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ENERGY AND TAX POLICY

HEARING

BEFORE THE

COMMITTEE ON WAYS AND MEANS
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

FEBRUARY 28, 2007

Serial No. 110–9

Printed for the use of the Committee on Ways and Means

U.S. GOVERNMENT PRINTING OFFICE

35–774 WASHINGTON : 2007

For sale by the Superintendent of Documents, U.S. Government Printing Office
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ENERGY AND TAX POLICY

WEDNESDAY, FEBRUARY 28, 2007

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON WAYS AND MEANS,
Washington, DC.

The Committee met, pursuant to notice, at 10:20 a.m., in room 1100, Longworth House Office Building, Hon. Charles B. Rangel (Chairman of the Committee) presiding.

[The advisory announcing the hearing follows:]

ADVISORY

FROM THE COMMITTEE ON WAYS AND MEANS

FOR IMMEDIATE RELEASE
February 21, 2007
FC–10

CONTACT: (202) 225–1721

Chairman Rangel Announces Hearing on Energy and Tax Policy

House Ways and Means Committee Chairman Charles B. Rangel (D–NY) today announced the Committee on Ways and Means will hold a series of hearings on energy and tax policy. The first hearing will focus on climate change and take place on Wednesday, February 28, 2007, in the main Committee hearing room, 1100 Longworth House Office Building, beginning at 10:30 a.m.

In view of the limited time available to hear witnesses, oral testimony at this hearing will be from invited witnesses only. However, any individual or organization not scheduled for an oral appearance may submit a written statement for consideration by the Committee and for inclusion in the printed record of the hearing. A list of invited witnesses will follow.

BACKGROUND:

For the past decade, there has been significant debate regarding the topic of global warming. Recent scientific evidence indicates that our dependence on fossil fuels as a source of energy is having an adverse impact on the environment. In his State of the Union address, President Bush asked Congress to work with him to reduce American dependence on gasoline and to increase the supply of alternative fuels. Numerous bills have already been introduced this Congress by Members of both parties that would create new tax incentives or extend existing tax incentives for the development of renewable resources and increased energy efficiency.

In announcing the hearing, Chairman Rangel said, "Climate change and global warming will have a tremendous impact on the quality of life here in America and around the world. The Federal Government needs a better understanding of what contributes to global warming so that we may play a significant role in preventing further damage."

FOCUS OF THE HEARING:

This hearing will focus on a scientific discussion of the factors contributing to global warming and the effects of such changes on climate changes.

DETAILS FOR SUBMISSION OF WRITTEN COMMENTS:

Please Note: Any person(s) and/or organization(s) wishing to submit for the hearing record must follow the appropriate link on the hearing page of the Committee website and complete the informational forms. From the Committee homepage, *http://waysandmeans.house.gov*, select "110th Congress" from the menu entitled, "Committee Hearings" (*http://waysandmeans.house.gov/Hearings.asp?congress=18*). Select the hearing for which you would like to submit, and click on the link entitled, "Click here to provide a submission for the record." Once you have followed the online instructions, completing all informational forms and clicking "submit" on the final page, an email will be sent to the address which you supply confirming your interest in providing a submission for the record. You MUST REPLY to the email and ATTACH your submission as a Word or WordPerfect document, in compliance with the formatting requirements listed below, by close of business **Wednesday, March 14, 2007**. Finally, please note that due to the change in House mail policy, the U.S. Capitol Police will refuse sealed-package deliveries to all House Office Buildings. For questions, or if you encounter technical problems, please call (202) 225–1721.

FORMATTING REQUIREMENTS:

The Committee relies on electronic submissions for printing the official hearing record. As always, submissions will be included in the record according to the discretion of the Committee. The Committee will not alter the content of your submission, but we reserve the right to format it according to our guidelines. Any submission provided to the Committee by a witness, any supplementary materials submitted for the printed record, and any written comments in response to a request for written comments must conform to the guidelines listed below. Any submission or supplementary item not in compliance with these guidelines will not be printed, but will be maintained in the Committee files for review and use by the Committee.

1. All submissions and supplementary materials must be provided in Word or WordPerfect format and MUST NOT exceed a total of 10 pages, including attachments. Witnesses and submitters are advised that the Committee relies on electronic submissions for printing the official hearing record.

