, with the lowest October temperature recorded since 2003. Scotland was the coolest since 1993. Meanwhile, central and southeastern Europe were warmer than average during the month. Temperatures were up to 1.6°C (2.9°F) above the 1961–1990 average across large parts of Croatia, while the Republic of Moldova reported monthly temperatures across the country that ranged from 2.5° to 3.5°C (4.5° to 6.3°F) above average.

November was cooler than average in New Zealand, while maximum temperatures were the fourth highest for November on record in Australia. In Europe, Hungary, Austria, Croatia, and the Republic of Moldova were warmer than average. However, in East Asia it was the fifth coolest October maximum temperature for South Korea. It was also colder than averge in China, with the national average temperature 0.9°C (1.6°F) below average. The regions of northern Xinjiang and central Inner Mongolia were 2°–4°C (4°–7°F) colder than average.

Beginning in late November, severe cold swept across much of Eurasia as the Arctic Oscillation became negative and remained strongly negative through December. This negative phase led the polar jet stream to dip down over Eurasia bringing frigid air from the north to the region to close out 2012. Northern and eastern China had its coldest period for this time of year in the past 28 years, according to China's National Climate Center. The capital city of Beijing observed its lowest average temperature since at least 1951. Through December, Russia experienced its coldest winter to date since 1938, with temperatures as much as 10°–15°C (18°–27°F) below average. Temperatures fell to as low as -50°C (-58°F) in some parts of Siberia. In Europe, the Republic of Moldova, Hungary, Sweden, Finland, and Norway were all colder than average during December. The U.S. state of Alaska observed its 18th coolest December since records began in 1918, with the average monthly temperature 3.3°C (5.9°F) below the 1971–2000 average. Conversely, Australia had its fourth highest December maximum temperatures since records began in 1910. And in New Zealand, many record or near-record monthly temperatures were reported across the North Island, around Nelson, and parts of the South Island.

Notably, for 2012 as a whole, the contiguous United States had its warmest year in its 118-year period of record, surpassing the previous record set in 1998 by 0.6°C (1.0°F). A list the top 10 weather and climate events for the United States is also available.

With winter, spring, and summer all among Canada's top 10 warmest for their respective seasons, the January–November period for 2012 was the fourth warmest since records began in 1948, according to Environment Canada. A list of Canada's top 10 weather and climate events of 2012 is also available.

In Europe, Austria experienced its seventh warmest year since national records began in 1767, at 1.0°C (1.8°F) above the long-term average. Norway had its 45th warmest year since records began in 1900, at 0.4°C (0.7°F) above average.

The 2012 temperature across the United Kingdom was 0.1°C (0.2°F) below the 1981–2010 average. This is in part attributed to the UK's coolest summer since 1998 and coolest autumn since 1993.

With the first half of 2012 cooler than average and the second half warmer than average, on balance the annual 2012 temperature across Australia was 0.06°C (0.11°F) above the 1961–1990 average. Only the year 2011 has been below average in the past decade.

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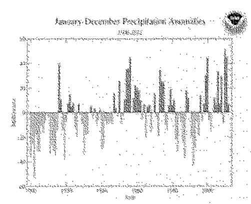
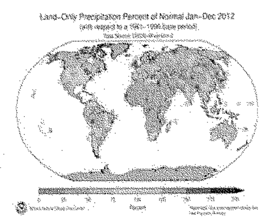
Global Precipitation

Following the two wettest years on record (2010 and 2011), 2012 saw near average precipitation on balance for land areas across the globe. Precipitation anomalies were variable from region to region.



January–December 2012 Global Precipitation Anomalies



January–December 2012 Land-Only Precipitation Percent of Normal

La Niña conditions brought heavy rainfall to Australia, especially in the east, during the first few months of 2012, but conditions turned drier during the latter half of the year after ENSO-neutral conditions took hold. From April through December, rainfall was generally below average for the period. According to the Bureau of Meteorology, a positive Indian Ocean dipole, associated with cooler sea surface temperatures off the northwest coast of Australia and typically drier conditions across parts of the continent, emerged in early August and continued into October. This likely contributed to drier-than-average conditions across southern Australia. Overall, following the record wet year of 2011, 2012 precipitation was near the median of annual values dating back to 1900.

The year started off rather dry for the United Kingdom and then changed fairly abruptly. Following its driest March on record, the UK observed its all-time wettest April. A series of low pressure systems continued to impact the country, with June also being record wet. Remarkably, even with the dry conditions early on, the UK had its second wettest year since records began in 1910, falling just 7.3 mm (0.29 inches) shy of the record wetness of 2000. Provisionally, England had its all-time wettest year on record.

Finland was wetter than average for 2012, with many stations observing their wettest year in the past half century. The capital city of Helsinki reported its second wettest year, behind 1944, since records began in the early 19th century.

In northern Brazil, lack of rain during first half of 2012 led to the worst drought in five decades and resulted in "water wars" which provoked extreme behavior and led to fatalities. An estimated 4 million people were affected. Water supplies were threatened in 1,100 municipalities. Some regions in northeastern Brazil had their record driest January–October on record, according to the World Meteorological Organization (WMO).

In the contiguous United States, in addition to the summer being hot for a large part of the country, it was also dry, resulting in a drought footprint comparable to the drought episodes of the 1950s. The drought peaked in July, when the percent area of the CONUS in at least moderate drought was 61.8 percent, according to the Palmer Drought Severity Index (PDSI). The summer was the 14th driest on record for the country. The epicenter of the drought stretched from the Rockies through the Great Plains and into the Midwest. The drought resulted in a multi-billion dollar agricultural disaster—the most severe and extensive drought impact since 1988.

At the same time, drought gripped western Russia, western Siberia, Ukraine, and Kazakhstan, damaging agricultural crops. According to the WMO, more than $630 million U.S. dollars in damages were incurred in western Russia and western Siberia alone.

Several countries in eastern Europe, including Romania, Hungary, Bulgaria, and Poland, experienced drought during September. It was one of worst droughts for Hungary in two decades.

It was also extremely wet in some areas of the world. According to the Japan Meteorological Agency, record 24-hour rainfall of up to 500 mm (20 inches) was observed on Japan's southern island of Kyushu in mid-July. Subsequent flooding and landslides killed more than two dozen residents. In and around Beijing, China, up to 170 mm (6.7 inches) of rain fell within a 16-hour period on July 21st, leading to the worst flooding in six decades in the region.

The South Asian monsoon season in India starts around the beginning of June and lasts into October. Rainfall during the pre-monsoon season was the lowest on record since 1901 and rainfall continued to be deficient during the first half of the monsoon season. However, the monsoon stalled over northwestern India before beginning its annual withdrawal, bringing excessive rainfall to most of the region during the month of September. The heavy rainfall brought seasonal precipitation totals to within the normal range and alleviated drought conditions for much, but not all, of the country. By the withdrawal date on October 10th, India as a whole experienced rainfall that was 92 percent of average, within the normal range, according to the India Meteorological Department.

During mid-September, Super Typhoon Sanba—the year's first category 5 storm among all tropical cyclone basins—brought locally heavy rainfall to Okinawa Island, Japan, parts of the Philippines, including the capital city of Manilla, and both North and South Korea. Super Typhoon Jelawat—the year's second category 5 storm—also impacted part of the eastern Philippines and parts of Japan, including Okinawa and Tokyo.

At the end of September, Sandy dumped copious rain over Jamaica, Haiti, the Dominican Republic, Cuba, and much of the eastern United States. Post-tropical storm Sandy also brought blizzard conditions to the Central and Southern Appalachians, shattering all-time U.S. October monthly and single storm snowfall records.

The rainy season was wetter-than-normal across western and central Africa. From July to October, over 3 million people were affected across 15 countries, most notably in Nigeria, Niger, Senegal, and Chad.

Tropical cyclones rarely hit the southern Philippines; however, Category 5 Super Typhoon Bopha struck southern Mindanao Island in early December, dumping copious rainfall over the region, killing more than 900 residents, and leaving more than 600 missing. This is the same region where Tropical Storm Washi hit just one year earlier, in December 2011, killing more than 1300 people.

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Deficit Reduction Rises on Public's Agenda for Obama's Second Term

Public's Policy Priorities: 1994-2013

OVERVIEW

When Barack Obama took office four years ago, reducing the budget deficit was a middle-tier item on the public's agenda. Only about half of Americans (53%) viewed it as a top policy priority in January 2009, placing it ninth on a list of 20 policy goals.

But as Obama begins his second term, only the economy and jobs are viewed as more important priorities for the coming year. Currently, 72% say that reducing the budget deficit should be a top priority, up 19 points from four years ago. (*Click here for a graphic of the public's 2013 priorities*).

Public's Policy Priorities for 2013

% saying each is a "top priority" for president and Congress this year	4 years ago Jan 2009 %	1 year ago Jan 2012 %	Now Jan 2013 %	4 year chg
Strengthening economy	85	86	86	[illegible]
Improving job situation	82	82	79	[illegible]
Reducing budget deficit	53	69	72	+19
Defending against terrorism	76	69	71	[illegible]
Making Social Security financially sound	63	68	70	[illegible]
Improving education	61	65	70	[illegible]
Making Medicare financially sound	60	61	65	[illegible]
Reducing health costs	59	60	63	[illegible]
Helping poor and needy	50	52	57	[illegible]
Reducing crime	46	48	55	[illegible]
Reforming tax system	--	--	52	[illegible]
Protecting environment	41	43	52	+11
Dealing w/ energy problem	60	52	45	-15
Reducing influence of lobbyists	36	40	44	+8
Strengthening the military	44	39	41	[illegible]
Dealing w/moral breakdown	45	44	40	[illegible]
Dealing w/ illegal immigration	41	39	39	[illegible]
Strengthening gun laws	--	--	37	
Dealing w/ global trade	31	38	31	[illegible]
Improving infrastructure	--	30	30	[illegible]
Dealing w/ global warming	30	25	28	[illegible]

The latest national survey by the Pew Research Center for the People & the Press, conducted Jan. 9-13, 2013 among 1,502 adults, finds that Americans continue to view other domestic initiatives as important priorities as well, despite their focus on the deficit. Growing numbers give high priority to dealing with education, the problems of the poor, crime and the environment.

Fully 70% say that improving the educational system should be a top priority, up from 61% in January 2009. And 57% rate dealing with the problems of the poor and needy as a top priority; four years ago, 50% viewed this as a top priority.

Related

Graphic: Twelve years of the public's top policy priorities

Views of priorities in Obama's first year

Where the public stands on deficit reduction proposals

The survey finds that 52% view protecting the environment as a top policy priority, up 11 points from January 2009. However, dealing with global warming remains at the bottom of the public's agenda for 2013; just 28% see this as a top priority, little changed from recent years.

Gun control also ranks relatively low on the public's priority list; just 37% rate it as a top priority, 18th out of 21 policy goals tested. This item was last asked in 2001, when support for gun control was much broader nationwide, and 47% rated it as a top priority. However, reducing crime has become a more important policy priority in the past year; 55% rate this as a top priority, up seven points since last January and the highest percentage since 2007.

The public also continues to view the financial security of Social Security and Medicare as major goals. While 70% say taking steps to make Social Security financially sound should be a top priority, a comparable percentage (65%) says the same about making Medicare financially sound.

The survey finds that energy has slipped as a policy priority since Obama took office. Currently, 45% say that dealing with the nation's energy problems should be a top priority, down from 60% four years ago.

Partisan Differences over Priorities

As in past Pew Research policy priority surveys, Republicans and Democrats offer differing views about the importance of many of the country's most pressing issues.

Broad majorities of Republicans and Democrats see the economy and jobs as top priorities. And more than seven-in-ten Republicans (74%) and Democrats (72%) say making the Social Security system financially sound should be a top priority, though they may have different views about how to do so.

There is far less consensus on other issues, with some of the largest differences over the environment, gun control, and health care. Nearly seven-in-ten Democrats (69%) say protecting the environment should be a top priority compared with just 32% of Republicans. Democrats also are much more likely to emphasize strengthening gun controls laws (56%) and reducing health care costs (79%) than are Republicans (22% and 46%, respectively).

By contrast, Republicans are far more likely than Democrats to say strengthening the military is a top priority (58% vs. 31%). Republicans also are 17 points more likely than Democrats to say the budget deficit is a top priority, though a majority of Democrats (67%) also give the deficit top priority.

Democrats view more issues as top priorities than do Republicans. Across the 21 issues tested, majorities of Democrats say 13 are top priorities for the president and Congress. Among Republicans, majorities consider eight issues as top priorities.

Widest Partisan Gaps Over Environment, Gun Control, Health Care

% considering each as a "top priority"	Rep %	Dem %	Ind %	R-D diff
Protecting the environment	32	69	49	-37
Strengthening gun control laws	22	56	32	-34
Reducing health care costs	46	79	63	-33
Dealing with problems of the poor	46	71	53	-25
Dealing with global warming	13	38	31	-25
Reducing crime	44	63	55	-19
Improving educational system	64	80	68	-16
Improving roads, bridges, transportation	24	36	29	-12
Making Medicare financially sound	62	73	61	-11
Reducing the influence of lobbyists	39	49	43	-10
Reforming nation's tax system	48	57	51	-9
Improving job situation	77	84	75	-7
Dealing with global trade	30	33	30	-3
Strengthening nation's economy	89	89	84	0
Dealing with nation's energy problem	45	45	46	0
Making Social Security financially sound	74	72	67	+2
Defending against terrorism	80	72	64	+8
Dealing with illegal immigration	44	35	40	+9
Dealing with moral breakdown	50	34	40	+16
Reducing budget deficit	84	67	71	+17
Strengthening the military	58	31	38	+27

[illegible]

Deficit Concerns Increase

The budget deficit has increased as a priority since 2009 among Democrats, independents and especially Republicans. Currently, 84% of Republicans say that deficit reduction should be a top priority. While that is unchanged from last year, it is 33 points higher than four years ago, when just 51% of Republicans viewed reducing the deficit as a top priority.

Democrats and independents also rate the deficit as a more important priority than they did in January 2009, though the increases have been smaller. Currently, 67% of Democrats view deficit reduction as a top priority, up from 52% four years ago; the increase among independents has been comparable (71% now, 57%).

For the last few years more Republicans than Democrats have rated reducing the deficit as a top policy priority, but this represents a reversal from the Bush administration, when Democrats typically viewed the deficit as a more important issue. At the start of George W. Bush's second term in January 2005, for instance, 64% of Democrats and 48% of Republicans said that reducing the budget deficit should be a major priority for the president and Congress.

By contrast, during the Clinton administration, more Republicans viewed deficit reduction as a top policy objective. In January 1997, at the start of Bill Clinton's second term, 66% of Republicans said reducing the deficit should be a top priority, compared with 54% of Democrats.

Republicans, Democrats Trade Places on Deficit

% rating deficit "top priority"	Rep %	Dem %	Ind %	R-D diff
Jan 2013	84	67	71	+17
Jan 2012	84	66	62	+18
Jan 2011	68	61	65	+7
Jan 2010	61	60	60	+1
Jan 2009	51	52	57	-1
Jan 2008	52	64	57	-12
Jan 2007	42	57	53	-15
Jan 2006	45	62	56	-17
Jan 2005	48	64	54	-16
Jan 2004	44	57	55	-13
Jan 2003	38	48	33	-10
Jan 2002	27	41	38	-14
Jan 2001*	49	55	58	-6

Gun Control a Lower Priority than in 2001

Jan 2000*	39	41	50	
Jan 1999*	42	42	43	
Jan 1998*	54	38	47	[illegible]
Jan 1997	66	54	62	[illegible]
Dec 1994	65	61	68	[illegible]

Currently, 37% rate strengthening the nation's gun laws as a top policy priority. In 2001, that last time this item was included on a January priorities survey, 47% viewed this as a top policy priority.

More than half of Democrats (56%) give top priority to strengthening gun control laws compared with 32% of independents and just 22% of Republicans. Since 2001, the priority given to gun control laws has fallen by 12 points each among Republicans and independents while remaining more stable among Democrats; 61% of Democrats viewed gun control as a top priority in 2001, about the same percentage as today (56%).

Women (42%) are somewhat more likely than men (33%) to call gun control a top priority. However, smaller percentages of both women and men view gun control as a top priority than did so at the start of George W. Bush's first term.

The current survey finds that views of the importance of strengthening gun laws are correlated with gun ownership and opinions about whether it is more important to control gun ownership or to protect gun rights. Nearly half (47%) of those who do not have a gun in their household view strengthening gun laws as a top priority, compared with 24% of those who do. And while 61% of those who say gun control is more important than gun rights prioritize stronger gun laws, just 12% of those who say it is more important to protect gun rights do so. For more on opinions about gun control, see "In Gun Control Debate, Several Options Draw Majority Support," Jan. 14, 2013.

Partisan, Gender Differences in Views of Gun Control as Priority

% top priority for strengthening gun control laws	2001	2013	Change
	%	%	
Total	47	37	-10
Men	41	33	-8
Women	53	42	-11
18-29	53	33	-20
30-49	45	33	-12
50-64	40	41	+1
65+	55	46	-9
College grad+	39	35	-4
Some college	40	32	-8
HS or less	51	44	-7
$75,000 or more	26	31	+5
$30,000-75,000	45	30	-15
Less than $30,000	56	49	
Republican	34	22	-12
Independent	44	32	-12
Democrat	61	56	-5

Environment, Energy and Global Warming

Currently, 52% of Americans say protecting the environment should be a top priority, up nine points from last year. But that is still lower than the high of 63% who said the environment should be a top priority in 2001.

At the same time, the percentage saying that dealing with the nation's energy problems should be a top priority has slipped from 52% to 45% since last year. For the first time in five years, energy now ranks slightly lower than the environment on the public's list of priorities.

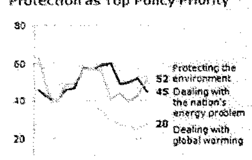
Dealing with global warming ranks at the bottom of the public's priority list. Just 28% say it should be a top priority for the president and Congress, little changed from 2012.

More Democrats and independents say the environment should be a top priority than did so a year ago. Fully 69% of Democrats say that, up 11 points from last year. About half (49%) of independents think environmental protection should be a top priority, up somewhat from 40% in 2012. Just 32% of Republicans say that protecting the environment should be a top priority, little changed from a year ago. The 37-point partisan gap on this issue is among the largest for all the policy priorities.

There also is a wide partisan gap over whether global warming should be a major priority. Just 13% of Republicans say dealing with global warming should be a top priority, compared with 38% of Democrats. This is among the lowest priority items for Democrats and Republicans. More independents think global warming should be a top priority (31%) than did so a year ago (21%).

By contrast, there continues to be very little partisan difference on whether dealing with the nation's energy problems should be a top priority; 45% of both Republicans and Democrats say this.

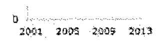
More View Environmental Protection as Top Policy Priority



More Republicans View Stronger Military as Top Priority

Far more Republicans view strengthening the U.S. military as a top policy priority than did so a year ago. In the current survey, 58% of Republicans say this, up from 46% in January 2012. By comparison, 38% of independents and just 31% of Democrats say strengthening the military should be a top priority; both percentages are little changed from January 2012.

Over the past decade, Republicans have consistently been much more likely than Democrats to view strengthening the military as a top policy goal. In January 2009, 64% of Republicans and just 38% of Democrats said strengthening the military should be a top priority for the president and Congress. But those differences narrowed considerably in 2011 and 2012, before widening again this year.



Crime Concerns Increase

A majority of Americans (55%) view reducing crime as a top priority for the president and Congress. This represents a sharp increase from recent years. In 2011, just 44% said crime was a top priority. While up over the past two years, the percentage calling crime a top priority still pales in comparison to the percentages saying this in the 1990s and early 2000s. In 1994, for example, 78% said reducing crime should be a top priority, making it first among the items tested on that survey.

The rise in crime as a top priority has taken place among Democrats and independents, while Republican views are little changed. About six-in-ten Democrats (63%) say crime should be a top priority, up 17 points from 2011. More than half of independents (55%) give top priority to reducing crime, up 11 points over the last two years. By contrast, just 44% of Republicans give high priority to reducing crime, unchanged from January 2011. As a result of these shifts, the gap between Democrats and Republicans is now as large as it has ever been, at 19 points.

Public's Policy Priorities During Obama and Bush Presidencies

% considering each as a "top priority"	Jan 2001 %	Jan 2005 %	Jan 2009 %	Jan 2010 %	Jan 2011 %	Jan 2012 %	Jan 2013	[illegible] change
Strengthening nation's economy	81	75	85	83	87	86	86	[illegible]
Improving job situation	60	68	82	81	84	82	79	[illegible]
Reducing budget deficit	--	55	53	60	64	69	72	[illegible]
Defending against terrorism	--	75	76	80	73	69	71	[illegible]
Securing Social Security	74	70	63	66	66	68	70	[illegible]
Improving education	78	70	61	65	66	65	70	[illegible]
Securing Medicare	71	67	60	63	61	61	65	[illegible]
Reducing health care costs	--	--	59	57	61	60	63	[illegible]
Dealing with problems of the poor and needy	63	59	50	53	52	52	57	[illegible]
Reducing crime	76	53	46	49	44	48	55	[illegible]
Reforming tax system	--	--	--	--	--	--	52	
Protecting environment	63	49	41	44	40	43	52	[illegible]
Dealing with nation's energy problem	--	47	60	49	50	52	45	[illegible]
Reducing influence of lobbyists	--	--	36	36	37	40	44	[illegible]
Strengthening the military	48	52	44	49	43	39	41	[illegible]
Dealing with moral breakdown in country	51	41	45	45	43	44	40	[illegible]
Dealing with illegal immigration	--	--	41	40	46	39	39	[illegible]
Strengthening gun control laws	47	--	--	--	--	--	37	
Dealing with global trade	37	32	31	32	34	38	31	[illegible]
Improving roads, bridges, and public transportation	--	--	--	--	33	30	30	[illegible]
Dealing with global warming	--	--	30	28	26	25	28	[illegible]

Democrats, Independents More Likely to Prioritize Environment

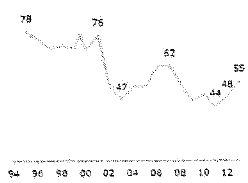
	Jan 2012 %	Jan 2013 %	Change
Protecting the environment	**43**	**52**	+9
Republican	27	32	[illegible]
Democrat	58	69	[illegible]
Independent	40	49	[illegible]
Dealing with the nation's energy problems	**52**	**45**	[illegible]
Republican	55	45	[illegible]
Democrat	57	45	[illegible]
Independent	46	46	[illegible]
Global warming	**25**	**28**	[illegible]
Republican	11	13	[illegible]
Democrat	38	38	[illegible]
Independent	21	31	[illegible]

Strengthening the U.S. Military

% "top priority"	Rep %	Dem %	Ind %	[illegible]
Jan 2013	58	31	38	[illegible]
Jan 2012	46	37	36	[illegible]
Jan 2011	51	45	39	[illegible]
Jan 2010	64	44	47	[illegible]
Jan 2009	64	38	41	[illegible]
Jan 2008	62	37	34	[illegible]
Jan 2007	56	42	45	[illegible]
Jan 2006	56	34	39	[illegible]
Jan 2005	62	48	47	[illegible]
Jan 2004	51	43	42	[illegible]
Jan 2003	59	41	43	[illegible]
Jan 2002	68	50	41	[illegible]
Jan 2001	63	38	41	[illegible]

Crime Rebounds as Top Priority

% saying reducing crime is a top priority

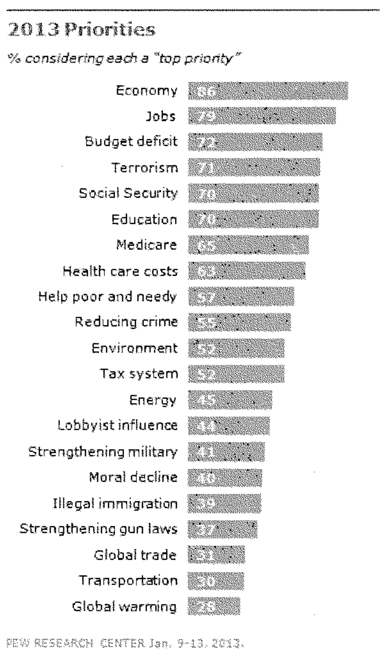


More Democrats Prioritize Reducing Crime

% rating reducing crime "top priority"	Rep %	Dem %	Ind %	R-D diff

Jan 2013	44	63	55	+19
Jan 2012	47	55	45	[illegible]
Jan 2011	44	46	44	[illegible]
Jan 2010	46	55	46	[illegible]
Jan 2009	41	47	47	[illegible]
Jan 2008	49	62	50	+13
Jan 2007	56	69	57	13
Jan 2006	62	67	56	[illegible]
Jan 2005	49	54	55	[illegible]
Jan 2004	51	60	53	[illegible]
Jan 2003	44	49	47	[illegible]
Jan 2002	50	59	49	[illegible]
Jan 2001	69	82	72	+13
Jan 2000	67	75	65	[illegible]
Jan 1999	67	73	68	[illegible]
Jan 1998	68	74	69	[illegible]
Jan 1997	64	70	73	[illegible]
Dec 1994	80	77	78	[illegible]

[illegible]


2013 Priorities
% considering each a "top priority"
Economy 86
Jobs 79
Budget deficit 72
Terrorism 71
Social Security 70
Education 70
Medicare 65
Health care costs 63
Help poor and needy 57
Reducing crime 55
Environment 52
Tax system 52
Energy 45
Lobbyist influence 44
Strengthening military 41
Moral decline 40
Illegal immigration 39
Strengthening gun laws 37
Global trade 31
Transportation 30
Global warming 28
PEW RESEARCH CENTER Jan. 9-13, 2013.