2. Copies of whole documents submitted as exhibit material will not be accepted for printing. Instead, exhibit material should be referenced and quoted or paraphrased. All exhibit material not meeting these specifications will be maintained in the Committee files for review and use by the Committee.

3. All submissions must include a list of all clients, persons, and/or organizations on whose behalf the witness appears. A supplemental sheet must accompany each submission listing the name, company, address, telephone and fax numbers of each witness.

Note: All Committee advisories and news releases are available on the World Wide Web at *http://waysandmeans.house.gov*.

The Committee seeks to make its facilities accessible to persons with disabilities. If you are in need of special accommodations, please call 202–225–1721 or 202–226–3411 TTD/TTY in advance of the event (four business days notice is requested). Questions with regard to special accommodation needs in general (including availability of Committee materials in alternative formats) may be directed to the Committee as noted above.

Chairman RANGEL. Now the Committee will come to order.

Let me welcome these outstanding witnesses that we have today as this Committee embarks on a concern that has attracted late but international attention.

This debate has come a long way since our former Member of this Committee, Tom Downing, and his buddy Al Gore, many, many years ago, attempted to bring this issue before the Committee and the Congress.

The curiosity and the debate is over. Global warming is a fact, and human energy consumption is driving some of the detrimental effects of climate change.

The Federal Government can and must play a role in changing this behavior. Carbon-based fuel consumption is one of the contributing factors to global warming problems, and the Federal Government can and must use the Tax Code to encourage the development of alternative sources of energy, reducing Americans' reliance on oil and other traditional carbon fuels as a priority on her agenda.

Since we last met, the Committee has developed legislation to that effect.

The goal of this hearing is to offer members a full scientific understanding of climate change and global warming so that with the understanding the Committee is able to move forward with tax policies that will move forward with the responsibility of solving the problem.

We intend to frame the Committee's future work in crafting a package of tax incentives that will accelerate the development of clean, renewable energy and promote greater energy efficiency.

I would like to welcome our panel of witnesses and thank them for taking the time to join with us and to share their views with us.

Dr. Ronald Prinn, professor, Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology; Dr. Stephen Schneider, professor, Department of Biological Sciences, Stanford; Ms. Eileen Claussen, president, Pew Center on Global Climate Change; and W. David Montgomery, vice president of environmental practice, CRA International.

The panel of witnesses includes some of the leading academic perspectives on climate change. These witnesses will be able to quantify the effects of our nation's reliance on carbon-based fuels, on climate change, and summarize the effects of scientific and business communities to address global warming.

These witnesses can also provide some big picture overview of how the tax system can be utilized to complement regulatory efforts and to encourage the development of clean and renewable energy alternatives.

I am happy to yield to the Ranking Member, James McCrery, for his comments.

Mr. MCCRERY. Thank you, Mr. Chairman.

Today's hearing marks the start of what is likely to be a series by this Committee to explore issues dealing with two important goals, one of which is to improve America's energy independence; the other is to address issues relating to global climate change.

As we begin to explore the issue of climate change, I do note the lack of disagreement—another way of saying the agreement—among the panelists on the fact that the Earth is experiencing a period of warming.

A related issue, which I am sure the panelists will discuss, is the degree to which human activity is responsible for these changes.

We need not attempt to settle that debate here. Rather, we should focus on whether the tools at this Committee's disposal can be appropriately deployed to address the issue of climate change.

In making such an evaluation, I would like to suggest three questions that we should apply to this discussion. I hope they will be useful to all of us as we debate whether to ask our constituents to make difficult sacrifices today that might only marginally reduce largely unknown risks in the future.

First, what are the dangers of global climate change and when do they manifest themselves?

Any inquiry into the issue of global climate change must examine the impact of changes in the Earth's temperature and when those changes are going to be felt.

Second, can the United States, acting on its own, reverse or even slow global warming?

As this issue begins to take shape, I'm sure that each of us will be urged by various interest groups to support a variety of solutions to global warming, which could include an array of tax-based carrots and sticks to encourage the development of greenhouse gas-reducing technologies as well as punishments on those who are deemed to be contributing to the problem.

Before we rush to enact legislation, let's be sure we understand whether placing new burdens on our economy in the name of fighting global warming—an economy I should point out which is already significantly more greenhouse gas-efficient than many other nations—is going to make a measurable dent in the pace of climate change.

Third, what are the direct and indirect costs on our economy for what improvement in the global climate?

This is, in many ways, the single most important issue for this Committee, as the true costs of our actions must be considered in a broader context.

What level of damage are we willing to do to our economy in exchange for what level of reduction in the rage of global climate change?

Is it worth sacrificing one percentage point of growth in our GDP for 1 degree less in the planet's average temperature in 2107?

How many lost jobs does that translate into for American workers?

What exactly are the negative effects of that 1 degree of average higher temperature?

These are tough questions, but they are questions we must ask if we are to reach the right conclusions.

Similarly, if countries like China, India, and Russia do not implement similar restrictions, or even make a commitment to reduce their greenhouse gas emission to levels of most of the developed world, we need to ensure that we are not making the problem worse.

After all, if the sticks that we apply to our economy drive up the cost of producing goods in the United States, the inevitable result will be to chase good jobs overseas, where manufacturing is often done with far less regard to its impact on the environment and the global climate.

Surely, that is a result that each of us would find unsettling.

Mr. Chairman, I hope that this Committee will consider these three major questions as we go through this discussion.

I yield back the balance of my time.

Chairman RANGEL. Thank you, Mr. McCrery.

[The opening statement of Ms. Tubbs Jones follows:]

Opening Statement of The Honorable Stephanie Tubbs Jones, a Representative in Congress from the State of Ohio

Today we are facing what some have termed an energy "crisis." Others are calling it an energy "crunch." I would call it an opportunity for Cleveland, Ohio and the United States to lead the world in alternative energy technology.

Cleveland has suffered from a shift away from heavy manufacturing in recent decades, allowing a well-educated workforce to atrophy and our heavy industry to decline. However, if we act soon to invest in the research and manufacture of wind turbines and other equipment for alternative fuel technologies, we can use this industry as a stimulus to bring Cleveland, Northeast Ohio, and other communities hurting in the same way back to the vanguard of high technology industry. It has been estimated that 11,000 sustainable jobs could be created by the growth of wind turbine manufacture in Ohio. We cannot afford to ignore this opportunity of our children's economic and environmental future.

Despite the current Administration's unwillingness to confront this global challenge, I am confident this Congress can create greater opportunities for Ohio and American business. With the right mix of federal policy and development of new technology, we can find a way forward.

I appreciate the testimony by the distinguished panel, and I look forward to discussing these issues with you both today and in the future.

Chairman RANGEL. Dr. Prinn, thank you so much for making yourself available to the Committee, and therefore to Congress and our great Nation.

It took a long time for us to catch up to where you've been for so long, so I ask your indulgence and your patience with us, but together, you can be assured that probably what has been a long-lived dream is about to become a reality, not just for us but for humankind.

So, we thank you for being here, and I say to the entire panel, don't be surprised that we'll be calling you back.

Dr. Prinn.

STATEMENT OF RONALD G. PRINN, Sc.D., PROFESSOR, DEPARTMENT OF EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Dr. PRINN. Honorable Chairman and Members, I want to thank you all for the opportunity to present some key issues regarding climate.

First, is climate changing?

Global warming or cooling can be driven by any imbalance between the energy the Earth receives through the sun and the energy it radiates back to space, as invisible infrared radiation. It is that simple.

The concentrations of carbon dioxide and many other long-lived greenhouse gases have increased substantially over the past two centuries, due in large part to human activity.

These greenhouse gas increases temporarily lower the flow of infrared energy back to space and increase the flow of this infrared energy down toward the surface.

These straightforward facts lead to the rising of temperatures at the surface and in the lower atmosphere.

Recently, the Intergovernmental Panel on Climate Change, in its fourth assessment, concluded that warming of the climate system is unequivocal.

As one example, the last 12 years include the two warmest and 11 of the 12 warmest years since the year 1850.

There is no doubt in my mind that climate is already changing in very significant ways.

This begs the obvious question, how much of this is due to human activity?

Ten years ago, I gave testimony during the House Countdown to Kyoto hearings, in which I stated that I was not convinced at that time that the human signal had arisen from the noise of natural variability.

I am now convinced that the human influence is proven with significant probability.

The observations of continued rapid warming and the recent improvements in climate theory and models are among the reasons for the change in my conclusion.

Now, human influence on climate is indicated if the observed global patterns of climate change over, say, the past 50 to 100 years, are shown to be consistent with those predicted by climate models which include the human influences but not consistent with the patterns predicted when the human influences are neglected.