Why we need a 'Red Team' approach in climate science

By Richard McNider and John Christy

The recent draft of the U.S. National Climate Assessment, which has been released for public review, underscores the dangers of the kind of consensus science that has been the hallmark of the climate change movement.

While this document is intended to be an objective assessment of climate change's potential impacts on the U.S., there is virtually no mention of any scientific uncertainty, potentially contrary information or inconsistencies in the notion that greenhouse gases are making dramatic and deleterious changes in the Earth's climate. A large list of anticipated climate change impacts, such as more droughts, reduced snow cover, heat waves and stronger storms, is provided.

A supposed scientific document, it is filled with mantras of "climate change is real" and "climate change is happening now." While forecast impacts are attributed to global warming, there is absolutely no mention that the fundamental expected signal of greenhouse gas-enhanced climate change — rapid warming of the deep global atmosphere, especially in the tropics — is not occurring at an alarming rate.

It never points out that the models to which most of the changes are linked on average forecast warming in the deep atmosphere at a rate more than twice that seen in direct observations of the atmosphere. (See attached graph.)

It never discusses that the theorized atmospheric feedback mechanisms in the climate models, which contribute substantially to the forecasts of high rates of warming, are based on assumptions that have not been verified through observations. It does not mention that these feedback mechanisms (where warming causes effects which then lead to additional warming) vary greatly between climate models — even models that arrive at essentially the same warming forecasts.

The assessment never points out that nighttime warming — which accounts for most of the actual surface temperature warming over land in the past century — is not related to warming in the deep atmosphere.

While it might be that none of these inconsistencies refute the fundamental concern about climate change associated with greenhouse gases, it is disturbing that an "assessment" document would not acknowledge such discrepancies. However, this lack of objectivity and skepticism is endemic in the climate change movement. From the beginning it has embraced the notion that consensus on climate change is the path to taking action. Skeptics have been ridiculed and marginalized in the Intergovernmental Panel on Climate Change (IPCC) process. Discrepancies in climate change theory such as mentioned above have been suppressed in the IPCC and in the scientific literature (see the Climategate saga).

The climate change community has employed what it calls the overwhelming majority of scientists as agreeing with the tenet that greenhouse gases are causing climate change as *evidence* that climate change is real. It uses this to push the view that "the science is settled."

However, the past is riddled with instances in which consensus has been wrong and terrible prices have been paid. Oddly relevant to the case of climate change are the examples of Saddam Hussein's weapons of mass destruction (WMD) and scurvy in the 18th century.

After the Iraq War, in which no WMD were discovered, a central question was, "How could the intelligence community have been so wrong about its conclusions on WMDs?"

These pre-war conclusions were largely expressed in the October 2002 National Intelligence Estimate, which was a summation of the community's views and consensus on Iraq's WMD. It was one of the key documents available to Congress, U.S. allies and the United Nations prior to the war. In some respects the 2002 National Intelligence Estimate is similar to the IPCC 2007 and the current National Climate Assessment.

A 2004 presidential commission came to several conclusions about why the intelligence community failed so completely in its assessment. The most prominent was that the intelligence community was "too wedded to assumptions about Saddam's intentions," i.e. past uses of chemical weapons by Saddam, the expressed desire of the Saddam regime to obtain nuclear weapons, Saddam's previous deception and his continued obstruction of U.N. inspectors.

The commission's report said: "At some point, however, these premises stopped being working hypotheses and became more or less un-rebuttable conclusions; worse, the intelligence system became too willing to find confirmations of them in evidence that should have been recognized at the time to be of dubious reliability."

This is exactly the same attitude taken in the National Climate Assessment and the IPCC process. They are too wedded to beliefs in CO2 climate change. Data are cherry picked or interpreted only in the context of the belief in climate change.

For example, the NCA shows an increase in hurricanes since 1970, a period when there was a relative lull in hurricane activity. If one looks at the entire historic record for hurricanes, however, there is no trend up or down. The NCA also makes it appear that more maximum temperature records than ever were set in the past decade. In fact, the number of maximum high temperature records has been declining while minimum temperature records are rising.

In the second example, many more British seamen died of scurvy in the 18th century than died in battle. What is tragic about this is that sea captains and some ship's doctors knew, based on observation early in the century, that fresh vegetables and citrus cured scurvy. But, the Admiralty's onshore Sick and Health Board of scientists and physicians (like the IPCC) dismissed this evidence as "mere emperik's" for more than 50 years because it did not fit their consensus theory of scurvy.

This is analogous to the facts mentioned above in that observations of the deep global atmosphere are at odds with model projections. But the IPCC continues to squelch and marginalize this information rather than acknowledging it as real science should.

The common thread in all of the above is that the push for consensus encourages the suppression of minority views. This goes beyond just the National Climate Assessment and the IPCC process. The peer review process of both scientific papers and proposals for funding is largely a democratic process. In today's ideologically-polarized environment, however, getting a majority vote to approve a minority position proposal or paper is virtually impossible.

Since academic positions at most universities are filled by votes of the faculty, it is also almost impossible for young skeptics to land academic jobs. Thus, the current process not only prevents contrary climate change evidence from being published, it squelches both the development of information that does not support popular theories and the propagation of scientists who are not "true believers."

The tragedies of the Iraq War and the lives lost to scurvy show that there is a price when the "consensus" is wrong. The nation, the world and the scientific community deserve a full and open debate about the science and consequences of climate change. We should not have a publicly-funded climate science research program that only allows research which supports popular climate change theories.

To avoid this, the U.S. needs to adopt and fund a "Red Team" approach to climate change and atmospheric science research.

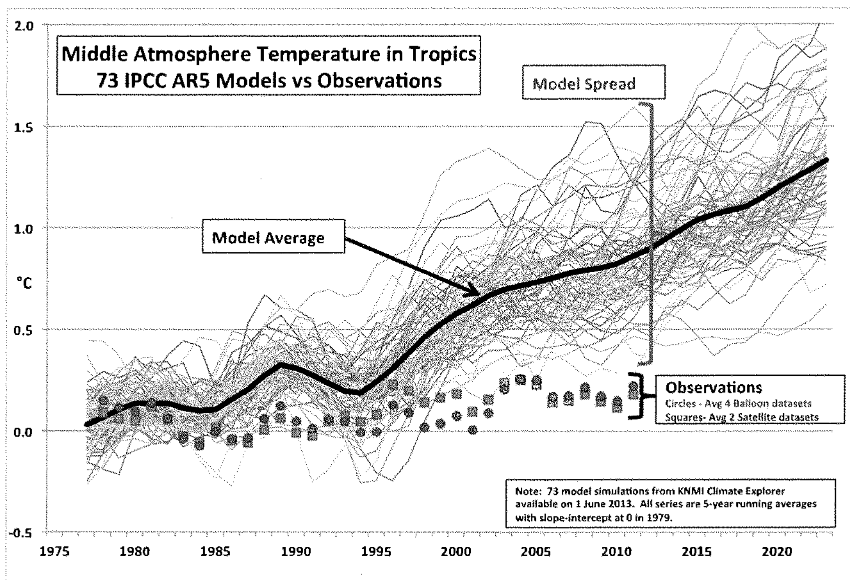
Red Teams have long been used by the military and private industry as a way to challenge consensus strategies or positions. While the climate change community often talks about how well funded and organized climate skeptics are, in fact nothing could be further from the truth.

If tallied, the funds going to "skeptical" climate scientists — including industry funds — are certainly less than one percent of that funding pro-climate change research. Climate skeptics who take money from industry are immediately branded as shills of industry, as Congressman Henry Waxman noted in a recent letter complaining about witnesses who testified at hearings on the science of climate change. We don't see the same outcry when other industries — such as the re-insurance industry, which has made billions of dollars by raising rates based on anticipated climate change — support climate change agendas.

Congress should require the National Science Foundation (NSF) to coordinate an interagency process that would allocate 5 percent of the federal climate change research budget to a Red Team effort. The review of Red Team science or policy research proposals could be carried out by review panels selected from the "skeptic community," with minority representation from the pro-climate change community. The House and Senate science committees could approve the selection of an NSF program manager.

If we do this, in the future if the nation and the world take action on climate change and it is wrong, at least history will record that we looked at the issue from all sides. If we do not, in the future climate change might be discussed along with WMD and scurvy as failures of consensus science, and some future commission might ask, "How could the climate science community have been so wrong about climate change?"

Richard McNider and John Christy are atmospheric scientists at the University of Alabama in Huntsville. They initiated temperature measurements of the global atmosphere using satellite data.



The Greenhouse Effect, Climate Sensitivity, and The Limitations of One Dimensional Thinking Plus Comments on Security

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June 5, 2012

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Summary

In the early 80's, though Global Warming was already high on the environmental agenda, it had not yet fully penetrated most of academia. Climate was still mostly considered an application of meteorology, oceanography, geochemistry and geology. My department at MIT had no one listed as a climate scientist. If one had been asked to put forward a list of major problems in climate, it would have involved questions like

what determines the equator-to-pole temperature difference

and

what determines the vertical lapse rate.

Major phenomena to explain would have included

the cycles of glaciation over the past million years,

as well as

the Eocene climate of 50 million years ago.

There was also Sagan's

early faint sun paradox,

and the Budyko-Sellers picture of unstable ice caps remained under consideration.

Of course, the sensitivity of climate to increasing CO2 was also being looked at, but it was but one of many more fundamental questions. Nevertheless, by the end of the 80's the picture of climate as consisting in a single variable,

global mean temperature anomaly,

and forcing consisting in a single number,

global and annually averaged radiative forcing

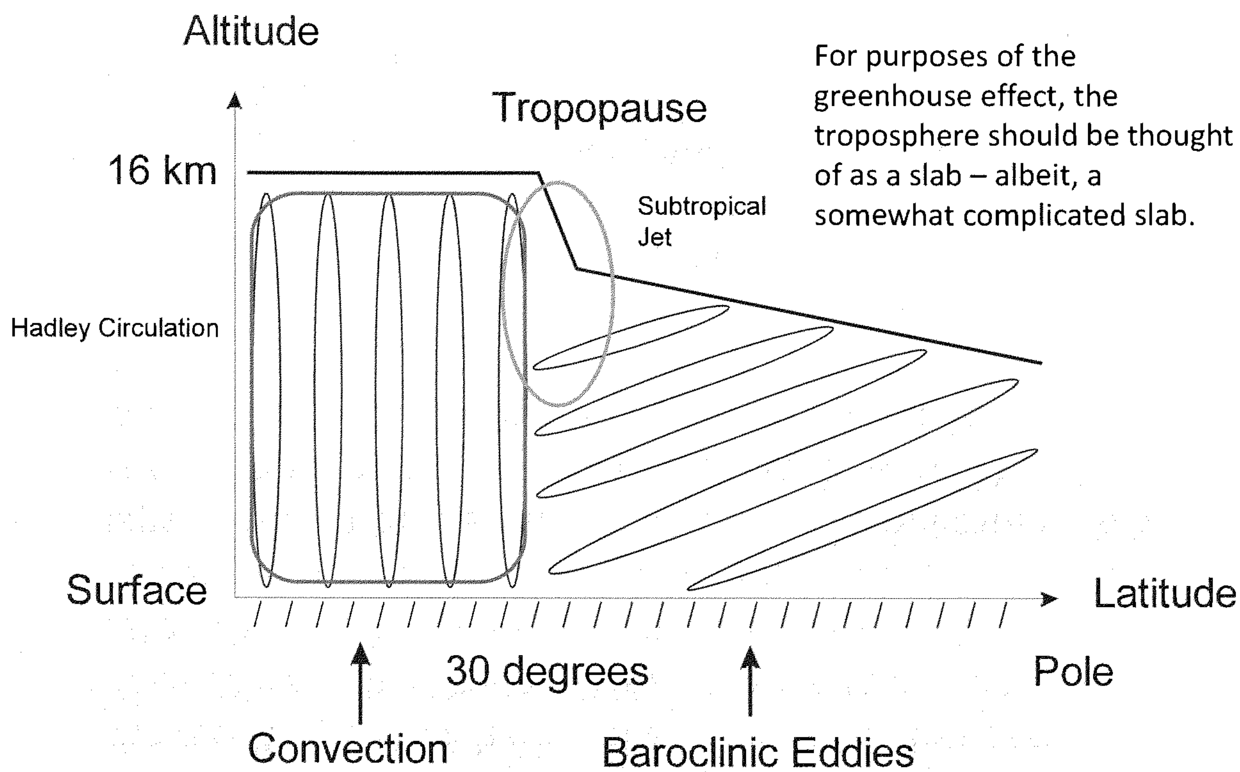
had taken hold with the greenhouse effect constituting the fundamental physical principle. All the other features were held to follow from this though no explanation existed as to why this should be so.

To be sure, this reductionist picture may be appropriate for forcings like increasing CO2 and varying solar output, and we will begin this talk by reviewing this approach, but we will also examine the problems of the glaciation cycles and the Eocene to see why the approach is inappropriate (and unsuccessful) for these actual examples of major climate change. Given the interest at Sandia in climate as a security issue, I will end with some obvious remarks relating to this question.

Real nature of greenhouse effect

All attempts to estimate how the climate responds to increasing CO_2 depend on how the climate greenhouse actually works. Despite the concerns with the greenhouse effect that have dominated environmental thinking for almost a quarter of a century, the understanding of the effect is far from widespread. Part of the reason is that the popular depiction of the effect as resulting from an infrared 'blanket' can be seriously misleading. The following description is, itself, somewhat oversimplified; however, it is probably adequate for understanding the underlying physics.

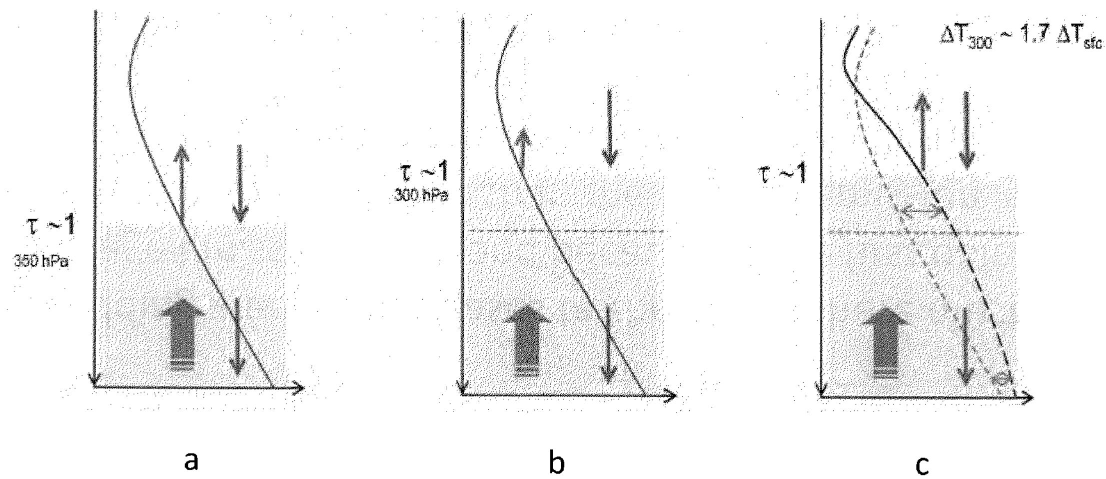
First, one must recognize that the troposphere, the layer of the atmosphere in contact with the surface, is a dynamically mixed layer. For a gaseous atmosphere, mixing requires that the resulting atmosphere is characterized by temperature decreasing with altitude. This is referred to as a positive lapse rate. The rate of decrease is approximately 6.5K/km which is sometimes taken as an approximation to the moist adiabatic lapse rate, but the real situation is more complicated. To be sure, in the tropics, the mixing is effected by moist convection, but outside the tropics, the mixing is accomplished mostly by baroclinic eddies. Moreover, the moist adiabat in the tropics does not have a uniform lapse rate with altitude (viz the ‘hot spot’). For our immediate purposes, the important facts are that the lapse rate is positive (not zero or negative), and relatively uniform over most of the globe.



Schematic of the troposphere as a dynamically mixed layer.

Second, one must recognize that gases within the atmosphere that have significant absorption and emission in the infrared (ie greenhouse gases) radiate to space with a flux characteristic of the temperature of the atmosphere at about one optical depth (measured from space downward). To be sure, this level varies with wavelength, but the average emission level is about 5-6 km above the surface and well within the troposphere.

Third, adding greenhouse gases to the atmosphere must elevate the average emission level, and because of the first point, the new emission level is colder than the original emission level. This reduces the outgoing infrared radiative flux, which no longer balances the net incoming solar radiation. ***Thus, the troposphere, which is a dynamically mixed layer, must warm as a whole (including the surface) while preserving its lapse rate.***

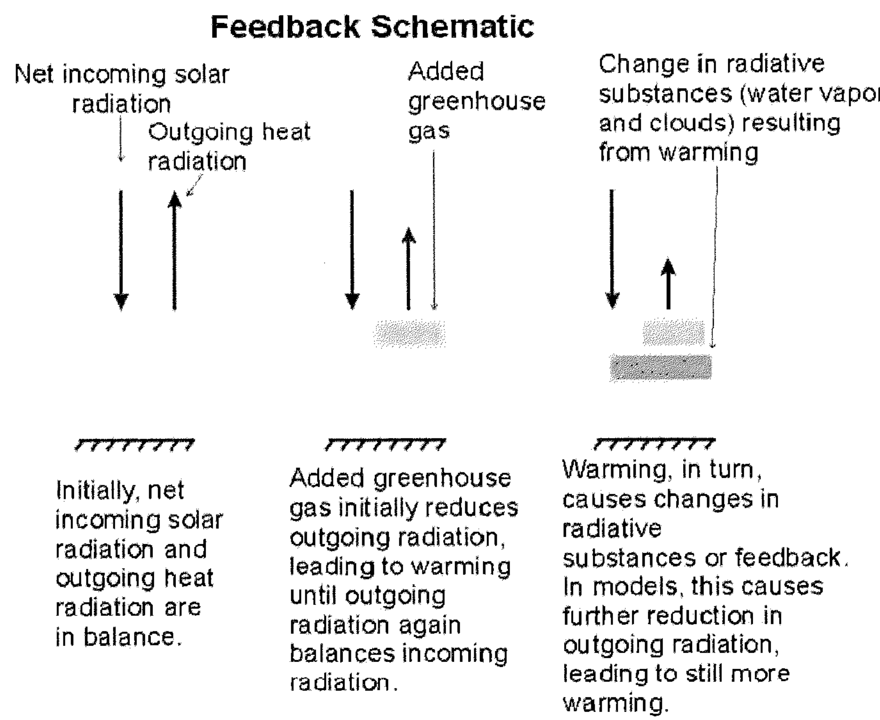


a) Situation with atmosphere in equilibrium with space. b) The situation when added greenhouse gas elevates the characteristic emission level to a cooler level, leaving a radiative imbalance that constitutes the radiative forcing. c) Re-equilibration with moist adiabat.

Note that this mechanism leads to the simple result that doubling CO_2 gives rise to warming of about 1C. This would not suggest significant concern. Larger warming calls for positive feedbacks.

A point worth noting is that the greenhouse effect will always lead to a warmer earth than the black body temperature of a sphere. The point is simply that the black body temperature will be the emission temperature of the characteristic emission level, and that this level is ~5km above the surface. Because of dynamics, this level is connected to the surface by a positive lapse rate so that the surface must be warmer.

An obvious approach to measuring feedbacks would be to see how outgoing radiation responds to surface temperature fluctuations, but it has difficulties.



The crucial point about the feedbacks is that they respond to surface temperature fluctuations regardless of the origin of the fluctuations.

The basis of the approach is to see if the satellite measured outgoing radiation associated with short term fluctuations in Sea Surface Temperature (SST) is larger or smaller than what one gets for zero feedback. Remember that a positive feedback will lead to less outgoing radiation, while a negative feedback will lead to more.

It turns out that the model intercomparison program has the models used by the IPCC, forced by actual SST, calculate outgoing radiation. So one can use the same approach with models, while being sure that the models are subject to the same surface temperature fluctuations that applied to the observations.

In principle, this should be a straightforward task. However, in practice, it is rather difficult. The first two difficulties involve basic physical considerations.

First, not all time scales are appropriate for such studies. Greenhouse warming continues until equilibrium is reestablished. At equilibrium, there is no longer any radiative imbalance. If one considers time intervals that are long compared to equilibration times, then one will observe changes in temperature without changes in radiative forcing. The inclusion of such long time scales thus biases results inappropriately toward high sensitivity. Equilibration times depend on climate sensitivity. For sensitivity on the order of 0.5C for a doubling of CO_2, it is on the order of years, and for higher sensitivities it is on the order of decades. In order to avoid biasing sensitivity estimates, one should restrict oneself to time intervals less than a year.

There is also the need to consider time intervals long enough for the relevant feedback processes to operate. For water vapor and cloud feedbacks, these time scales are typically on the order of days. For practical time resolution, this is generally not a problem.

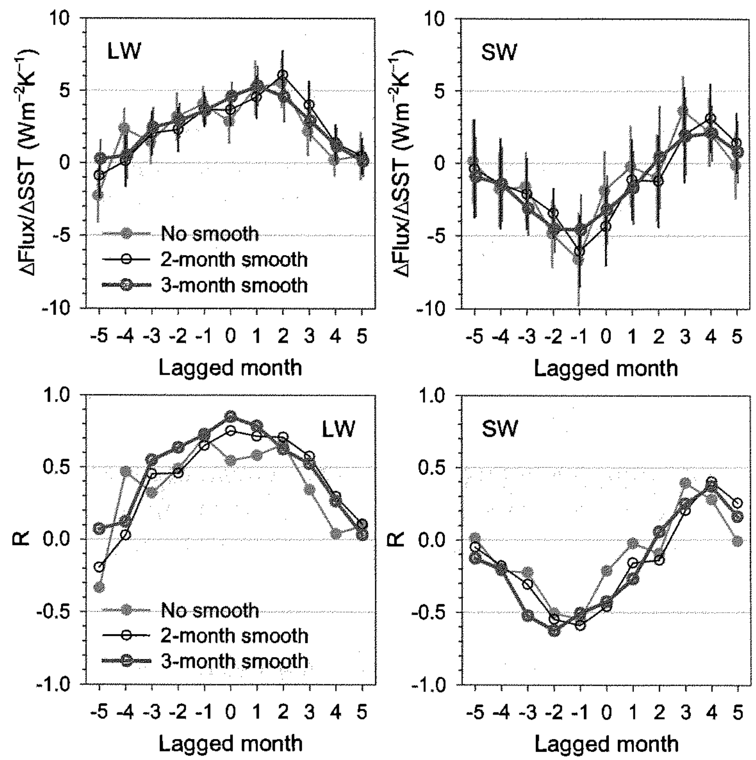
Time scales on the order of 1-3 months are, thus, certainly appropriate for sensitivity studies. Longer time scales also involve 'pollution' from seasonal effects, etc. Restricting consideration to such short time scales is the approach taken in Lindzen and Choi (2009, 2011).