The observed 1906 to 2005 temperatures at the global and continental scales are compared by the IPCC to the range of temperatures from multi-model simulations with and without human forcing.

The separation of these two model temperature ranges during recent decades, and the fact that the observations follow the forced model range much more closely, argues that the signal of human influence has indeed arisen from the noise, and I agree.

The IPCC fourth assessment has specifically concluded that there is greater than 90 percent chance that most of the observed increase in globally average temperatures since the mid-20th century is due to the observed increase in anthropogenic greenhouse gas levels.

The conclusions about human influence by the IPCC provide a substantial impetus for lowering future greenhouse gas emissions.

Now, concern about climate change is driven, also and especially, by forecasts of significant warming over the next century, but how good are these forecasts?

At MIT, we have developed an integrated global system model which consists of coupled models of economic development and its associated emissions, natural bio-geochemical cycles, climate processes, and ecosystems.

We've used several hundred runs of this model with different assumptions to estimate the probability of changes in surface temperature between 1990 and the year 2100 for two hypothetical cases, no explicit climate policy, and a stringent policy.

The stringent policy keeps atmospheric carbon dioxide in the year 2100 to be below twice its pre-industrial level. That's chosen somewhat arbitrarily.

For clarity, the probabilities of the various amounts of warming from the MIT study are projected onto two wheels, as shown in this illustration.

The no-policy wheel that you see in front of you shows about one chance in four of greater than 3 degrees Centigrade warming by the year 2100.

That's one quarter of the circle.

Such a warming is regarded by most climate scientists as very dangerous.

The policy wheel indicates that the odds of exceeding 3 degrees Centigrade warming drop dramatically when the carbon dioxide level is capped in the way I mentioned.

Imagine now that you are playing a game called the greenhouse gamble, and you have $100,000 in winnings.

To end the game and collect your money, you must finally spin one of these two wheels.

If you land on any part of the wheel corresponding to warming exceeding 3 Degrees Centigrade, you lose, say, $10,000 of your winnings.

You can spin the no-policy wheel, on the left-hand side, for free, but you must pay to spin the policy wheel, with its much lower odds of losing your money.

How much of your $100,000 would you be willing to give up in order to spin the policy wheel?

The world is currently spinning the no-policy wheel. We are not spinning the one on the right-hand side.

To help you make the decision on how much money you want to spend to spin the policy wheel, we should ask, what are the risks of climate change?

I advise you not to look too much on the spinning wheels. It can be quite disturbing.

The projected warming of the polar regions in the no-policy case is about twice the value shown on the wheel, twice.

Also, the no-policy case projects sea level rises of about 8 to 31 inches due to the warming oceans and melting of mountain glaciers.

These conclusions point to the great vulnerability of coastal and polar regions to global warming.

The Greenland and west Antarctic ice sheets together contain the equivalent of 39 feet of sea level rise.

It's therefore very significant that the IPCC fourth assessment concludes that the last time the polar regions were significantly warmer than present for an extended period of time, the reductions in polar ice volume led to four to six meters of sea level rise, which is 13 to 19½ feet of sea level rise.

Also, recent research has suggested a significant connection between increasing sea surface temperatures and the duration and wind speeds in typhoons and hurricanes.

If further research confirms this, the increased storm damages, which typically rise as the cube of the wind speed, could be very costly.

Regarding the needed emission reductions, it's important to know that it matters very little where the long-lived greenhouse gases are emitted, and that substantial reductions of the type in the policy wheel that I show there, require ultimate participation by all nations, not just the currently rich nations.

To better calibrate the policy response, we also need to improve the accuracy of estimates of the impacts of climate change on natural and human systems.

Natural ecosystems may not be able to adapt. Some of these effects can be potentially mitigated by adaptation, particularly in the human systems.

Finally, I emphasize that we cannot wait for perfection in either the climate forecasts or the impact assessments before taking action.

The long-lived greenhouse gases emitted today will last for decades to centuries in the atmosphere.

Added to this is the multi-decade period needed to change the global infrastructure for energy and agricultural production and utilization without serious economic impacts, and we certainly do not want serious economic impacts.

Thank you.

[The prepared statement of Dr. Prinn follows:]

Statement of Ronald G. Prinn, Sc.D., Professor, Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts

Honorable Chairman and Members of the House Committee on Ways and Means, I respectfully submit the following testimony in response to your invitation of February 14, 2007.

I have been a member of the faculty of the Massachusetts Institute of Technology since 1971. I specialize in atmospheric science, and in my capacity as Director of the MIT Center for Global Change Science and Co-Director of the MIT Joint Program on the Science and Policy of Global Change, I have also gained appreciation of the various other disciplines in the natural and social sciences involved in the climate debate.

I will address here some key issues that in sum provide a significant scientific impetus for lowering greenhouse gas emissions. First, I will briefly say something about the current evidence for climate change. Second, I will discuss detection of the human influence on climate that is so important to policy. Third, I will address the uncertainty in current forecasts. Fourth, I will review the risks to humans and natural ecosystems that arise from allowing very significant future global warming to occur. Finally, I will comment on the unresolved issues in climate science that need future resolution.

IS CLIMATE CHANGING?

Climate is usefully defined as the average of the weather we experience over a ten- or twenty-year time period. Long-term temperature, rainfall and sea level changes are typical measures of climate change, and these changes can be expressed at the local, regional, country, or global scale. When the global average temperature changes we call that global warming or cooling.

Global warming or cooling can be driven by any imbalance between the energy the Earth receives, largely as visible light, from the sun, and the energy it radiates back to space as invisible infrared radiation. The greenhouse effect is a warming influence caused by the presence in the air of gases and clouds which are very efficient absorbers and radiators of this infrared radiation. The greenhouse effect is opposed by substances at the surface (such as snow and desert sand) and in the atmosphere (such as clouds and colorless aerosols) which efficiently reflect sunlight back into space and are thus a cooling influence. Easily the most important greenhouse gas is water vapor but this gas typically remains for only a week or so in the atmosphere. Water vapor and clouds are handled internally in climate models. Concerns about global warming revolve around less important but much longer-lived greenhouse gases, especially carbon dioxide. The concentrations of carbon dioxide and many other long-lived greenhouse gases (methane, nitrous oxide, chlorofluorocarbons, lower atmospheric ozone) have increased substantially over the past two centuries due totally or in large part to human activity. When the concentration of a greenhouse gas increases (with no other changes occurring) it temporarily lowers the flow of infrared energy to space and increases the flow of infrared energy down toward the surface which raises temperatures at the surface and in the lower atmosphere. The rate of surface temperature rise is slowed significantly by the uptake of heat by the world's oceans that then causes sea level to rise. This delaying action of the oceans means we are already committed to future warming due simply to the greenhouse gases already in the atmosphere.

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, whose summary for policy makers was released earlier this month, summarizes the direct observations of recent climate.[1] They conclude that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." They also conclude that "at continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones." There is no doubt in my mind that climate is already changing in very significant ways. This begs the obvious question; how much of this is due to human activity?

CAN WE DETECT HUMAN INFLUENCE?

Human influence on climate is indicated if the observed global patterns of climate change over say the past 50–100 years are shown to be consistent with those predicted by climate models which include the human influences, but not consistent with the patterns predicted when the human influences are neglected. The pre-

dictions which neglect human influence are taken as a measure of the natural variability of climate and are thus used to represent the "noise" out of which the human-caused "signal" must arise for a definitive detection. The imperfections of current climate models make them less than ideal tools for defining natural variability and uncertain predictors of the climate response to human forcing. There are other difficulties associated with the inadequacies in climate observations and poor knowledge of past levels of aerosols and their quantitative effects on sunlight reflection.

Ten years ago, I gave testimony during the House "Countdown to Kyoto" hearings in which I stated that I was not convinced at that time that the human signal had arisen from the noise of natural variability. I am now convinced that the human influence is proven with significant probability. The observations of continued rapid warming over the last 12 years, which include the 2 warmest years, and 11 of the 12 warmest years since 1850,[1] and the recent improvements in climate theory and number and quality of models, are among the reasons for the change in my conclusion.

The IPCC Fourth Assessment has concluded that there is greater than 90% chance that most of the observed increase in globally averaged temperatures since the mid-20th century is due to the observed increase in anthropogenic greenhouse gas levels.[1] Some of the arguments for this strong conclusion are visibly captured in Figure 1 reproduced here from the IPCC report.