The **second** problem is more difficult. Outgoing radiation varies (especially in the visible) for reasons other than changing surface temperature (volcanoes, non-feedback cloud fluctuations). Such changes are not responses to surface temperature fluctuations but they do cause surface temperature fluctuations.

Apart from basic physical issues, there are other practical problems such as the presence of significant gaps in the outgoing radiation data. Also, the radiation data involves two satellite systems (ERBE and CERES) with different properties.

Lindzen and Choi, 2011, describes how we deal with these issues. **Here, I will simply describe the signature of the second problem: namely, when one has an unambiguous feedback, a plot of r^2 and/or $\Delta F/\Delta T$ v. Lag has a single maximum at a small lag. If, however, the non-feedback variations are large, then these relations have an S-shape, and the regression at zero lag can be completely misleading because it consists primarily in artifacts from the fact that there is a finite decorrelation time for the non-feedback variations.**

Here are our results based primarily on SST and tropical radiation. In evaluating feedbacks, we require that radiative imbalances in the tropics be shared with the globe. Interestingly, the results are similar to what are obtained with data for the whole earth.



Note the unambiguous long wave feedback as well as the S-shape for the short wave feedback.

Lindzen and Choi, 2011, show that all IPCC models display positive (amplifying) feedbacks, but that the observations do not. Moreover, the long wave feedback is unambiguously negative in the data. Remember that the positive water vapor feedback, that is fundamental to the high sensitivity of models, is a long wave feedback.

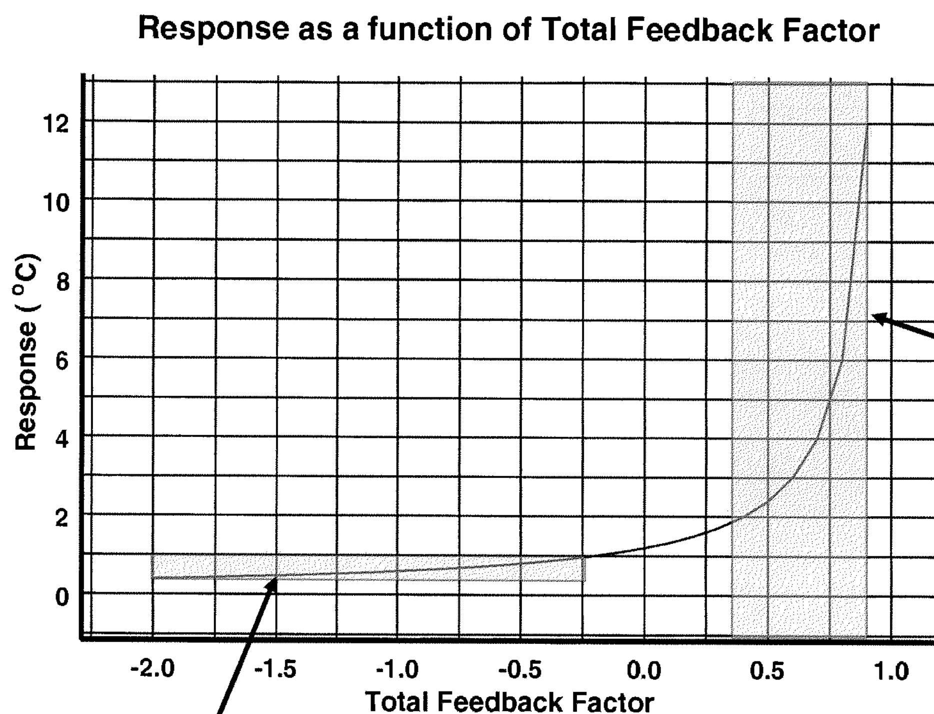
Models

Models	IPCC AR4	Estimate in this study			
	Sensitivity	Sensitivity	Confidence interval of sensitivity		
			90%	95%	99%
CCSM3	2.7	8.1	1.6 – Infinity	1.4 – Infinity	1.1 – Infinity
ECHAM5/MPI-OM	3.4	1.7	0.9 – 8.0	0.9 – 28.2	0.8 – Infinity
FGOALS-g1.0	2.3	7.9	2.2 – Infinity	2.0 – Infinity	1.6 – Infinity
GFDL-CM2.1	3.4	2.2	1.1 – 351.4	1.0 – Infinity	0.8 – Infinity
GISS-ER	2.7	2.5	1.5 – 8.7	1.4 – 16.4	1.2 – Infinity
INM-CM3.0	2.1	2.7	1.3 – Infinity	1.2 – Infinity	1.0 – Infinity
IPSL-CM4	4.4	10.4	2.1 – Infinity	1.8 – Infinity	1.4 – Infinity
MRI-CGCM2.3.2	3.2	Infinity	2.5 – Infinity	2.0 – Infinity	1.4 – Infinity
MIROC3.2(hires)	4.3	2.2	1.3 – 6.4	1.2 – 10.0	1.1 – Infinity
MIROC3.2(medres)	4	2.4	1.3 – 14.7	1.2 – Infinity	1.0 – Infinity
UKMO-HadGEM1	4.4	1.7	1.0 – 8.8	0.9 – 38.9	0.8 – Infinity

Observations

Sensitivity, mean	0.7
Sensitivity, 90%	0.6–1.0
Sensitivity, 95%	0.5–1.1
Sensitivity, 99%	0.5–1.3

At first the agreement with model sensitivity seems modest, but there is no inconsistency at the 90% confidence level.



For positive feedbacks, relatively small variations in feedback lead to large changes in response.

It is the positive feedbacks in the models that leads to the large variations in model results, and to the potential for instability.

For negative feedbacks, large variations in the feedback lead to only small changes in response.

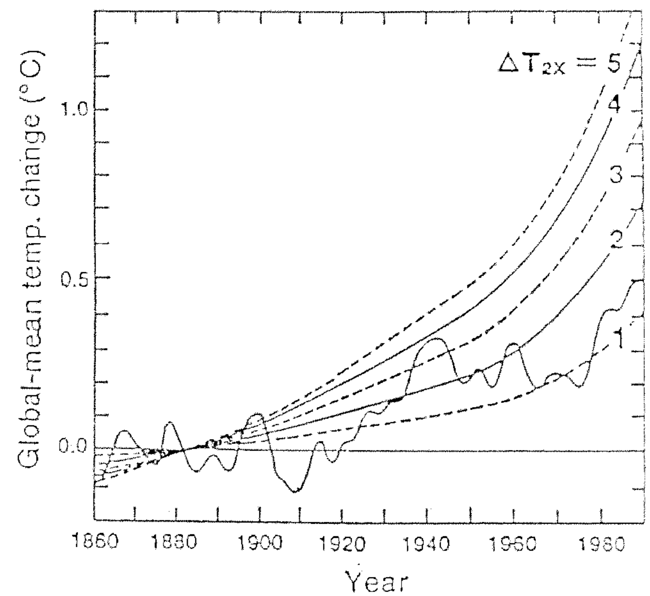
$$\Delta T = \frac{\Delta T_0}{1-f},$$

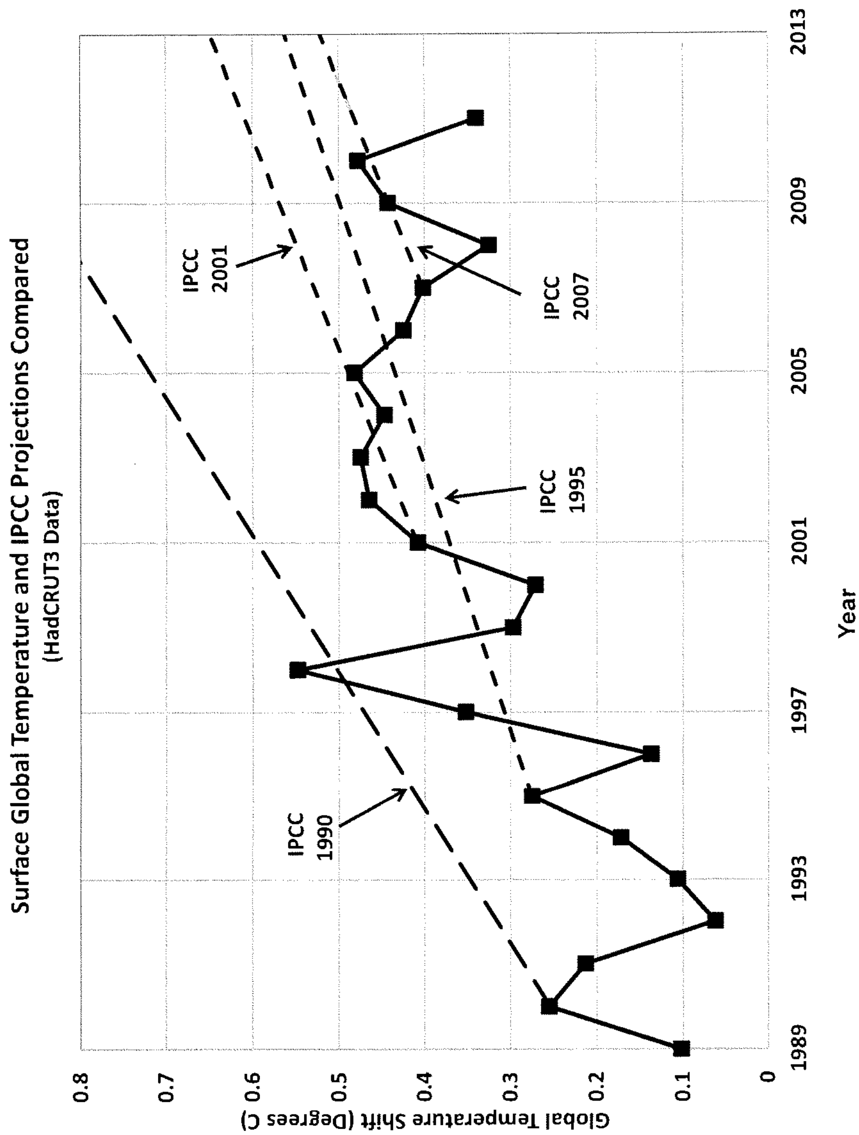
To be sure, the analysis by myself and Choi has proven controversial. Despite the controversy, the approach taken is almost certainly appropriate for such global forcings such as increasing CO2.

One may reasonably ask why the results were controversial since the temperature record, itself, hardly demanded a high sensitivity.

The figure on the right is from the first (1990) IPCC report.

The figure on the next slide shows that little has changed since then.




Surface Global Temperature and IPCC Projections Compared
(HadCRUT3 Data)
Global Temperature Shift (Degrees C)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1989
1993
1997
2001
2005
2009
2013
Year
IPCC 1990
IPCC 1995
IPCC 2001
IPCC 2007

The claim that the models adequately account for past climate is specious, since aerosols are used as an adjustable parameter.

The IPCC 4th AR listed the cloud albedo effect for aerosols as being negative. However, this excludes the all-important ice clouds for which the effect is likely to be positive. The added red line shows this.

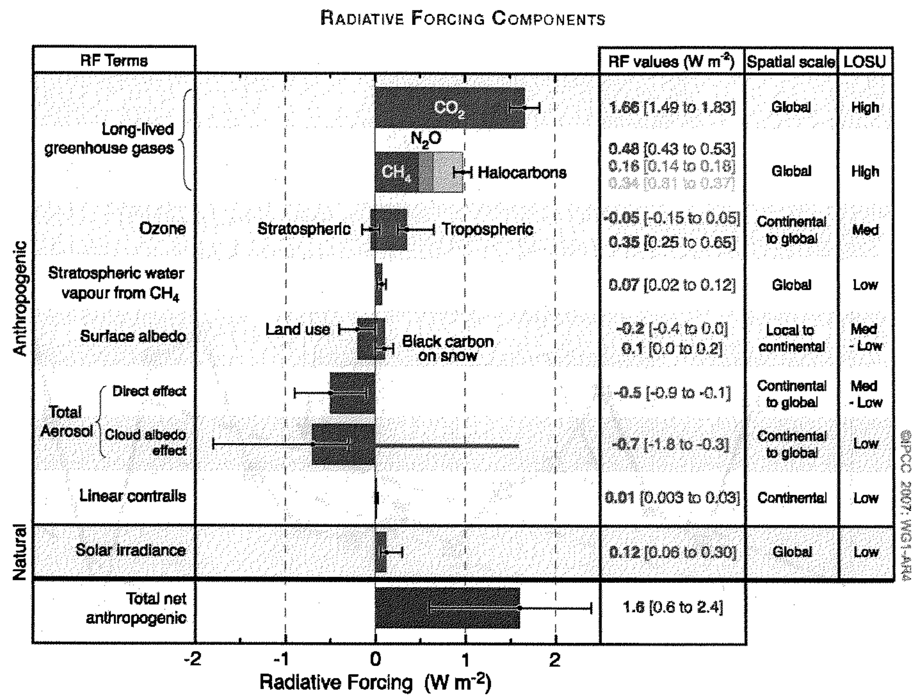
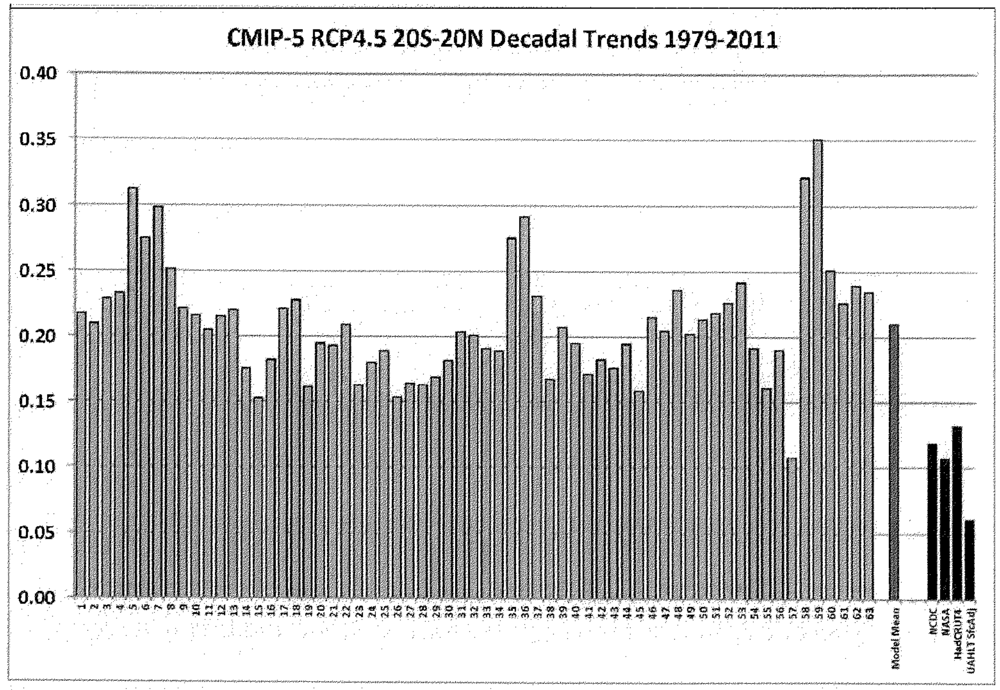


Figure SPM.2. *Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}*

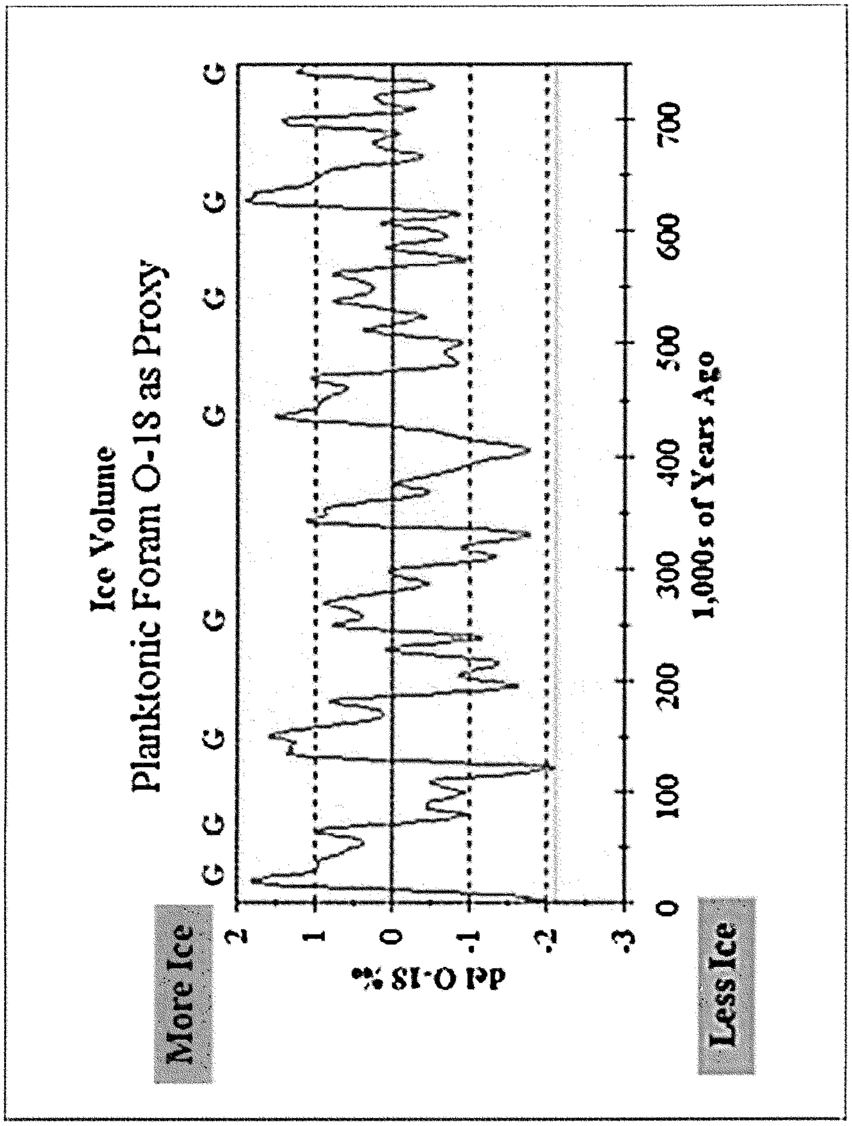
Even when adjusted, problems seem to remain.

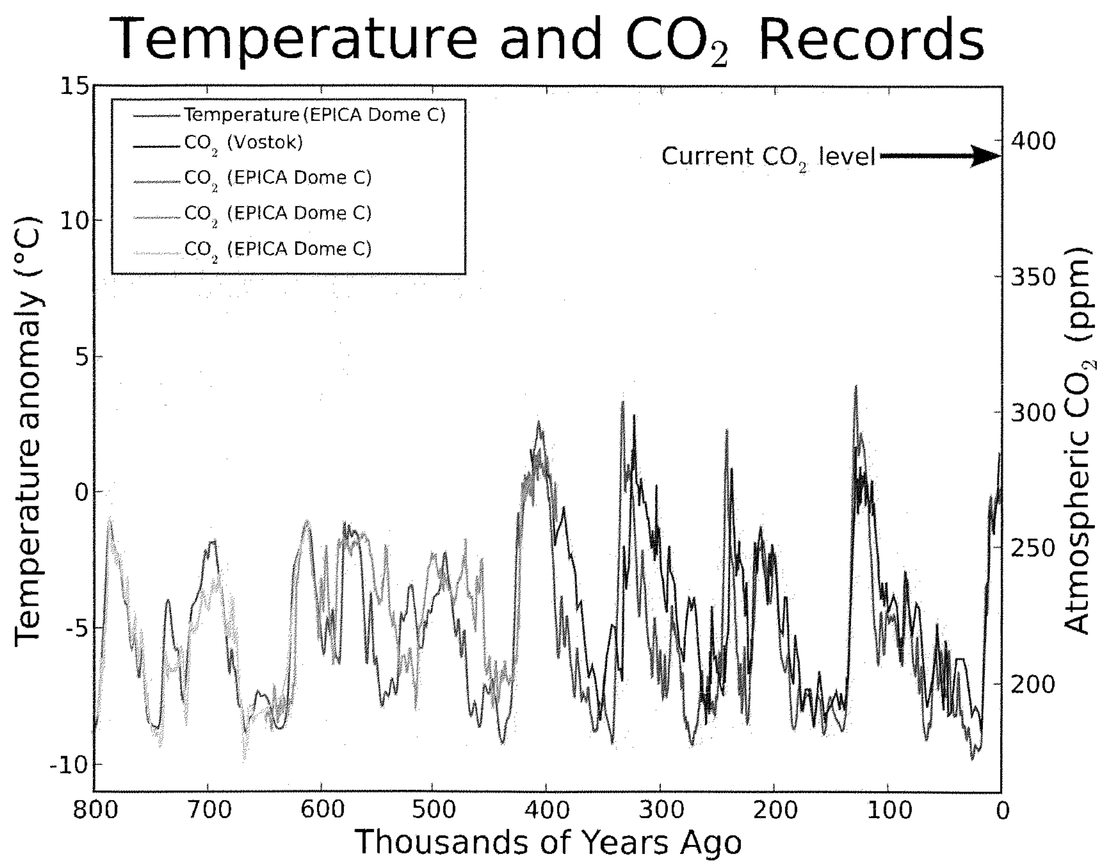


Moreover, still other tests involving response time, ocean storage, etc. also point to low sensitivity.

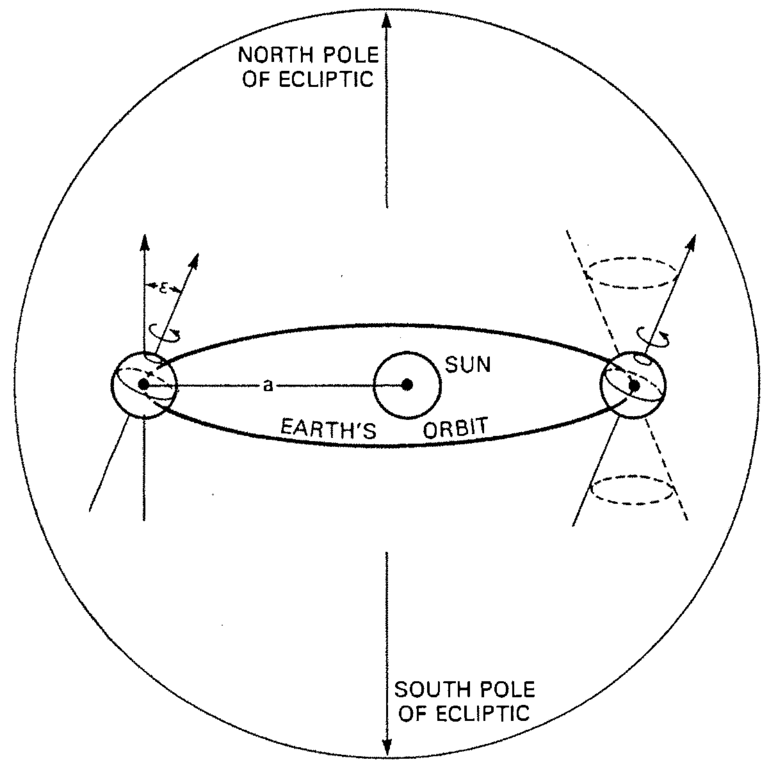
However, it is important to consider whether the simplistic one dimensional picture is even relevant to major climate variations of the past.

We will begin with the cycles of glaciation and deglaciation of the past 800 thousand years.

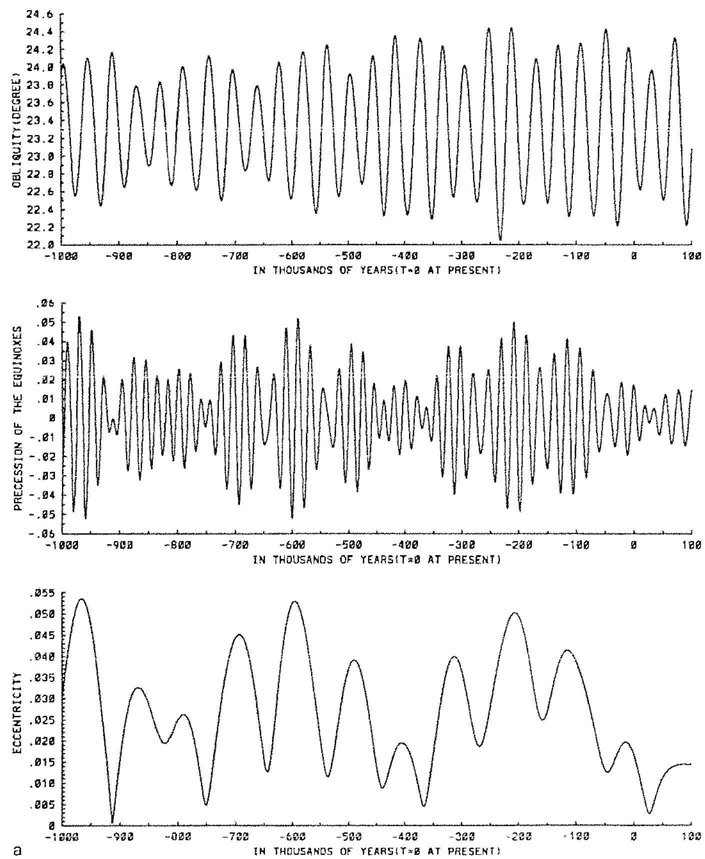

Ice Volume
Planktonic Foram O-18 as Proxy
More Ice
Less Ice
dd O-18 ‰
1,000s of Years Ago
G G G G G G G G G
2
1
0
-1
-2
-3
0
100
200
300
400
500
600
700


Temperature and CO_2 Records
Temperature (EPICA Dome C)
CO_2 (Vostok)
CO_2 (EPICA Dome C)
CO_2 (EPICA Dome C)
CO_2 (EPICA Dome C)
Current CO_2 level
Temperature anomaly (°C)
15
10
5
0
-5
-10
Atmospheric CO_2 (ppm)
400
350
300
250
200
800
700
600
500
400
300
200
100
0
Thousands of Years Ago

Schematic diagram illustrating effect of planetary forces on the earth's axis and orbit. These forces cause changes in the eccentricity or ellipticity of the orbit (a), the tilt of the rotational pole (ϵ), and the gyroscopic spin of the planet (precession).



The cycles are generally believed to be related to the Earth's orbital variations.



Milankovitch Hypothesis:

The growth of arctic ice sheets is primarily determined by the solar insolation in summer. The idea is that there will always be accumulation in winter, but that summer insolation determines whether the accumulation will survive.

For many years, people compared the Milankovitch parameter with ice volume. The correlation was poor.

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Astronomy & Astrophysics

Accurate spin axes and solar system dynamics: Climatic variations for the Earth and Mars

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Abstract. Celestial mechanical simulations from a purely classical point of view of the solar system, including our Moon and the Mars moons – Phobos and Deimos – are carried out for 2 millions of years before present. Within the classical approximation, the results are derived at a very high level of accuracy. Effects from general relativity for a number of variables are investigated and found to be small. For climatic studies of about 1 Myr, general relativity can safely be ignored. Three different and independent integration schemes are used in order to exclude numerical anomalies. The converged results from all methods are found to be in complete agreement. For verification, a number of properties such as spin axis precession, nutation, and orbit inclination for Earth and Mars have been calculated. Times and positions of equinoxes and solstices are continously monitored. As also observed earlier, the obliquity of the Earth is stabilized by the Moon. On the other hand, the obliquity of Mars shows dramatic variations. Climatic influences due to celestial variables for the Earth and Mars are studied. Instead of using mean insolation as in the usual applications of Milankovitch theory, the present approach focuses on the instantaneous solar radiation power (insolation) at each summer solstice. Solar radiation power is compared to the derivative of the icevolume and these quantities are found to be in excellent agreement. Orbital precessions for the inner planets are studied as well. In the case of Mercury, it is investigated in detail.

Key words. solar system: general – planets and satellites: general – methods: N-body simulations – celestial mechanics: spin axes – relativity – Earth – Mars

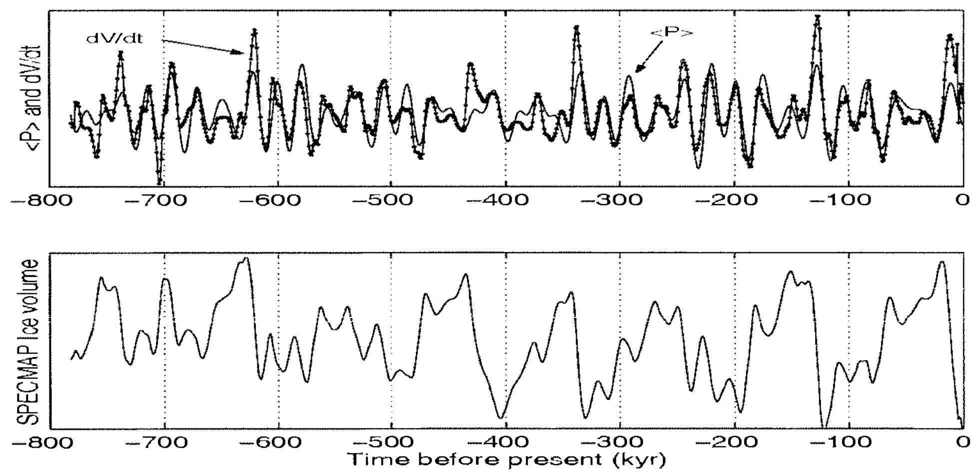


Fig. 14. (Top) Mean summer solar radiation power (insolation) and differentiated ice volume ($\langle P \rangle \propto \mathrm{d}V_{\mathrm{ice}}/\mathrm{d}t$). (Bottom) Ice volume (Imbrie et al. 1990).

the knowledge of this radiation power $\langle P \rangle$ will be very useful. According to thermodynamics, the energy $\mathrm{d}Q$ flowing into the glacial system causes melting of ice into water of mass $\mathrm{d}m$:

$$\mathrm{d}Q = L_{\mathrm{f}}\mathrm{d}m \tag{33}$$

where the proportionality constant L_{f} is the heat of fusion. The power is the incoming energy per unit of time:

$$\text{power} = \frac{\mathrm{d}Q}{\mathrm{d}t} = L_{\mathrm{f}}\frac{\mathrm{d}m}{\mathrm{d}t} = L_{\mathrm{f}}\rho\frac{\mathrm{d}V}{\mathrm{d}t} \tag{34}$$

ice sheets. However, it is likely that a relative increase in power above the atmosphere *in average* leads to a corresponding relative increase in power near the ice sheets. The SPECMAP data (Imbrie et al. 1990) are based on sea sediment measurements in the Northern Atlantic. The resolution in these ice volume data is 1000 yrs. We assume that melting mostly takes place during the summer half years. In Sect. 2.8, it is shown how the length of each summer half year is computed. The total melting period $\mathrm{d}t$ is then obtained by summing all these 1000 summer

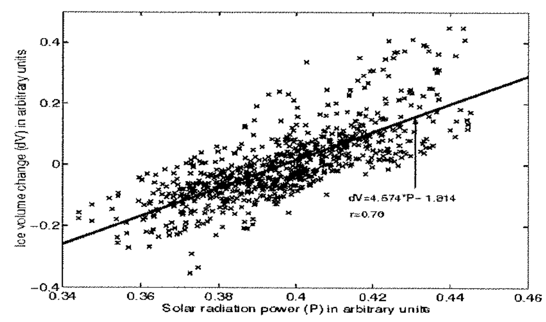


Fig. 15. This least square fit of summer radiation power and differentiated ice volume determines the proportionality constant between the curves. $r = 0.76$ is the correlation coefficient.

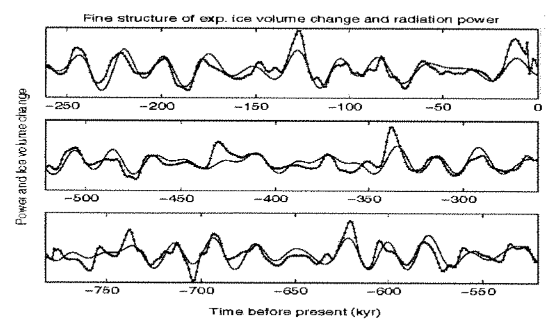


Fig. 16. Fine structure of the mean summer radiation power (solid curve) and differentiated ice volume (dotted curve). No ~5 kyr time lag is observed.

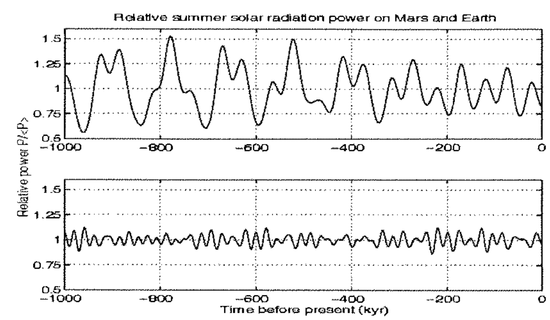


Fig. 17. Comparison of relative summer radiation power for Mars (top) and Earth (bottom) for their northern latitudes.

Note that Edvardsson et al have shown that the melting due to the changes in solstitial insolation are what is needed to account for the changes in ice volume

gases (water vapor, carbon dioxide etc.). This calls for further investigations. It is interesting to observe that the usual frequency problem with the 100 000 year period in the ice volume data disappears in our comparison. Neither are there any time lag problems between summer radiation power and dV_{ice}/dt. This problem occurs only when comparing summer radiation power (or insolation) with ice volume (V_{ice}). Figure 16 displays the fine-structure of our Fig. 14. It is evident that there exists no time lag of about 4–5 kyr as reported e.g. by Berger et al. (1993).

Finally, we compare the variations in summer radiation

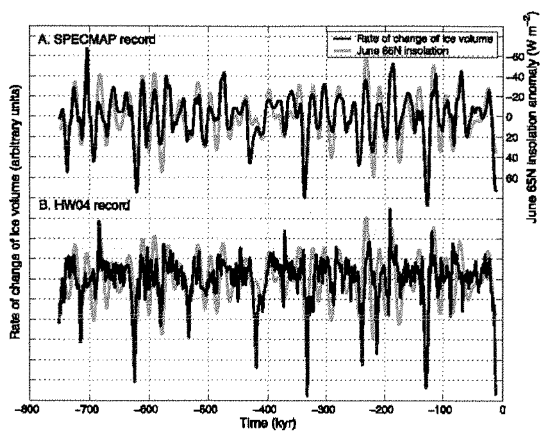


Figure 2. As for Figure 1, but comparing June 65N insolation anomaly with the time rate of change of global ice volume (*dV*/*dt*). The SPECMAP record has zero lag and HW04 record is lagged by only 1 kyr, in order to show the maximum lag correlation with the insolation time series of −0.8 and −0.4, respectively. Autocorrelation estimates suggest that the SPECMAP and HW04 time series of *dV*/*dt* have 106 and 123 degrees of freedom respectively. Therefore, in both cases the correlations are significant at well above the 99% confidence level. If the HW04 record is smoothed in the same manner as SPECMAP (using a nine-point Gaussian filter [*Imbrie et al.*, 1984]), the maximum lag correlation does not increase. Convention for units is as for Figure 1.

insolation curves. Figure 3 shows that, for the SPECMAP record, the best-fit combination is almost identical to the June 65N insolation. In the case of the HW04 record, the best-fit combination closely matches the summer half-year (April to September average) 65N insolation. Summer might arguably be better defined by the radiation half-year [*Huybers*, 2006]. We have not tried to distinguish here which should be preferred - the nonlinearity of total ablation (i.e., not just local ablation rate) to summertime temperatures makes it likely that peak summertime temperatures ought to be weighted more than average summertime temperatures. The key point for the purpose of this paper is that, while these analyses do not prove a causal link absolutely, both records confirm the a priori hypothesis based on physical arguments of a direct connection between some sensible measure of summertime insolation in the northern high latitudes and the rate of change of ice volume there.

[10] Atmospheric CO_2 has also been suggested as driving changes in global ice volume [e.g., *Shackleton*, 2000; *Lea*, 2004]. The concentration of CO_2 varied between about 200 and 280 ppmv over the last several ice age cycles, and caused approximately 2 Wm^{-2} variations in surface longwave radiation forcing [e.g., *Ramaswamy et al.*, 2001]. Comparisons of the impacts of shortwave and longwave radiative forcing appropriate over the ice sheets are not straightforward, but taking summer half-year insolation variations in shortwave (Figure 3), and assuming an albedo of 0.5 for melting ice, variations in summertime shortwave forcing exceed the direct CO_2 radiative forcing by about a factor of five. It has also been reported that the ice volume lags behind CO_2, and this has led to the suggestion that CO_2 variations drive ice age cycles [*Shackleton*, 2000; *Lea*, 2004; *Ruddiman and Raymo*, 2003]. However, cross

mountain glaciers and ice caps. However at the scale of the great continental ice sheets, theory, dynamic models, and

Note that we are dealing with variations in insolation of 100 watts per square meter.

time scale of adjustment. We note also that the nonlinearities of ice flow and mass balance preclude the application of a single adjustment time scale to an ice sheet. Ice sheet height, area, and volume all have different adjustment times [e.g., *Roe and Lindzen*, 2001], all of which are dependent on the ice sheet size, the climate state, and the magnitude of the forcing.

[9] It is not possible to unequivocally attribute a climate response to an insolation forcing at a particular latitude and season because, to a good approximation, any such forcing can be constructed from a linear combination of climatic precession and obliquity indices [*Imbrie and Imbrie*, 1980]. In theory then, an infinite set of insolation curves (or their meridional gradients) can be matched with a given climate signal, leaving the physical mechanisms producing the climate response ambiguous. To address this, regression analyses were performed to find the best-fit linear combinations of the obliquity and climatic precession indices for dV/dt from the SPECMAP and HW04 records (see auxiliary material for methods). These best-fit combinations of the orbital parameters were then compared with characteristic

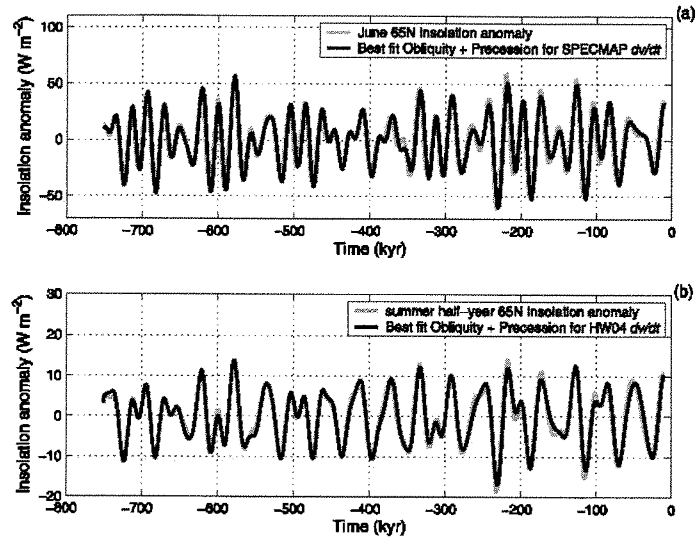


Figure 3. Results of optimized linear regression of climatic precession and obliquity indices onto the rate of change of ice volume allowing for arbitrary amplitude and lag, compared to indices of summer insolation variations at 65N, using (a) the SPECMAP record and (b) the HW04 record. The results of the linear regression are scaled to the insolation index in Figures 3a and 3b. Note the different scales on the y-axes. See auxiliary materials for methods.

So here, we have a simple theory that **quantitatively** accounts for the major changes in ice volume on the basis of the changes in the **seasonal** behavior of arctic insolation – involving changes of over 100 Watts per square meter. It is nonetheless argued that the Milankovitch mechanism cannot account for the ice age cycles because the annual and global mean variations of insolation associated with orbital cycles is small (even zero), and that the contribution of about 1.5 wm-2 from CO2 is essential. The change in CO2 comes from the change in temperature and is held to be essential to producing this temperature. No mechanism has ever been proposed for this seemingly absurd idea, but it is staunchly maintained by Hansen, the IPCC and various others.

While it is fair to say that the cause of the glaciation cycles is now well established, we still do not know why the 100kyr cycles began only about 700kyr ago. With the Eocene, we are not in such good shape, but there are a number of interesting results.

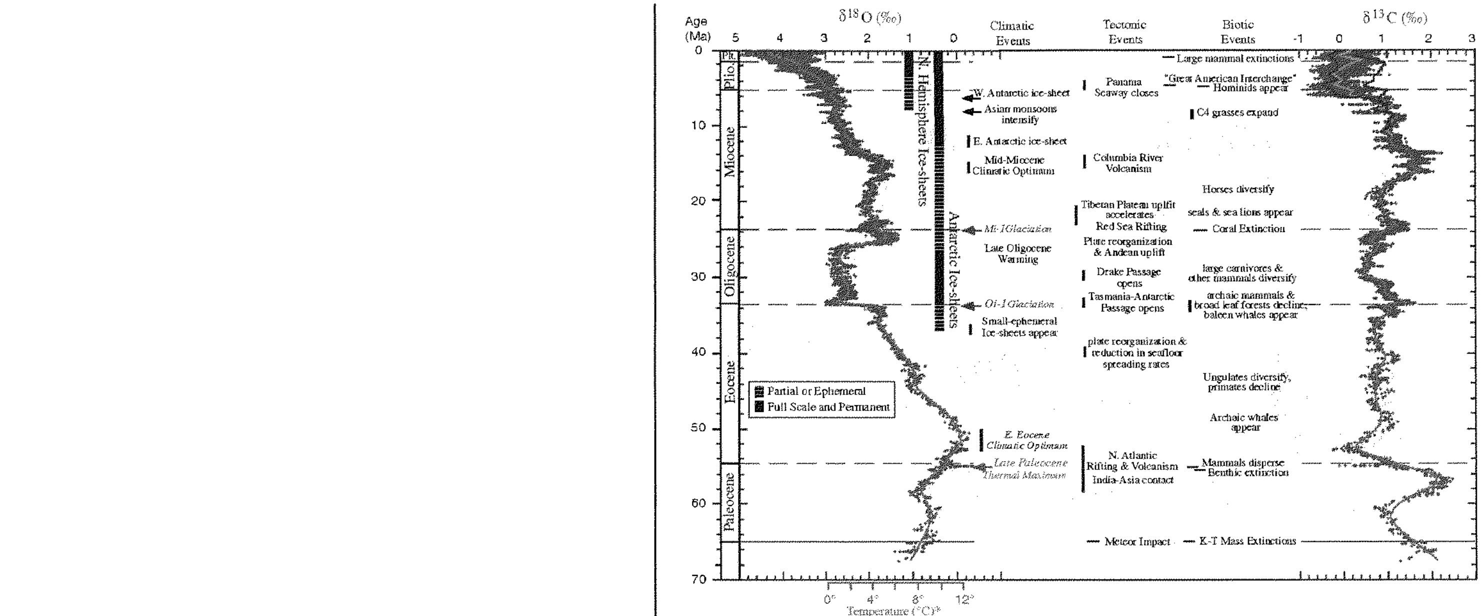
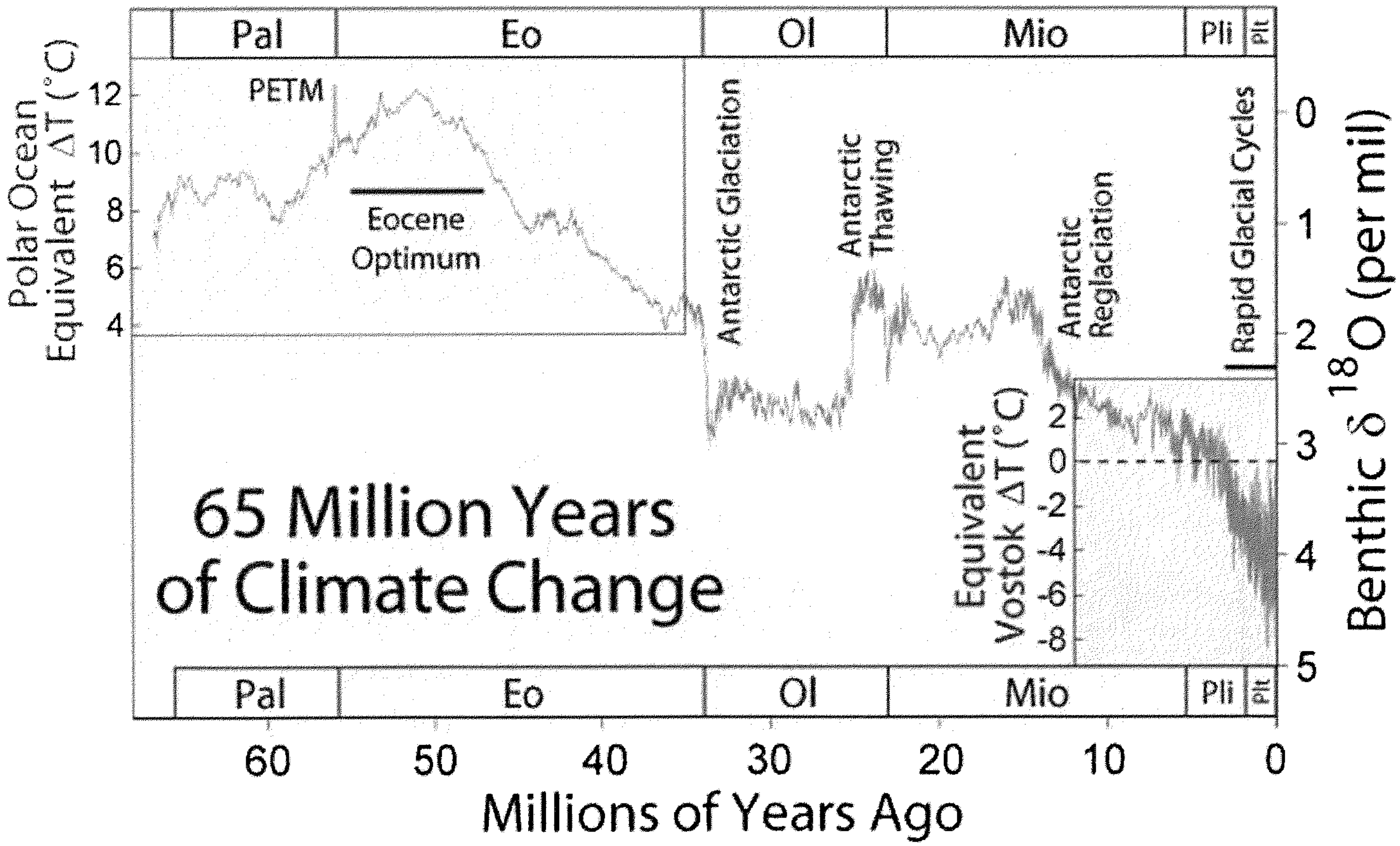


Fig. 2. Global deep-sea oxygen and carbon isotope records based on data compiled from more than 40 DSDP and ODP sites (*36*). The sedimentary sections from which these data were generated are classified as pelagic (e.g., from depths >1000 m) with lithologies that are predominantly fine-grained, carbonate-rich (>50%) oozes or chalks. Most of the data are derived from analyses of two common and long-lived benthic taxa, *Cibicidoides* and *Nuttallides*. To correct for genus-specific isotope vital effects, the $\delta^{18}O$ values were adjusted by +0.64 and +0.4‰ (*124*), respectively. The absolute ages are relative to the standard GPTS (*36, 37*). The raw data were smoothed using a five-point running mean, and curve-fitted with a locally weighted mean. With the carbon isotope record, separate curve fits were derived for the Atlantic (blue) and Pacific above the middle Miocene to illustrate the increase in basin-to-basin fractionation that exceeds ~1.0‰ in some intervals. Prior to 15 Ma, interbasin gradients are insignificant or nonexistent (*39*). The $\delta^{18}O$ temperature scale was computed for an ice-free ocean [~1.2‰ Standard Mean Ocean Water (SMOW)], and thus only applies to the time preceding the onset of large-scale glaciation on Antarctica (~35 Ma) (*43*). From the early Oligocene to present, much of the variability (~70%) in the $\delta^{18}O$ record reflects changes in Antarctica and Northern Hemisphere ice volume (*40*). The vertical bars provide a rough qualitative representation of ice volume in each hemisphere relative to the LGM, with the dashed bar representing periods of minimal ice coverage (≤50%), and the full bar representing close to maximum ice coverage (>50% of present). Some key tectonic and biotic events are listed as well (*4, 5, 35*).