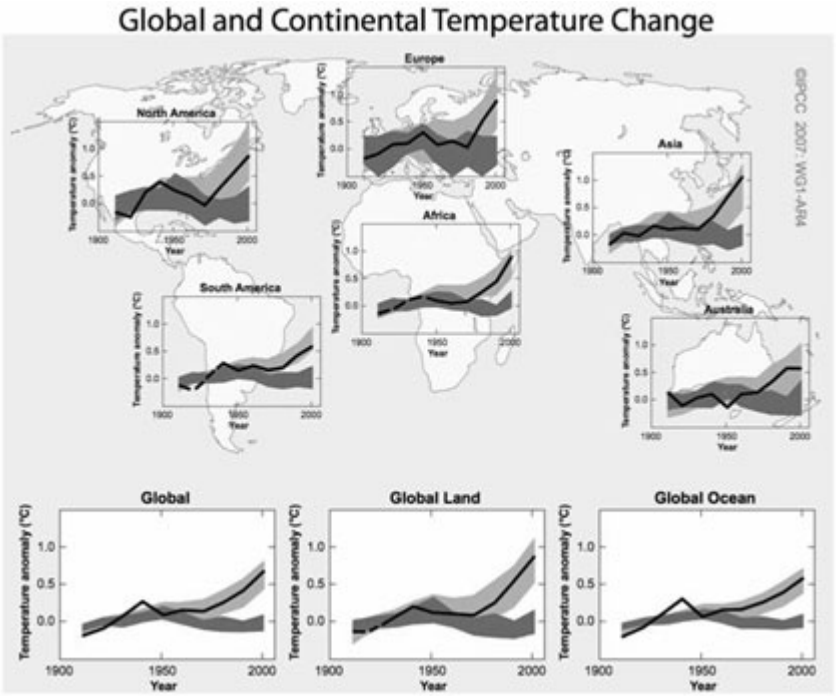

Figure 1. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings from the IPCC Fourth Assessment.[1] Decadal averages of observations are shown for the period 1906–2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage of observations is less than 50%. Dark gray shaded bands show the 5–95% range for 19 simulations from 5 climate models using only the natural forcings due to solar activity and volcanoes. Light gray shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings.

The observed 1906–2005 temperatures are shown at the global and continental scales and are compared to two bands; one band shows the range of multi-model

simulations without anthropogenic forcings (i.e. the "noise") while the other shows the range with these forcings (i.e. the "signal"). The separation of these two bands during recent decades, and the fact that the observations follow the "forced" band much more closely, argue that the "signal" of human influence has arisen from the "noise." Even if the probability is not quite 90%, the conclusions about human influence by the IPCC Fourth Assessment provide a substantial impetus for lowering future greenhouse gas emissions.

HOW GOOD ARE THE FORECASTS?

Concern about climate change is driven especially by forecasts of significant warming over the next century. The computer models used to make these forecasts attempt to simulate with some, but not complete success, the behavior of clouds, water vapor, long-lived greenhouse gases, atmospheric and oceanic circulation, and many other essential climate processes on the regional and global scale. These models are remarkable in their complexity and, despite their limitations, are invaluable tools for scientific research.

Integrating and understanding the diverse human and natural components of the problem is a must when informing policy development and implementation. As a result, climate research should focus on predictions of key variables such as rainfall, ecosystem productivity, and sea level that can be linked to estimates of economic, social, and environmental effects of possible climate change. Projections of emissions of greenhouse gases and atmospheric aerosol precursors should be related to the economic, technological, and political forces at play. In addition, such assessments of possible societal and ecosystem impacts, and analyses of mitigation strategies, should be based on realistic representations of the uncertainties of climate science. At MIT, we have developed an Integrated Global System Model (IGSM) to address some of these issues and to help inform the policy process. The IGSM consists of a set of coupled sub-models of economic development and associated emissions, natural biogeochemical cycles, climate, air pollution, and natural ecosystems. It is specifically designed to address key questions in the natural and social sciences that are amenable to quantitative analysis and are relevant to climate change policy.[2] The IGSM is arguably unique in its combination of scientific and economic detail, climate-atmospheric chemistry-ecosystem feedbacks, and computational efficiency. It does make some important simplifications to enable computational efficiency, but the effects of these are likely to become important, at least for global average climate forecasts, only after 2100.