Pal
Eo
Ol
Mio
Pli
Plt
Polar Ocean Equivalent ΔT (°C)
12
10
8
6
4
PETM
Eocene Optimum
Antarctic Glaciation
Antarctic Thawing
Antarctic Reglaciation
Rapid Glacial Cycles
Benthic δ 18O (per mil)
0
1
2
3
4
5
Equivalent Vostok ΔT (°C)
2
0
-2
-4
-6
-8
65 Million Years of Climate Change
60
50
40
30
20
10
0
Millions of Years Ago

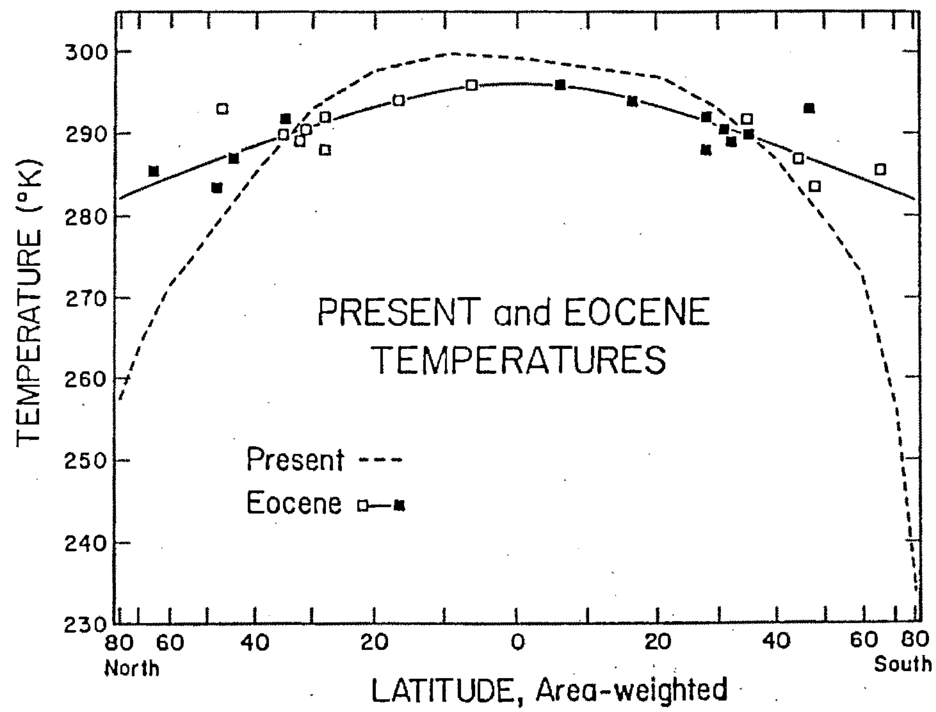
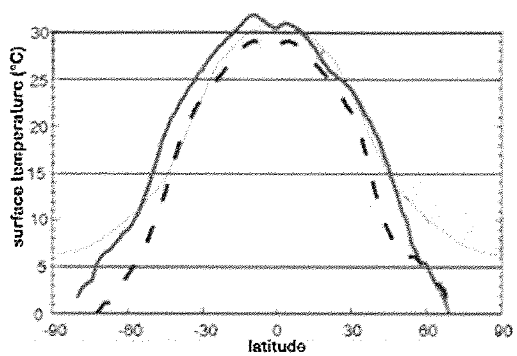


Fig. 1. Isotopic paleotemperatures of the Eocene surface ocean from Shackleton and Boersma [1981] in comparison with modern values. Northern and Southern hemisphere isotopic values are plotted in both hemispheres (mirror data sites are plotted as open squares) in order to draw a temperature distribution with respect to latitude. The latitude scale is area weighted.

Almost immediately, people tried to account for the Eocene temperature distribution by increasing CO2.



- - - - Modern Model SST
- Eocene Model SST
- Eocene Proxy SST

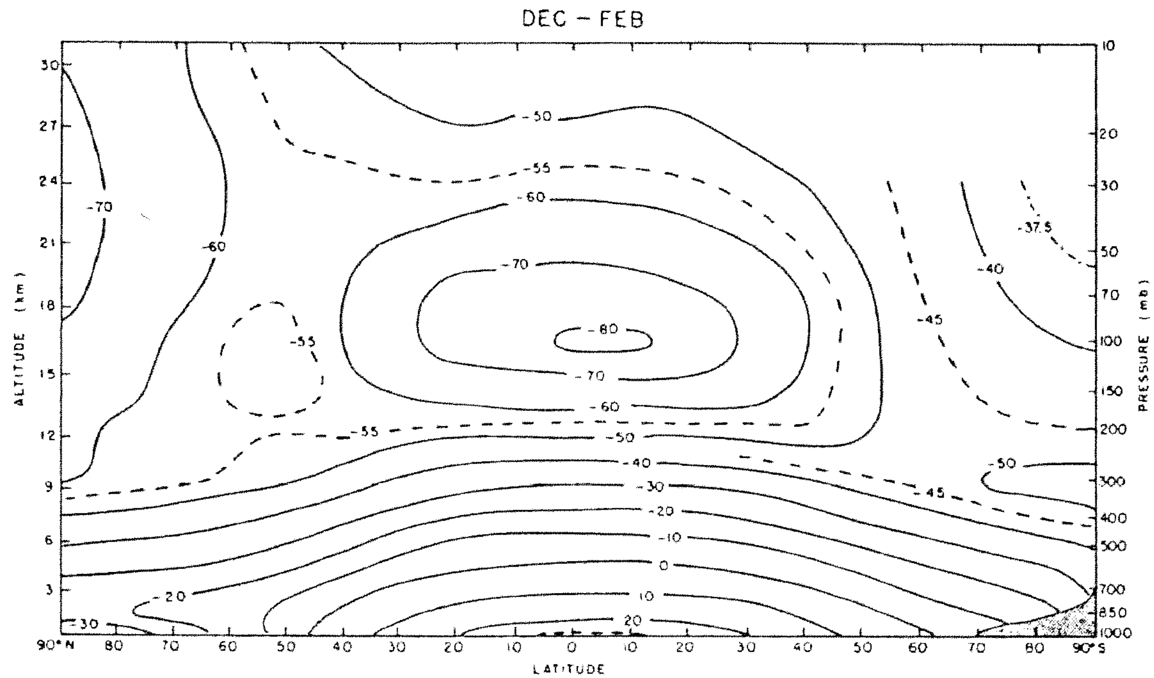
Coupled GCM study of [Huber and Sloan, 2001], for example. Uses best guess Eocene:

1. Bathymetry
2. Topography
3. Land Surface
4. Vegetation
5. CO_2 (560 ppm)

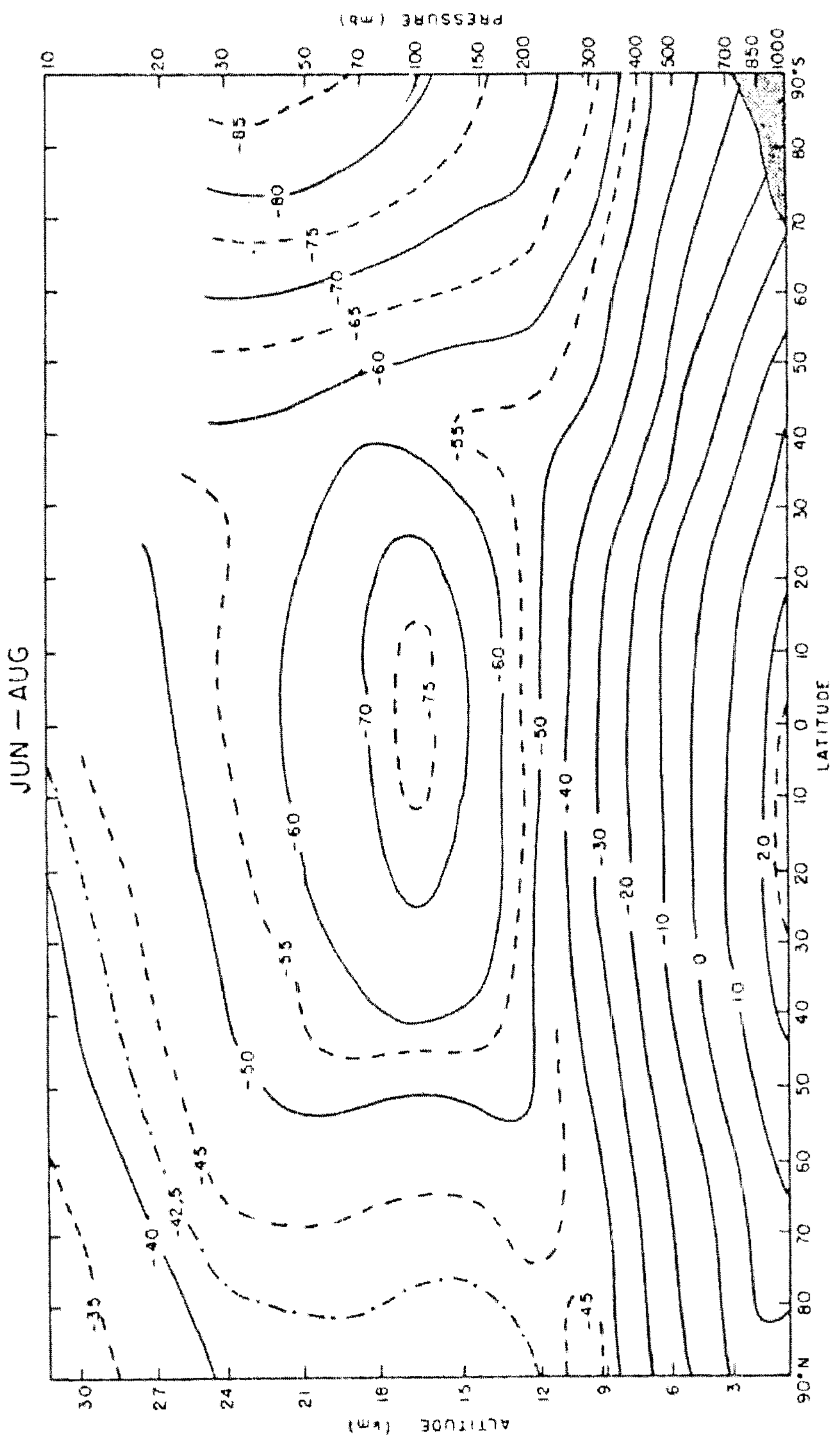
Sheillito et al 2003: AGCM at 2000 ppm gets closer, mechanism not clear

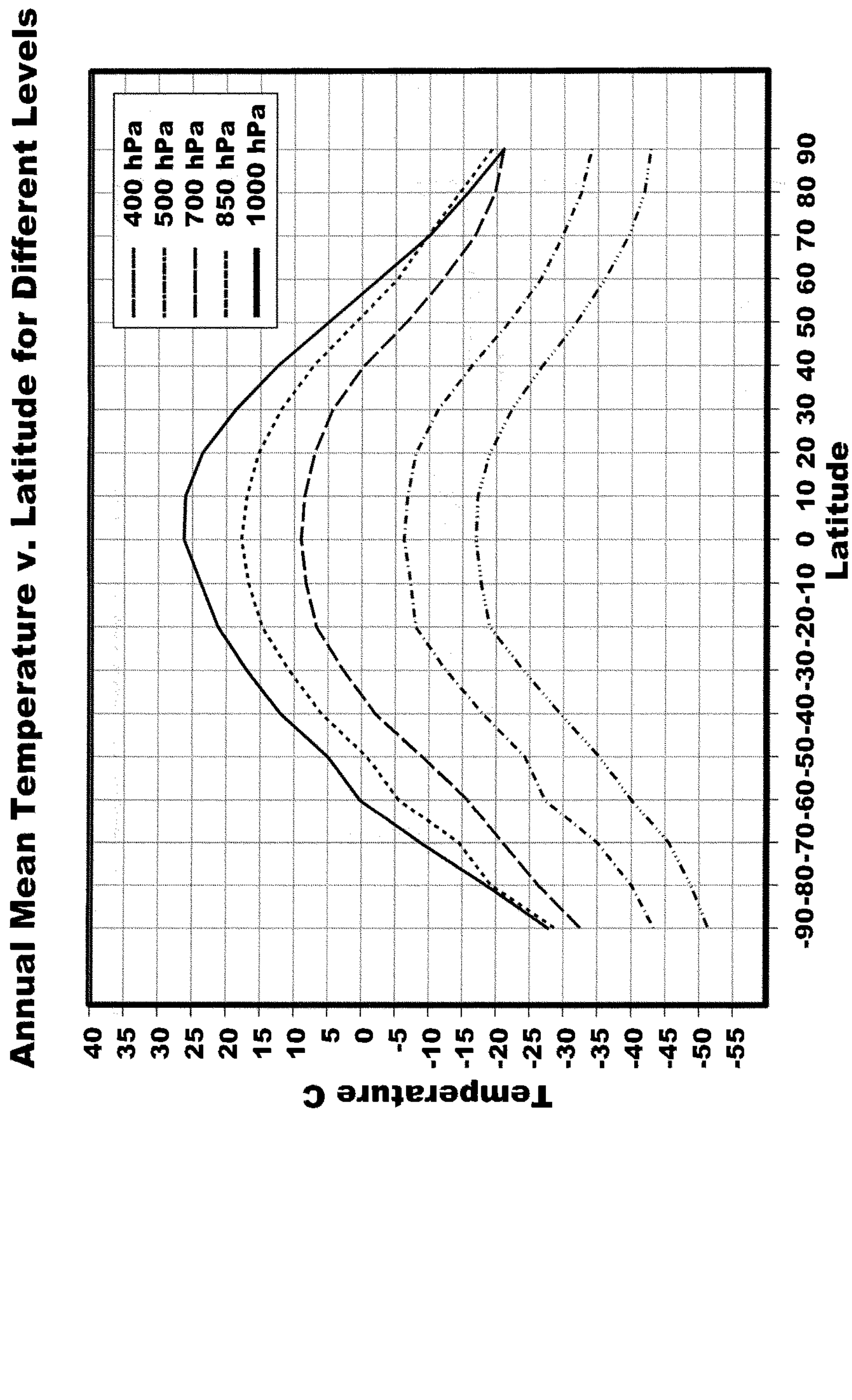
Such attempts always show warmer temperatures at the equator, and almost no change in the equator-to-pole temperature difference.

Not surprisingly, there has been considerable effort devoted to getting rid of the cooling in the tropics, and it is now thought that tropical temperatures were not cooler than at present.



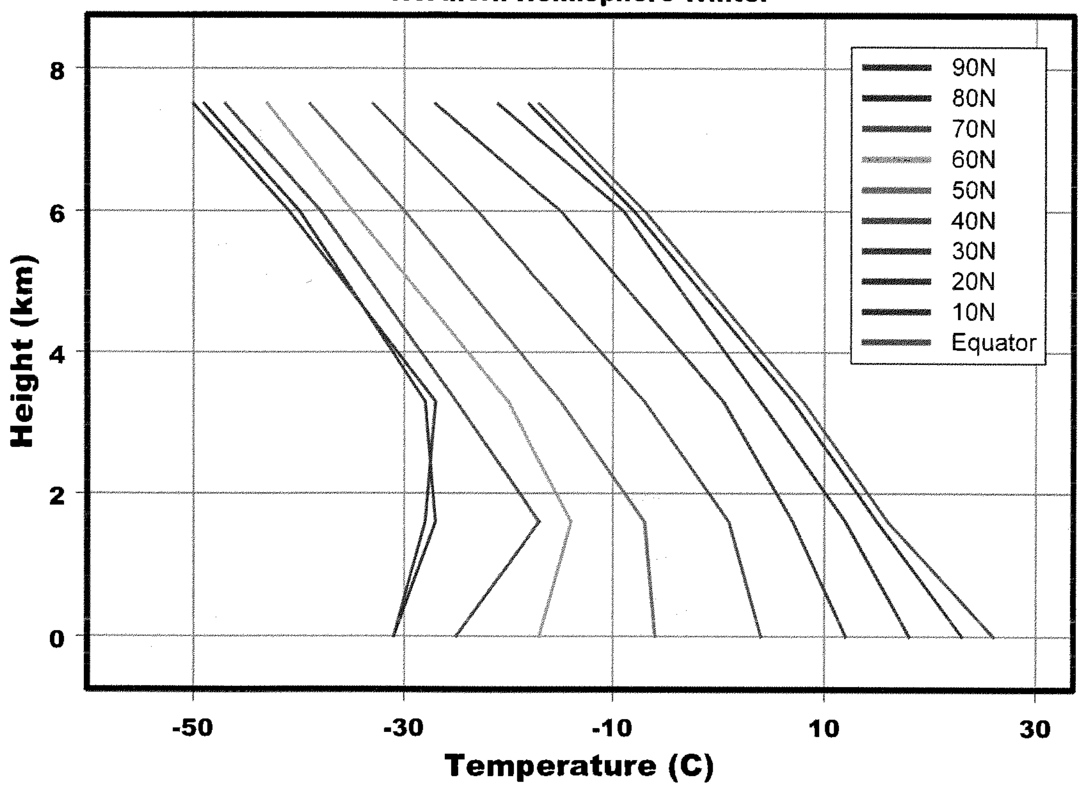
Note that the equator-pole temperature difference is much smaller above about 400 HPa than at the surface.


JUN – AUG
PRESSURE (mb)
ALTITUDE (km)
LATITUDE
90°S
90°N

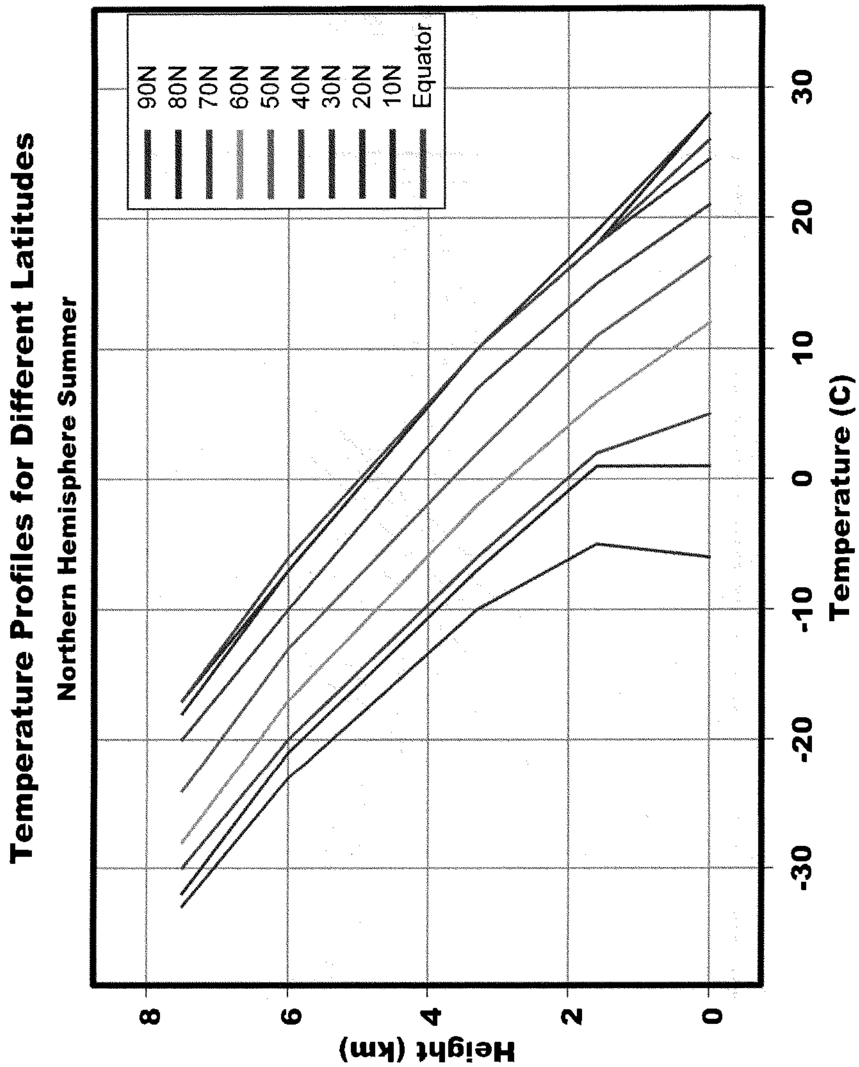

Annual Mean Temperature v. Latitude for Different Levels
400 hPa
500 hPa
700 hPa
850 hPa
1000 hPa
Temperature C
40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55
Latitude
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90

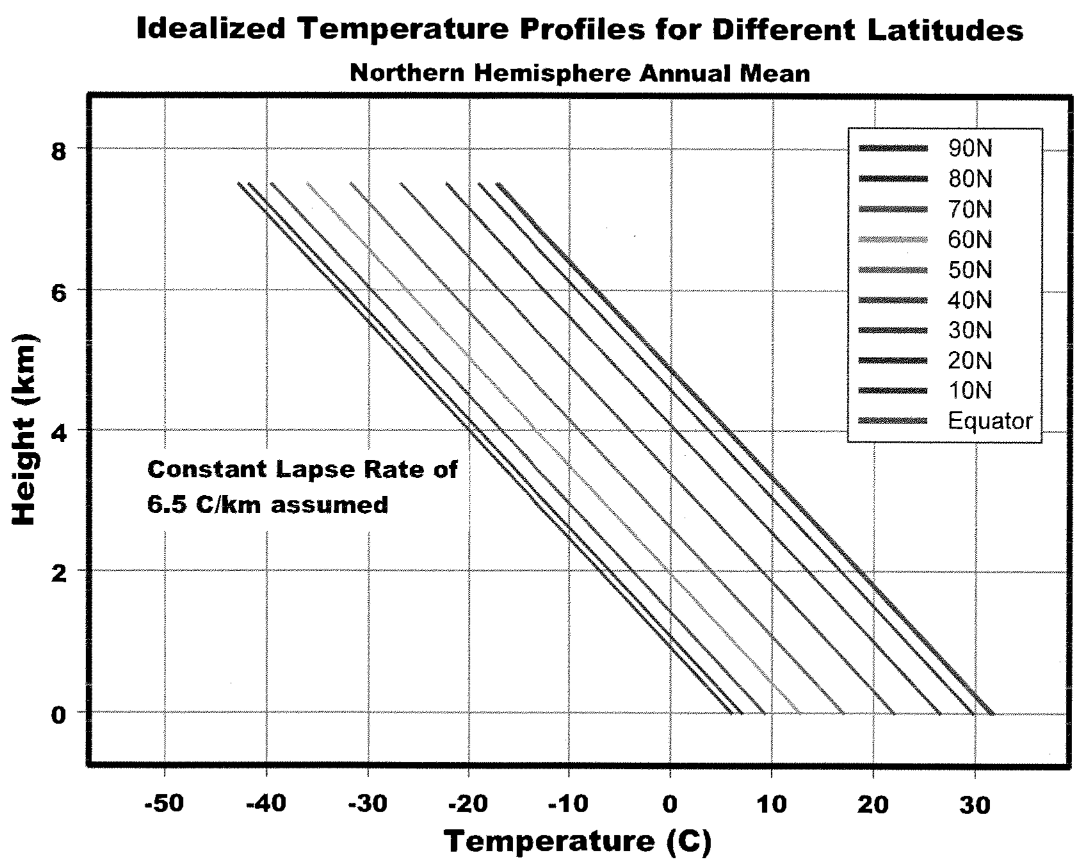
Temperature Profiles for Different Latitudes

Northern Hemisphere Winter

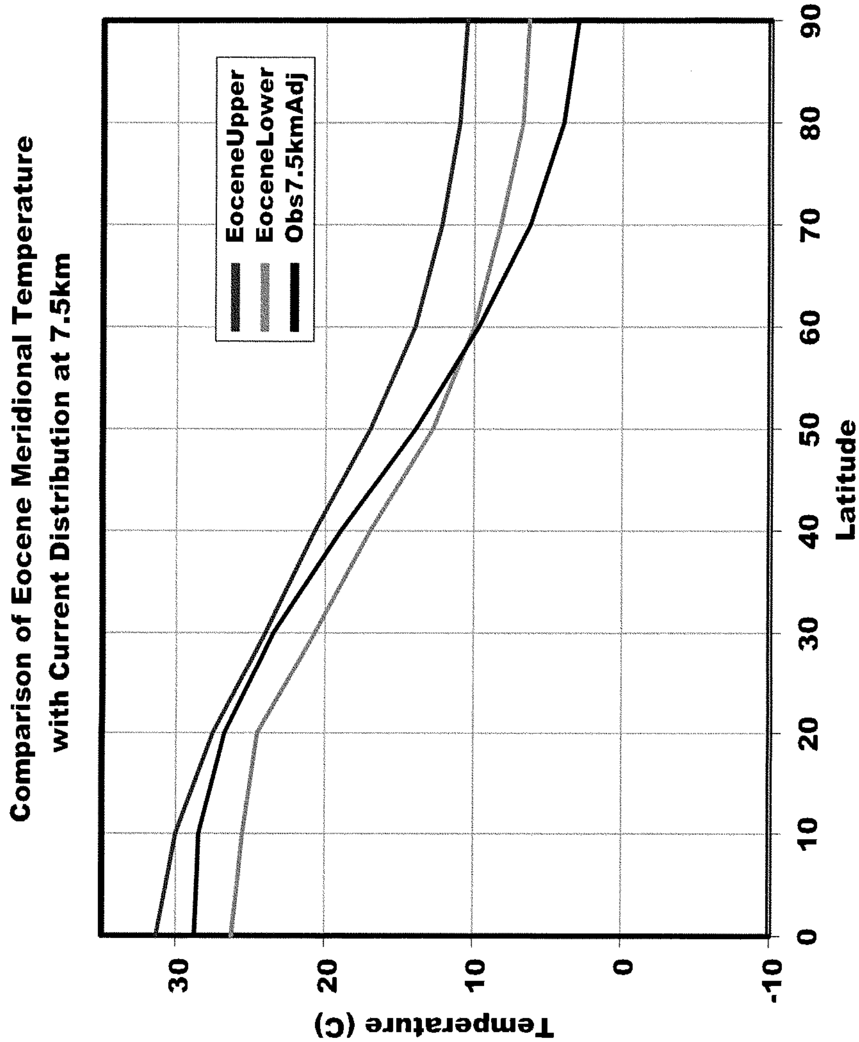


The difference is seen to be due to the arctic inversion.


Temperature Profiles for Different Latitudes
Northern Hemisphere Summer
90N
80N
70N
60N
50N
40N
30N
20N
10N
Equator
Height (km)
0
2
4
6
8
Temperature (C)
-30
-20
-10
0
10
20
30

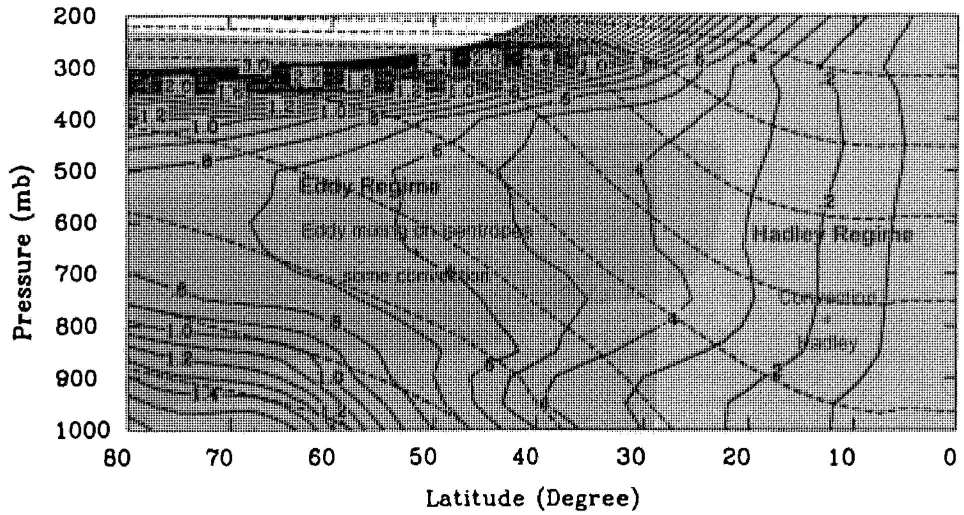


Without the arctic inversion, the surface temperature distribution is similar to that of the Eocene.


Comparison of Eocene Meridional Temperature
with Current Distribution at 7.5km
EoceneUpper
EoceneLower
Obs7.5kmAdj
Temperature (C)
30
20
10
0
-10
Latitude
0
10
20
30
40
50
60
70
80
90

So what actually determines the equator-to-pole temperature difference?

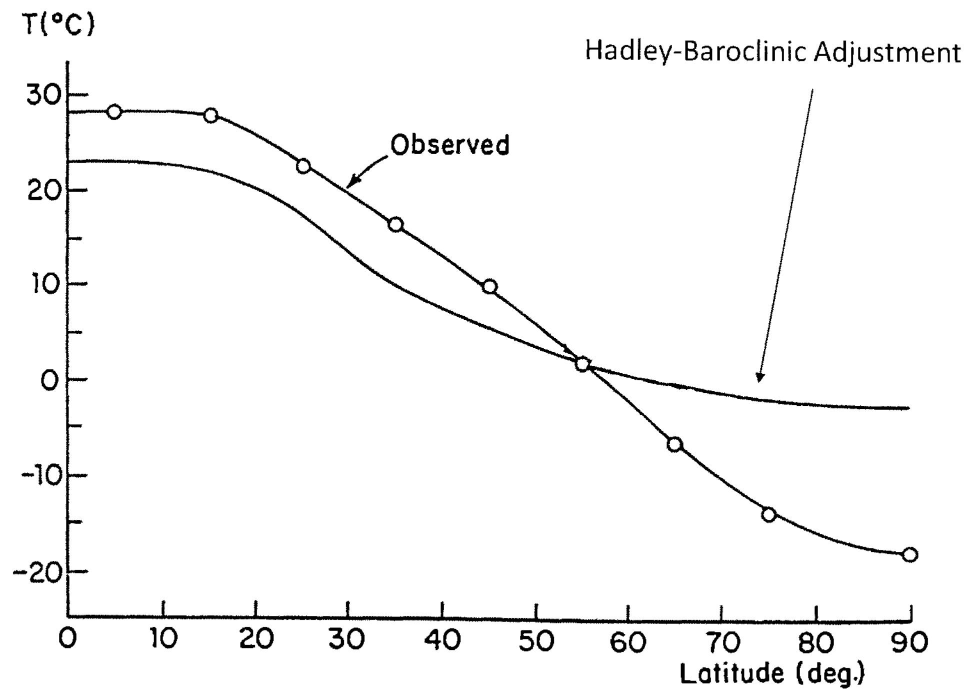
Baroclinic neutrality is basically a condition on the slope of isentropes wherein the last isentrope leaving the tropical surface becomes the polar tropopause. An attempt at a more basic theoretical foundation for this is in T. Schneider, 2004: The tropopause and thermal stratification in the extratropics of a dry atmosphere. *J. Atmos. Sci.*, **61**, 1317–1340.



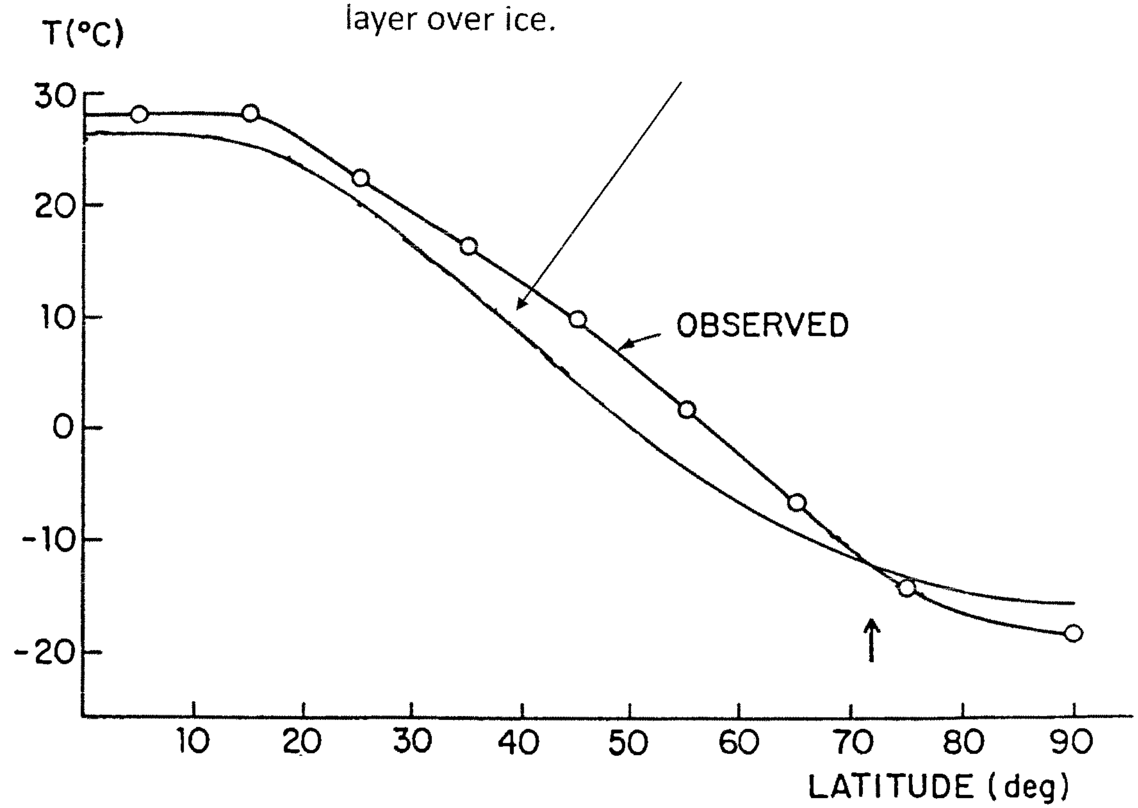
From Sun and Lindzen, 1994.

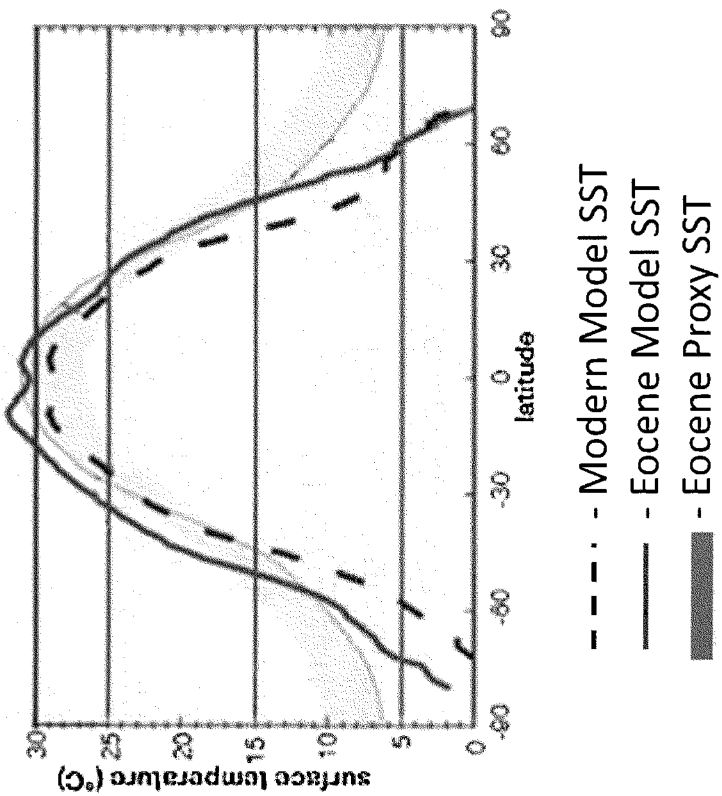
Note that heat from the tropics is essentially transported to the upper troposphere of the extratropics. How is it communicated to the surface?

R.S. Lindzen and B. Farrell (1980). The role of polar regions in global climate, and the parameterization of global heat transport. *Mon. Wea. Rev.*, **108**, 2064-2079.



Hadley-Baroclinic Adjustment with correction for inversion layer over ice.




surface temperature (°C)
latitude
- Modern Model SST
- Eocene Model SST
- Eocene Proxy SST

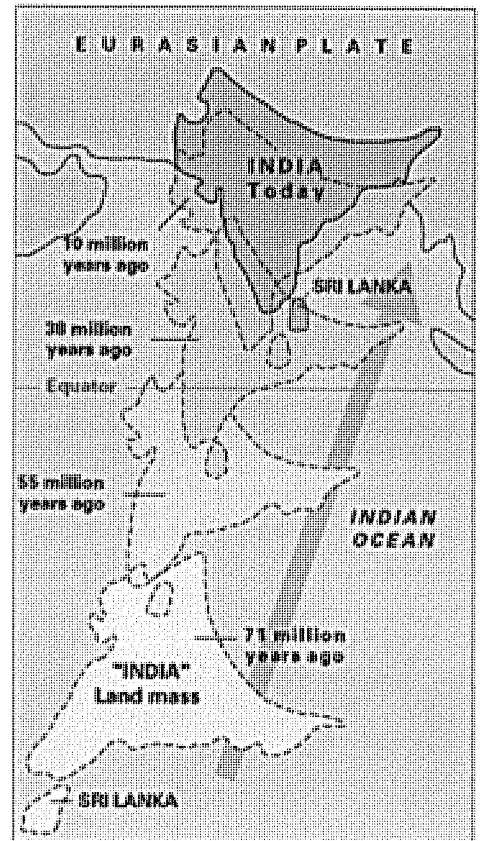
There remains the perplexing question of why GCMs maintain the large equator to pole temperature difference even when ice is removed.

There is also the question of what caused the Eocene Optimum. The preceding results suggest that Eocene temperature distributions are mostly due to the absence of ice. However, one might still wonder why the Eocene was warmer than adjacent periods.

The drift of India across the equator certainly looks like it is worth considering.

The exact position of India with respect to the equator will have a significant effect on the motion of the zonally averaged surface temperature resulting from the seasonal motion of the sun across the equator.

This has a potentially important impact on the strength of the Hadley circulation.



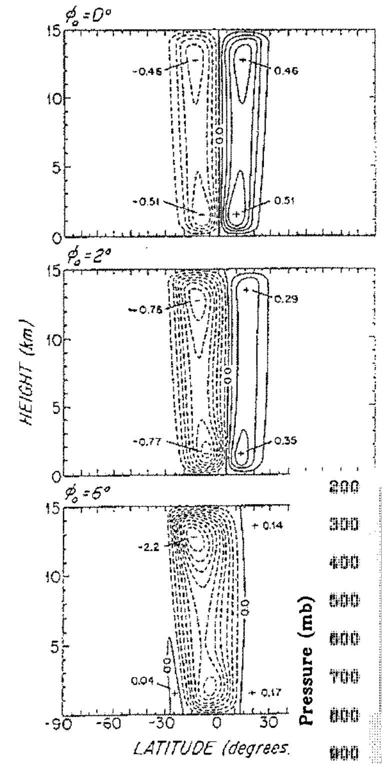


Fig. 2a–c. Numerical model results for str $\phi_0=0°$. b $\phi_0=2°$, and c $\phi_0=6°$. Units are in contour interval is 0.1×10^{10} kg s^{-1} for a and for c. From Lindzen and Hou (1988)

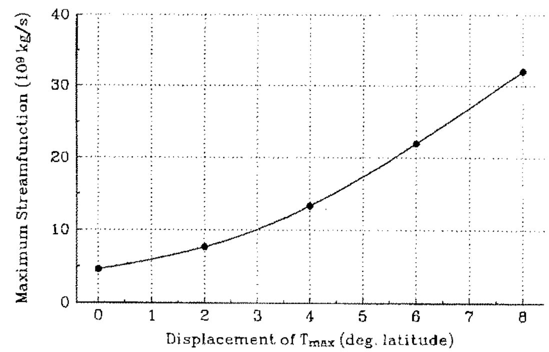
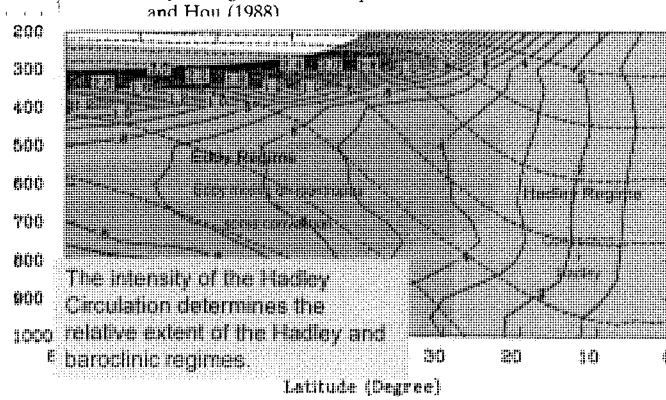


Fig. 1. The intensity of Hadley winter cell in terms of the maximum streamfunction as a function of the displacement of the zonally averaged surface temperature maximum. Data from Lindzen and Hou (1988)



We have, for about thirty years, been locked into a simple-minded identification of climate with greenhouse gas level. It is about time that other clearly identified mechanisms be considered.

We have seen that the inversion layer associated with ice cover plays a major role in creating a larger pole to equator temperature difference than is intrinsic to the dynamics that is associated with baroclinic adjustment. However, the ice – inversion layer connection constitutes a thus far unexplored positive feedback which might provide clues to snow ball episodes.

And, of course, Milankovitch realized that climate involved more than annual global mean insolation.

Other examples include the role of the iris effect in explaining the early faint sun paradox. The potential importance of varying cloud height is also beginning to be noticed.

The climate is a richly complex and interesting system, and there are undoubtedly many more possibilities to be considered. That it should simply be a function of a single parameter, has always seemed implausible. Yet an obsessive focus on such an obvious oversimplification has likely set back progress by decades.

Perhaps, it is time that we attempt to really understand the system better. This will call for more serious attention to explicit mechanisms and conceptual pictures. Models have, in this respect, proven less useful than one might have hoped. My personal suspicion is that too much has been built into models that is incorrect – sometimes for the goal of tuning the models to present behavior but for the wrong reasons. Model failures for the Eocene may well fall into this category.

So far, I have discussed climate as science rather than a source of alarm. To quote a recent attack on climate skeptics by the economist, William Nordhaus:

Climate scientists have moved way beyond global mean temperature in looking for evidence of human-caused climate change. Scientists have found several indicators that point to humancaused warming, including melting of glaciers and ice sheets, ocean heat content, rainfall patterns, atmospheric moisture, river runoff, stratospheric cooling, and the extent of Arctic sea ice. Those who look only at global temperature trends are like investigators using only eyewitness reports and ignoring fingerprints and DNA-based evidence.

Of course, all of these are aspects that depend on many factors other than global mean temperature anomaly, and most show no evidence of conforming to any predictions based on global warming.

And then there is the issue increases in extreme events. Even the IPCC notes that there is little if any evidence of this. Moreover, there are important physical reasons for doubting such anticipations.

The main driver of extratropical storms and variability is baroclinicity. This is proportional to the temperature difference between the tropics and the pole. In a warmer climate, this is expected to be reduced and not increased. Thus, on physical grounds, most of us should expect reduced intensity of storms and variability. However, this, apparently, is not 'alarming,' so the opposite is asserted.

Allowing for implausible alarm, Nordhaus reaches some interesting conclusions (and these would appear to assume a damage function of 23 trillion dollars -- accumulated over 50 -- years for a warming of less than two tenths of a degree). His optimum policy consists in the gradual introduction of a carbon tax, and this policy is only marginally better than doing nothing for 50 years. Indeed, it is only better if one assumes such things as universal harmonization and a high climate sensitivity.

Table 5-3. Incremental Abatement Costs and Damages Relative to Baseline, and Benefit-Cost Ratio of Different Approaches

Policy	Benefits (Reduced Damages)	Abatement Costs	Benefit-Cost Ratio
	(Trillions of 2005 U.S. $)		
50-year delay	3.69	1.55	2.4
Optimal	5.23	2.16	2.4
Concentration limits			
Limit to 1.5 × CO_2	12.60	27.20	0.5
Limit to 2 × CO_2	6.57	3.90	1.7
Limit to 2.5 × CO_2	5.24	2.16	2.4
Temperature limits			
Limit to 1.5°C	12.60	27.03	0.5
Limit to 2°C	9.45	11.25	0.8
Limit to 2.5°C	7.22	5.24	1.4
Limit to 3°C	5.88	2.86	2.1
Kyoto Protocol			
Kyoto with United States	1.17	0.54	2.2
Kyoto w/o United States	0.12	0.02	5.0
Strengthened	6.54	5.82	1.1
Stern Review *discounting*	13.53	27.70	0.5
Gore proposal	12.50	33.86	0.4
Low-cost backstop	17.63	0.44	39.9

Note: The numbers are differences from the baseline case of no controls.

From W. Nordhaus: *A Question of Balance*, Yale Univ. Press, 2008

Historically, there is little evidence of natural disasters leading to war. However, economic conditions prove much more serious. Almost all proposed mitigation policies lead to reduced energy availability and higher energy costs.

Here is a 2006 study by ESG, a liberal think tank whose clients include the UN Foundation, World Bank, Organization of American States, DOE, Rockefeller Brothers Fund, Climate Institute, and National Renewable Energy Laboratory. They find that energy use is linked to political stability among 91 developing countries surveyed. Here is a headline "Overall results from the study showed that investments in improving access to energy are expected to improve the likelihood of (political) stability as well as have positive benefits on quality of life indicators.... A one ton of oil [about 300 gal] equivalent per capita increase in energy consumption increases the odds of peace by a factor of 2.5."

ENERGY AND COUNTRY INSTABILITY
PROJECT REPORT

USAID Contract No: OUT-LAG-I-00-98-0004-00
Work Order 178

For Submission to:
U.S Agency for International Development

Prepared by:

Energy and Security Group	Advanced Engineering Associates International (AEAI)
Gurneeta Vasudeva and Steve Siegel 12110 Sunset Hills Road, Suite 450 Reston, VA 20190 Phone: 703-715-3024; Email: Gurneeta@energyandsecurity.com	Olga Mandrugina 1666 K Street, NW, Suite 620 Washington, DC 20006 Phone: 202-416-6611; Email: om@aeai.net

Figure 2. Examining Relationships

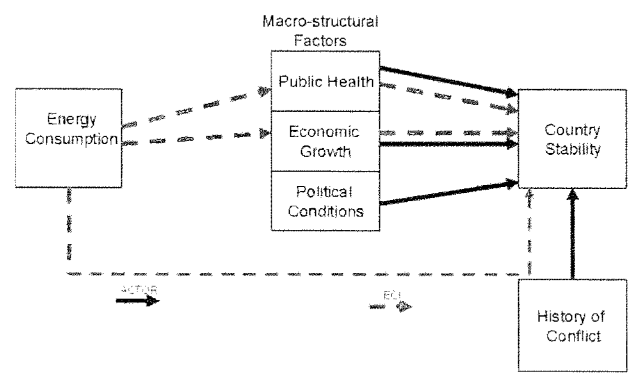
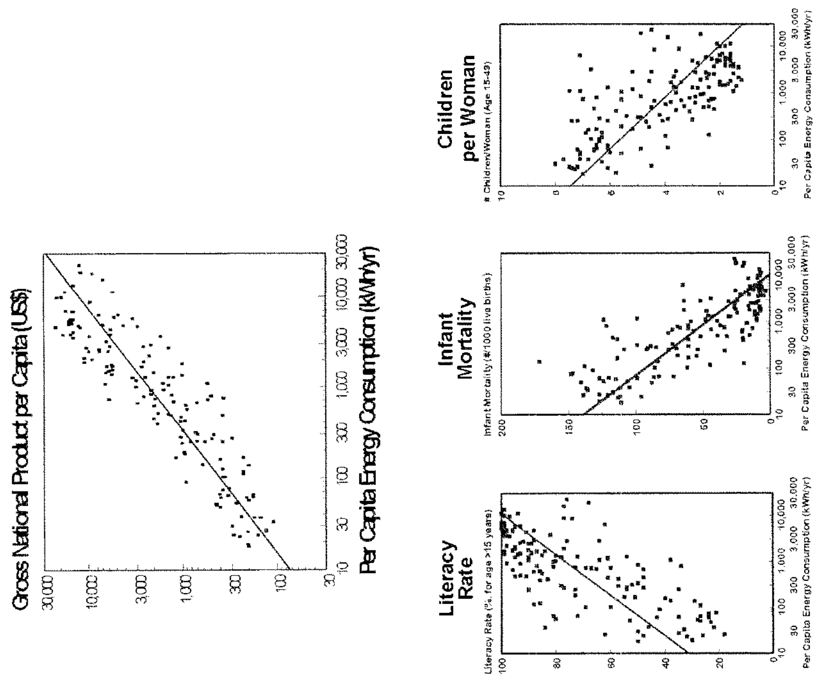
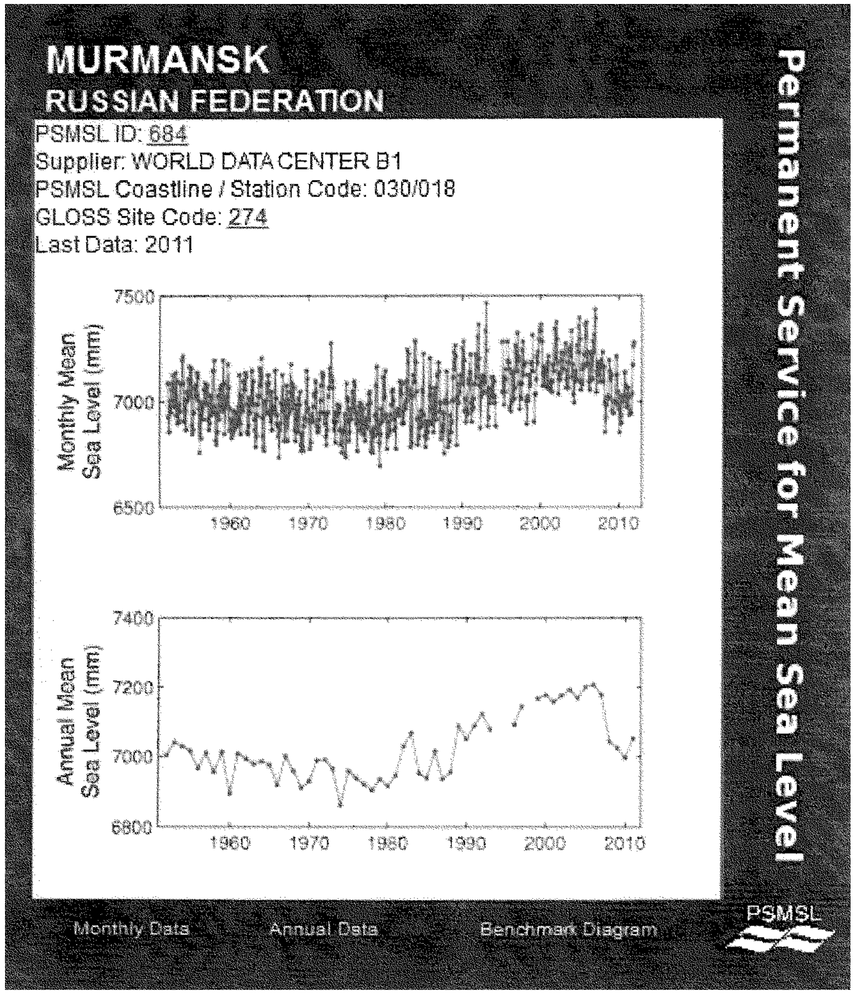


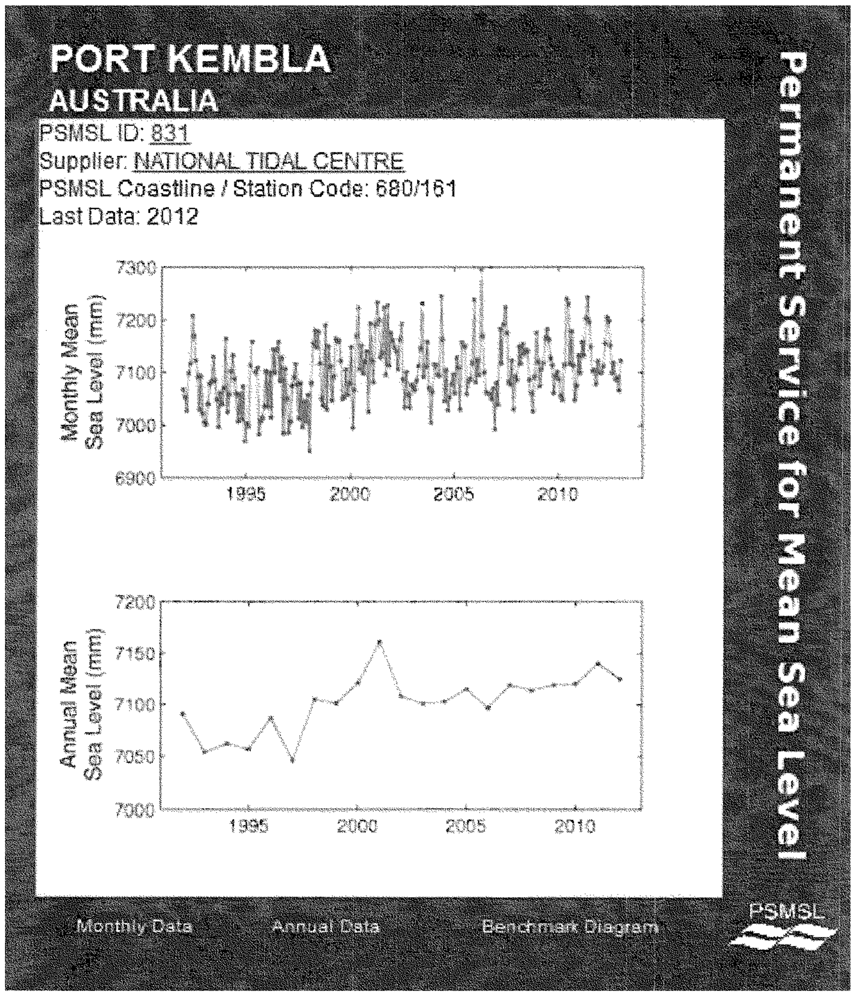
Figure 2 depicts the relationships that are *known* based on the ACTOR methodology and those that are being *estimated* by the ECI model. The relationships represented by the solid blue arrows are those estimated by the ACTOR methodology. Results from the ACTOR methodology show that public health, economic growth and positive political and social values increase the probability of stability. Also past conflict is shown to have a negative effect on stability, so that a country with a history of past conflict is more likely to be unstable.

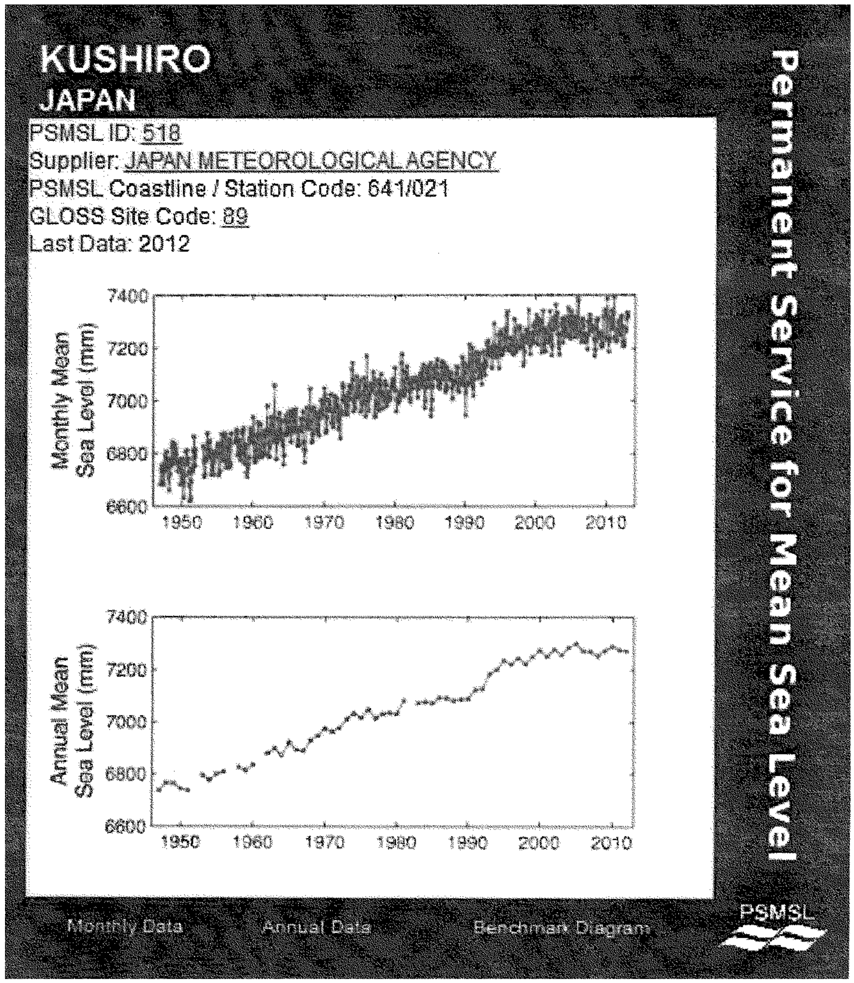
Figure[4] 1.

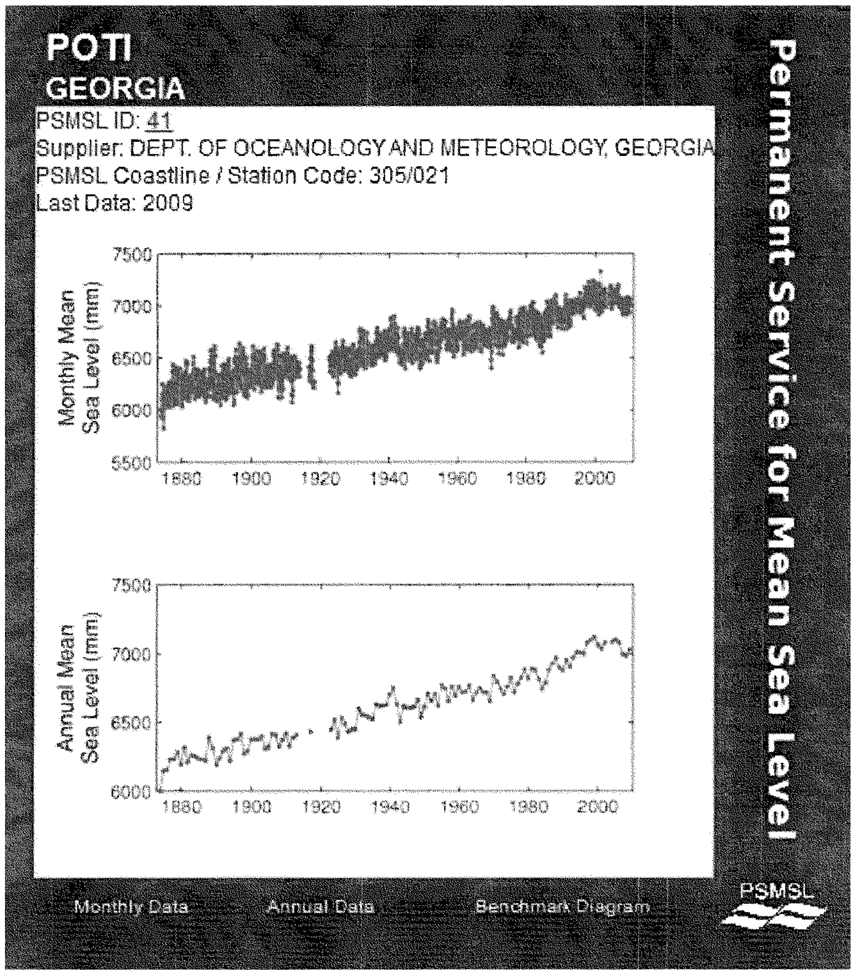

Gross National Product per Capita (US$)
Per Capita Energy Consumption (kWh/yr)
Literacy Rate
Infant Mortality
Children per Woman

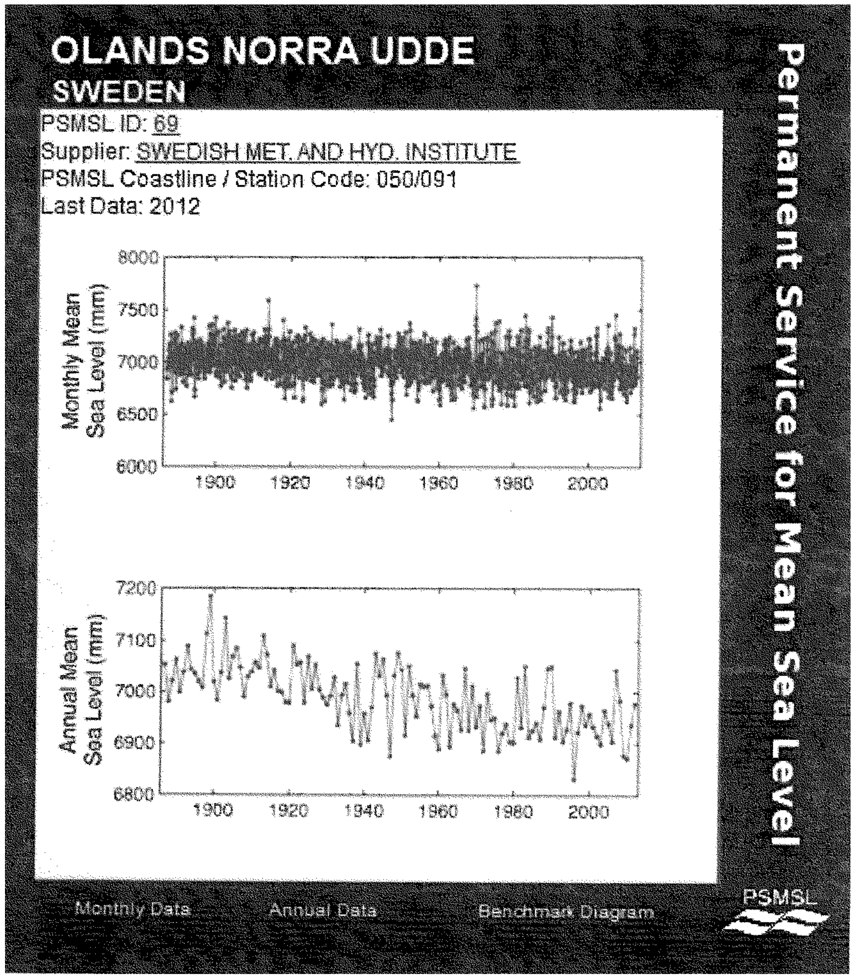
From a national security perspective, one must seriously consider whether the implications of remotely possible natural disasters are greater threats to security than would be the results of currently proposed mitigation policies – especially given that proposed policies are unlikely to significantly impact climate regardless of what one believes about climate sensitivity. Avoiding this question would, at the least, appear to be irresponsible.

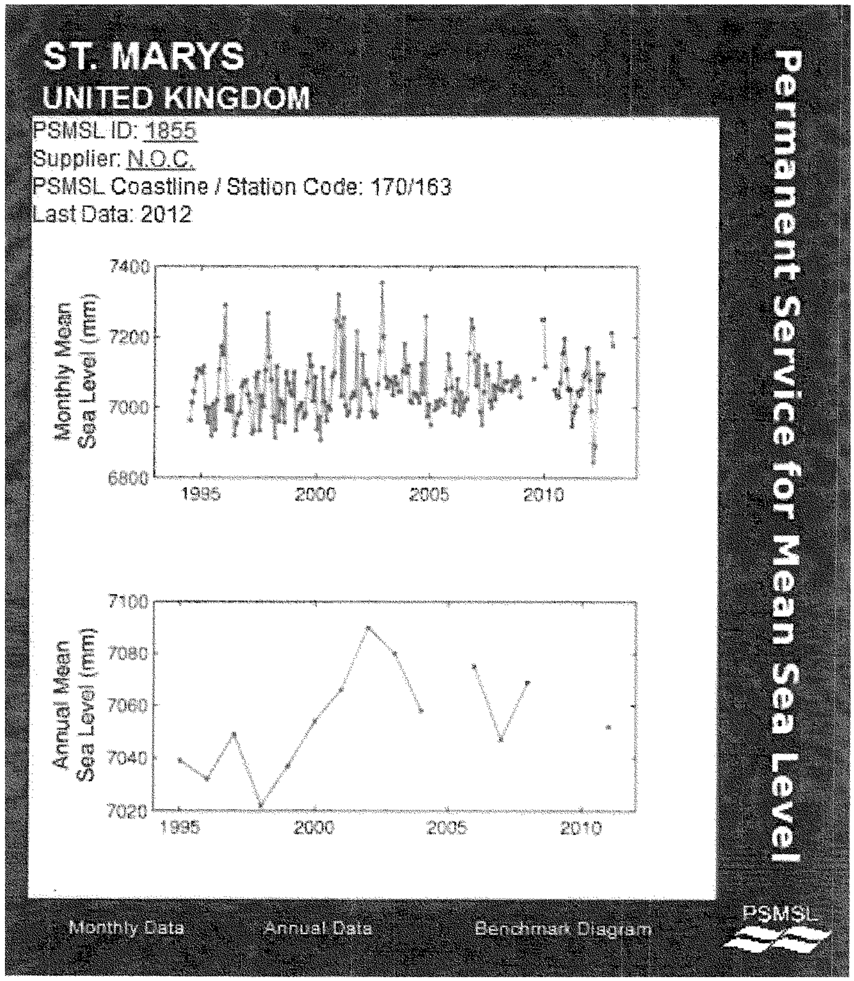

MURMANSK
RUSSIAN FEDERATION
PSMSL ID: 684
Supplier: WORLD DATA CENTER B1
PSMSL Coastline / Station Code: 030/018
GLOSS Site Code: 274
Last Data: 2011
Monthly Mean Sea Level (mm)
7500
7000
6500
1960 1970 1980 1990 2000 2010
Annual Mean Sea Level (mm)
7400
7200
7000
6800
1960 1970 1980 1990 2000 2010
Permanent Service for Mean Sea Level
Monthly Data
Annual Data
Benchmark Diagram
PSMSL


PORT KEMBLA
AUSTRALIA
PSMSL ID: 831
Supplier: NATIONAL TIDAL CENTRE
PSMSL Coastline / Station Code: 680/161
Last Data: 2012
Monthly Mean Sea Level (mm)
7300
7200
7100
7000
6900
1995
2000
2005
2010
Annual Mean Sea Level (mm)
7200
7150
7100
7050
7000
1995
2000
2005
2010
Monthly Data
Annual Data
Benchmark Diagram
Permanent Service for Mean Sea Level
PSMSL


KUSHIRO
JAPAN
PSMSL ID: 518
Supplier: JAPAN METEOROLOGICAL AGENCY
PSMSL Coastline / Station Code: 641/021
GLOSS Site Code: 89
Last Data: 2012
Monthly Mean Sea Level (mm)
Annual Mean Sea Level (mm)
7400
7200
7000
6800
6600
1950
1960
1970
1980
1990
2000
2010
Permanent Service for Mean Sea Level
Monthly Data
Annual Data
Benchmark Diagram
PSMSL


POTI
GEORGIA
PSMSL ID: 41
Supplier: DEPT. OF OCEANOLOGY AND METEOROLOGY, GEORGIA
PSMSL Coastline / Station Code: 305/021
Last Data: 2009
Monthly Mean Sea Level (mm)
7500
7000
6500
6000
5500
1880 1900 1920 1940 1960 1980 2000
Annual Mean Sea Level (mm)
7500
7000
6500
6000
1880 1900 1920 1940 1960 1980 2000
Permanent Service for Mean Sea Level
Monthly Data
Annual Data
Benchmark Diagram
PSMSL


OLANDS NORRA UDDE
SWEDEN
PSMSL ID: 69
Supplier: SWEDISH MET. AND HYD. INSTITUTE
PSMSL Coastline / Station Code: 050/091
Last Data: 2012
Monthly Mean Sea Level (mm)
8000
7500
7000
6500
6000
1900
1920
1940
1960
1980
2000
Annual Mean Sea Level (mm)
7200
7100
7000
6900
6800
1900
1920
1940
1960
1980
2000
Permanent Service for Mean Sea Level
Monthly Data
Annual Data
Benchmark Diagram
PSMSL


ST. MARYS
UNITED KINGDOM
PSMSL ID: 1855
Supplier: N.O.C.
PSMSL Coastline / Station Code: 170/163
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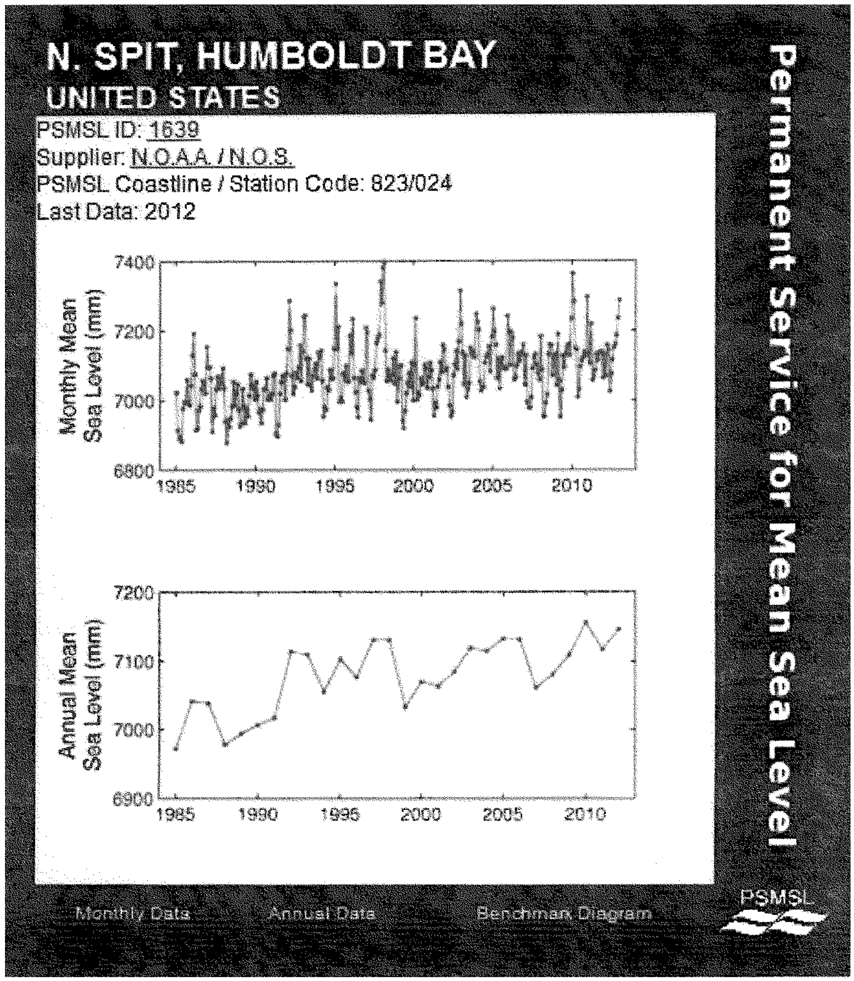
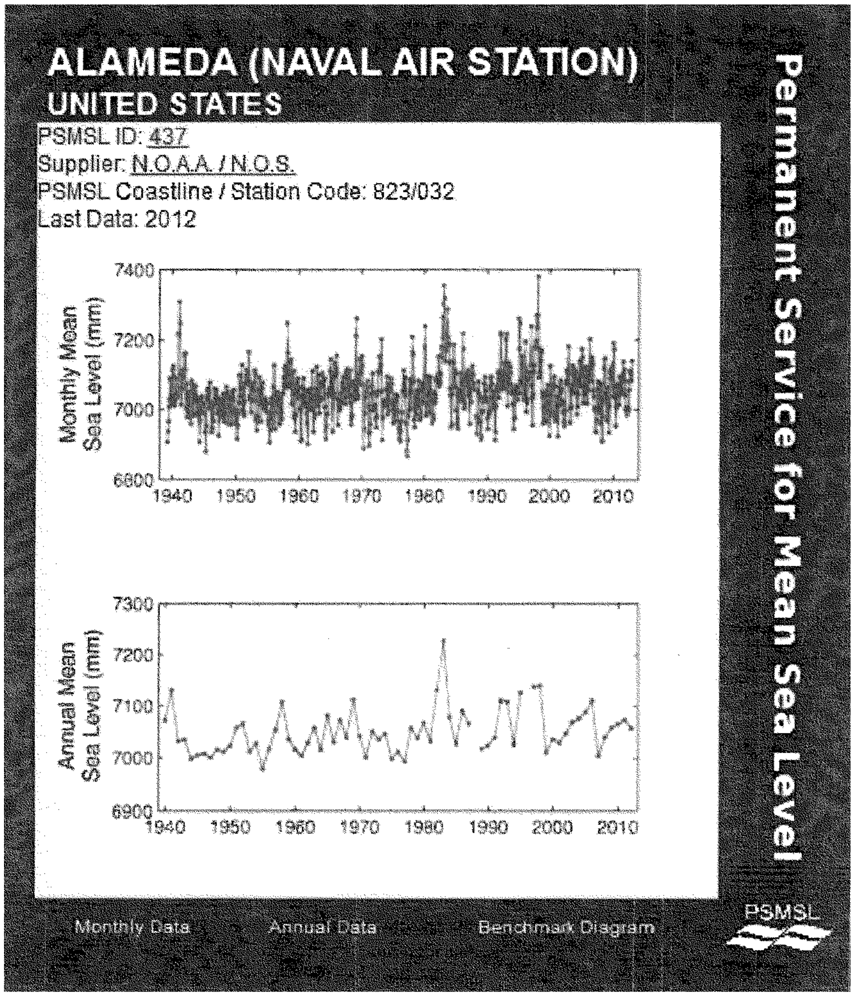
7400
7200
7000
6800
1995
2000
2005
2010
Annual Mean Sea Level (mm)
7100
7080
7060
7040
7020
1995
2000
2005
2010
Permanent Service for Mean Sea Level
Monthly Data
Annual Data
Benchmark Diagram
PSMSL


N. SPIT, HUMBOLDT BAY
UNITED STATES
PSMSL ID: 1639
Supplier: N.O.A.A. / N.O.S.
PSMSL Coastline / Station Code: 823/024
Last Data: 2012
Monthly Mean Sea Level (mm)
7400
7200
7000
6800
1985
1990
1995
2000
2005
2010
Annual Mean Sea Level (mm)
7200
7100
7000
6900
1985
1990
1995
2000
2005
2010
Permanent Service for Mean Sea Level
Monthly Data
Annual Data
Benchmark Diagram
PSMSL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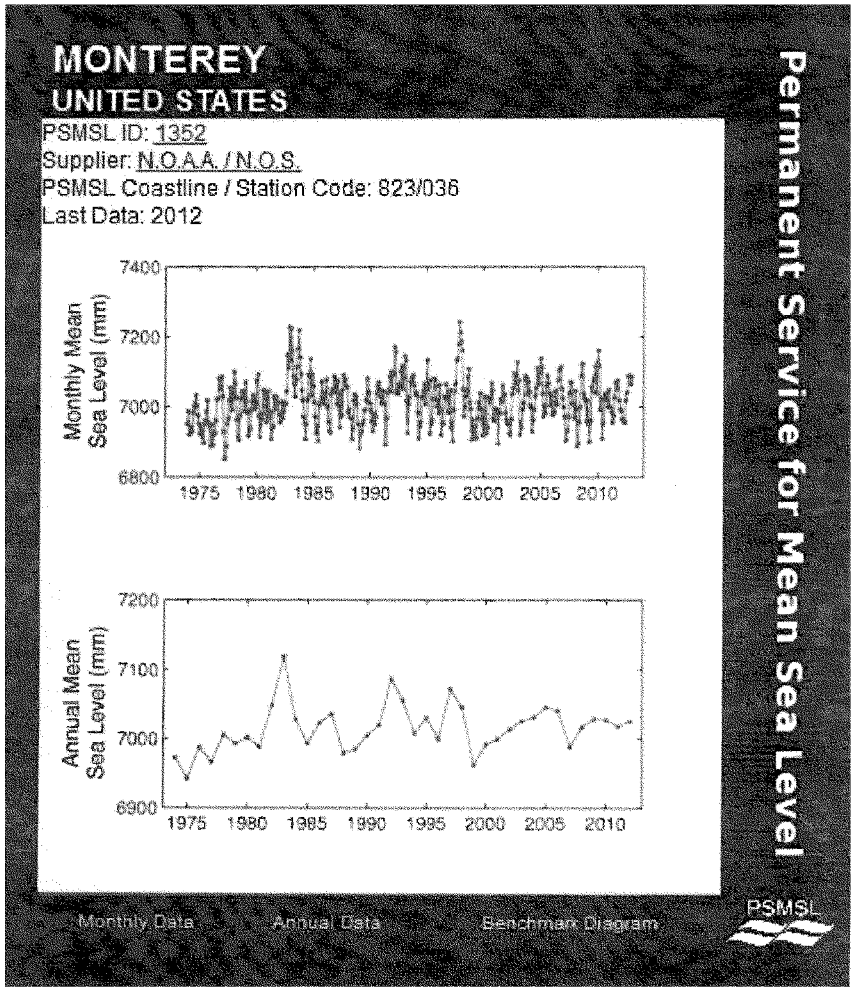
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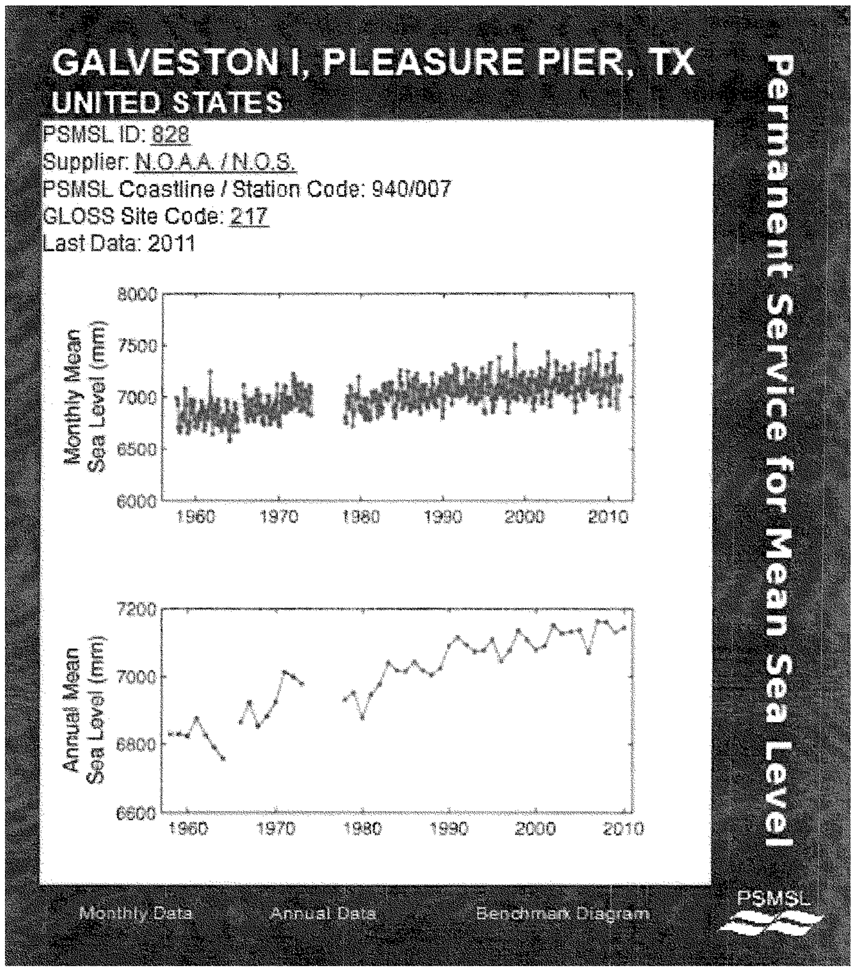
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Annual Data
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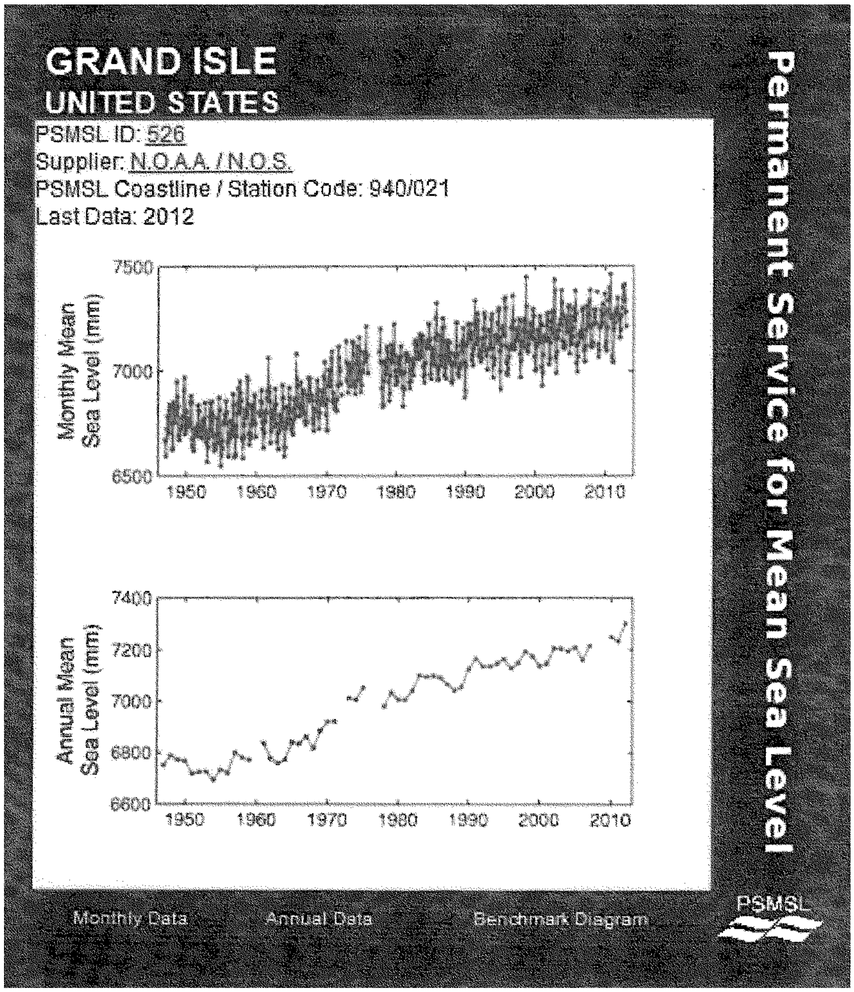
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PSMSL

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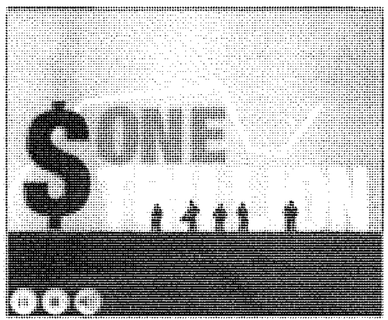

Solyndra: Politics infused Obama energy programs

By Joe Stephens and Carol D. Leonnig, Published: December 25, 2011

Linda Sterio remembers the excitement when President Obama arrived at Solyndra last year and described how his administration's financial support for the plant was helping create hundreds of jobs. The company's prospects appeared unlimited as Solyndra executives described the backlog of orders for its solar panels.

Then came the August morning when Sterio heard a newscaster announce that more than a thousand Solyndra employees were out of work. Only recently did she learn that, within the Obama administration, the company's potential collapse had long been discussed.

"It's not about the people; it's politics," said Sterio, who remains jobless and at risk of losing her home. "We all feel betrayed."

Since the failure of the company, Obama's entire $80 billion clean-technology program has begun to look like a political liability for an administration about to enter a bruising reelection campaign.

Meant to create jobs and cut reliance on foreign oil, Obama's green-technology program was infused with politics at every level, The Washington Post found in an analysis of thousands of memos, company records and internal e-mails. Political considerations were raised repeatedly by company investors, Energy Department bureaucrats and White House officials.

The records, some previously unreported, show that when warned that financial disaster might lie ahead, the administration remained steadfast in its support for Solyndra.

The documents reviewed by The Post, which began examining the clean-technology program a year ago, provide a detailed look inside the day-to-day workings of the upper levels of the Obama administration. They also give an unprecedented glimpse into high-level maneuvering by politically connected clean-technology investors.

They show that as Solyndra tottered, officials discussed the political fallout from its troubles, the "optics" in Washington and the impact that the company's failure could have on the president's prospects for a second term. Rarely, if ever, was there discussion of the impact that Solyndra's collapse would have on laid-off workers or on the development of clean-energy technology.

"What's so troubling is that politics seems to be the dominant factor," said Ryan Alexander, president of Taxpayers for Common Sense, a nonpartisan watchdog group. "They're not talking about what the taxpayers are losing; they're not talking about the failure of the technology, whether we bet on the wrong horse. What they are talking about is 'How are we going to manage this politically?' "

The administration, which excluded lobbyists from policymaking positions, gave easy access to venture capitalists with stakes in some of the companies backed by the administration, the records show. Many of those investors had given to Obama's 2008 campaign. Some took jobs in the administration and helped manage the clean-energy program.

Documents show that senior officials pushed career bureaucrats to rush their decision on the loan so Vice President Biden could announce it during a trip to California. The records do not establish that anyone pressured the Energy Department to approve the Solyndra loan to benefit political contributors, but they suggest that there was an unwavering focus on promoting Solyndra and clean energy. Officials with the company and the administration have said that nothing untoward occurred and that the loan was granted on its merits.

Most documents that have been made public in connection with a congressional investigation relate to the period after the loan was granted. The process began in the George W. Bush administration but resulted in the first loan in the program being granted under Obama. As a result, many factors that led to Solyndra winning a half-billion-dollar federal loan remain unknown.

White House officials said that all key records regarding Solyndra's loan approval have been released.

Officials acknowledged that some of the records provide an unvarnished view that they might have preferred to keep private — such as a senior energy adviser's reference to a conference call about Solyndra as a "[expletive] show," or a company investor writing that when Solyndra was mentioned in a meeting, Biden's office "about had an orgasm."

Officials said those unflattering disclosures reinforce their position that they are not hiding their actions and that, despite the blemishes, nothing suggests political considerations affected the original decision to extend the loan to Solyndra. They stressed that the administration disregarded advice to avoid political problems by replacing senior Energy Department managers and moving to abort Obama's visit to Solyndra.

"Everything disclosed . . . affirms what we said on day one: This was a merit-based decision made by expert staffers at the Department of Energy," White House spokesman Eric Schultz said in a statement.

Officials said that concern for workers was reflected in the administration's decision to allow Solyndra employees to receive aid under a program for workers displaced by foreign competition.

"When Solyndra's liquidity crisis became clear, the Department of Energy underwent a robust effort to find a viable path forward for the company," the White House's prepared statement said. "This administration is one that will fiercely fight to protect jobs even when it's not the popular thing to do."

Star power in D.C.

Like most presidential appearances, Obama's May 2010 stop at Solyndra's headquarters was closely managed political theater.

Obama's handlers had lengthy e-mail discussions about how solar panels should be displayed (from a robotic arm, it was decided). They cautioned the company's chief executive against wearing a suit (he opted for an open-neck shirt and black slacks) and asked another executive to wear a hard hat and white smock. They instructed blue-collar employees to wear everyday work clothes, to preserve what they called "the construction-worker feel."

White House e-mails suggest that the original idea for "POTUS involvement" originated with then-Chief of Staff Rahm Emanuel. Emanuel, now mayor of Chicago, did not respond to a request for comment from The Post.

Well beyond the details of the factory photo op, raw political considerations surfaced repeatedly in conversations among many in the administration.

Just two days before the visit, Obama fundraiser Steve Westly warned senior presidential adviser Valerie Jarrett that an appearance could be problematic. Westly, an investment fund manager with stakes in green-energy companies, said he was speaking for a number of Obama supporters in asking the president to postpone the visit because Solyndra's financial prospects were dim and the company's failure could generate negative media attention.

"The president should be careful about unrealistic/optimistic forecasts that could haunt him in the next 18 months if Solyndra hits the wall," Westly wrote. Westly did not respond to a request for comment from The Post.

Similar concerns arose repeatedly among officials inside the White House. One staffer at the Office of Management and Budget suggested to a colleague that the visit could "prove embarrassing to the administration in the not too distant future." Even Ron Klain, Biden's chief of staff, acknowledged "risk" in the trip.

But administration officials ultimately waved off the jitters, after assurances from Energy Department officials that their policy was sound and that Solyndra's troubles would be fleeting. After Obama's trip, the administration hung a photo from his visit on a wall in the West Wing, to underscore good things to come.

Solyndra's financial picture did not improve, however, and by year's end the company was crumbling. Its investors pitched bailout plans, seeking help from what a Solyndra executive referred to as the "Bank of Washington" — his apparent term for U.S. taxpayers. The Energy Department rebuffed the plans, at least initially.

In late 2010, Solyndra board member Steve Mitchell told his associates that Energy Department officials had conceded that additional financing was necessary yet said in private meetings that they lacked the political muscle to deliver it. "The DOE really thinks politically before it thinks economically," Mitchell concluded. A spokesman for Mitchell said he would have no comment for this article. An Energy Department spokesman said that all decisions regarding the loan were based on merit.

Solyndra eventually realized that it had to lay off workers to stay afloat — no small step for a company that the president had backed to create jobs in a recession. But records indicate that the Energy Department urged company officials to delay the move until after the contentious November 2010 midterm elections, which imperiled Democratic control of Congress.

Despite the effect that timing might have on workers, one e-mail among company investors ended the discussion by asserting: "No announcement till after elections at doe request." An Energy Department spokesman did not respond to requests for comment for this article.

More than once, investors wrote that the administration appeared to be making particular decisions to avoid looking "bad." A December 2010 e-mail between administration officials' staffers seemed to confirm the suspicions, concluding that "a meltdown" at Solyndra "would likely be very embarrassing for DOE and the Administration."

An outside energy adviser foresaw serious political damage, writing to senior West Wing officials in February to warn that because federal loans went to companies linked to Obama donors, a wave of Republican attacks "are surely coming." He recommended that Obama consider replacing Energy Secretary Steven Chu and his deputies, perhaps with a bipartisan management team.

A Solyndra board member, in a memo, described at length mistakes he thought that company founder Christian Gronet had made, saying that some of the stories about his actions "border on moronic" and that Gronet's missteps had sparked an executive mutiny. Gronet survived, the board member suggested, only because of his close relationship with Energy Department leaders and because he had "star power in D.C."

Gronet's attorney, Miles Ehrlich, said in a statement last week that Gronet did his best but - acknowledged that there had been internal debate about the business strategies he chose.

Political calculus was especially on display in an e-mail early this year between administration staffers who calibrated the damage that could result from pushing back Solyndra's collapse by a few months at a time.

"The optics of a Solyndra default will be bad whenever it occurs," an OMB staff member wrote to a colleague. "If Solyndra defaults down the road, the optics will arguably be worse later than they would be today. . . . In addition, the timing will likely coincide with the 2012 campaign season heating up."

Solyndra executives and investors were attuned to the value of playing politics. Memos from Solyndra's lobbying firm, McBee Strategic Consulting, stressed the need to "socialize" with leaders in Washington and to mobilize a lobbying effort described variously as quiet, surgical and aggressive.

Dinner in Vegas

Beyond the West Wing, the documents provide a vivid glimpse into high-level machinations inside the world of clean-energy entrepreneurs.

Solyndra's strongest political connection was to George Kaiser, a Democratic fundraiser and oil industry billionaire who had once hosted Obama at his home in Oklahoma. Kaiser's family foundation owned more than a third of the solar panel company, and Kaiser took a direct interest in its operations.

With the 2010 midterm elections just days away, Kaiser flew to Las Vegas to help the party cause. He was a guest at a private fundraising dinner for Senate Majority Leader Harry M. Reid (Nev.), but the real attraction at the event was its headliner — Obama. Realizing he might have an opportunity to talk with the president, Kaiser's staff prepped him with talking points about Solyndra.

Kaiser did not have to angle for Obama's attention. Organizers seated him next to the world's most powerful man — for two hours.

"OK, I'll admit it. It was pretty intoxicating," Kaiser effused in an e-mail to an associate at 5:30 the next morning. "Charming and incisive as always. Casual conversation; not speechifying."

Kaiser did not squander his time. While he avoided the use of the word "Solyndra," according to the account he later gave to colleagues, he complained to the president about Chinese manufacturers dumping cheap solar panels on the U.S. market and pressed Obama's deputy chief of staff about the need for a Buy American Act for federal agencies. The company was intent on making the federal government a major customer — part of what a Solyndra investment adviser called the "Uncle Sam" strategy — and the new act would give Solyndra an advantage.

Kaiser, who has declined interview requests, said through spokesman Renzi Stone that he has not discussed Solyndra's loan "with the U.S. government." Other e-mails show that he rejected requests to take a more forceful role in advocating for the company.

Nonetheless, records show that Kaiser, a frequent visitor to the White House, was in contact with officials at Solyndra and its biggest investors, and advised them on leveraging the power of the West Wing.

"Why don't you pursue your contacts with the WH?" Kaiser advised a Solyndra board member in October 2010.

Nonprofit law specialists said that Kaiser's focus on Solyndra was striking, because he had no official role at the company and had no personal investment in the corporation. After amassing a fortune in the oil and banking industries, Kaiser had endowed a nonprofit corporation that bore his name, but he did not sit on its board.

The nonprofit corporation, known as the George Kaiser Family Foundation, had its own investment fund, which owned a third of Solyndra. Mitchell, a Solyndra board member, was the fund's manager.

Despite those walls between Kaiser and Solyndra, e-mail exchanges show that Mitchell repeatedly sought Kaiser's counsel and in one instance requested "authority" to make a major move.

Nonprofit experts stressed that once Kaiser donated his money to charity — and thereby qualified for millions of dollars in tax breaks — the money was no longer his under federal law.

Kaiser arrived in Las Vegas on the Friday night of the fundraiser, carrying a photo of himself and the president, which Obama signed for him. Over the evening, the oilman's conversation moved from social chatter to business.

"I talked in general about the Chinese and solar but didn't want to get too specific with him," Kaiser told associates. "I did talk to him about the Chinese subsidy over the past nine months and the effect it was having on U.S. solar and wind manufacturers. . . . I thought that a more aggressive trade policy with the Chinese was essential. . . . [Obama] said that these issues would be addressed aggressively at the G-20."

As for majority leader Reid, Kaiser confided in his e-mails: "Harry was mushy nice . . . Barack said privately that Harry would win by a small margin. I hope he's right."

Stone said last week that the dinner was only the second time Kaiser had met the president and that there was nothing wrong with Kaiser taking an interest in the foundation and its investments. While the foundation's board respected Kaiser's advice, its members made all the financial decisions, he said.

Packing up

Today, a handful of Solyndra employees remain at its Silicon Valley factory, helping wind down operations. Of the 1,100 workers who lost their jobs, an estimated 90 percent remain unemployed, such as Sterio. She's relying on help from relatives to make payments on her home, where she lives with her ailing husband and four grandchildren.

Solyndra has failed to attract a buyer who would keep the plant operating, so it is trying to unload its assets piecemeal to pay off its debts. The first $75 million recovered is expected to go to Kaiser's nonprofit organization and other investors; it is unclear how much will be left for taxpayers.

Along with selling its microscopes and industrial robots, the company in November auctioned off the 30-foot-long blue banner that served as a backdrop for Obama's factory visit.

Winning bidder Scott Logsdon, a laid-off Solyndra worker who's been lucky enough to land a new job, snapped up the sign for $400. He's hoping that with all of the political attention Solyndra's failure has received, the value of the sign will appreciate by Election Day.

It reads: "Solyndra . . . Made in the USA."

Research director Alice Crites contributed to this report.