To help decision-makers evaluate how policies might reduce the risk of climate impacts, quantitative assessments of uncertainty in climate projections are very useful. We have used several hundreds of runs of the IGSM together with quantitative uncertainty techniques to achieve this assessment.[3] The IGSM physical climate model is flexible, which enables it to reproduce quite well the global behavior of more complex climate models. This flexibility allows for analysis of the effect of some of the structural uncertainties present in existing models. The MIT study includes uncertainties in anthropogenic emissions of all climatically important gases and aerosols, and in critical climate processes involving clouds, aerosols and deep ocean overturning. The MIT estimates of key climate model uncertainties are constrained by observations of the climate system. Also, uncertainty in emissions includes expert judgment about variables that influence key economic projections.

The probability of changes in the mean global surface temperature and sea level between 1990 and 2100 were calculated for two hypothetical cases: no explicit climate policy, and a stringent policy. The stringent policy keeps atmospheric CO_2 levels in the year 2100 in the median case to be just below 550 parts per million (which is about twice the preindustrial CO_2 level). Absent mitigation policies, the median projection in this study shows a global average surface temperature rise from 1990 to 2100 of 2.4°C, with a 95% confidence interval of 1.0°C to 4.9°C. For comparison, the recent Fourth Assessment Report of the IPCC reports a range for the global mean surface temperature rise by 2100 of 1.1 to 6.4°C for 6 assumed emission scenarios.

Communicating the results of an uncertainty study like this to the public and policy makers needs to be achieved with clarity. The average person on the street is in fact very familiar with the problems of dealing with uncertainty—they just do not describe it with probabilities. Anyone who plays cards, bets on horses, or plays roulette is gambling with significant knowledge about the odds of various outcomes. Similarly, people have become comfortable with these issues when it refers to their health—you have high bad cholesterol levels and your doctor informs you that your chances of a heart attack are significantly greater than average unless you take steps to lower these levels. With this in mind, I share with you one way that I (and my MIT colleagues) have found quite effective in communicating the value of cli-

mate policy despite the uncertainties.[4] We call it the "greenhouse gamble" which is a variant on the "wheel of fortune." The probabilities of various amounts of warming from the above MIT study are projected onto two wheels, as shown in Figure 2.

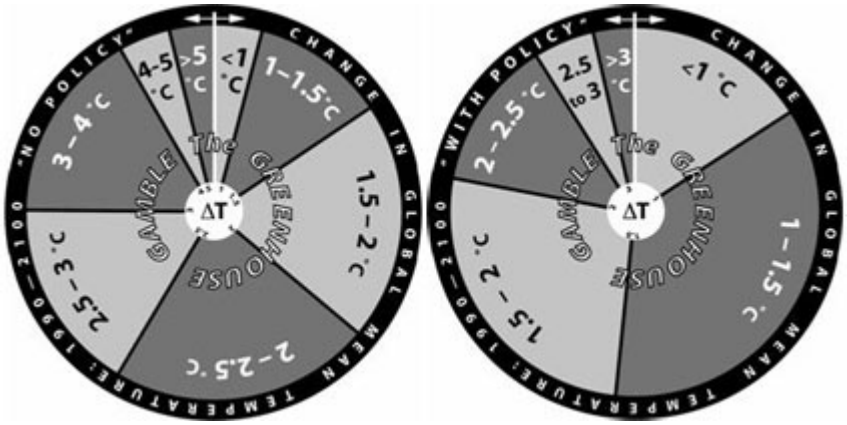

Figure 2. The probabilities for various amounts of global average warming between 1990 and 2100 calculated from two multi-hundred sets of model forecasts are projected onto two wheels.[3] The left-hand wheel is for "no policy" and the right-hand wheel is for "policy" (see text).

The "no policy" wheel shows about 1 chance in 4 of greater than 3 degrees centigrade warming between now and 2100 if there are no significant efforts to curb greenhouse gas emissions. Such a warming is regarded by most climate scientists as very dangerous. The "policy" wheel, that keeps greenhouse gas levels below twice their preindustrial levels, indicates that the odds of exceeding 3 degrees centigrade warming drop dramatically. Imagine that you are playing "the greenhouse gamble" and have $100,000 in winnings. To end the game and collect your money you must finally spin one of these two wheels. If you land on any of the sectors of the wheel corresponding to warming exceeding 3 degrees centigrade you lose say $10,000 of your winnings. You can spin the "no policy" wheel for free but must pay to spin the "policy" wheel with its much lower odds of losing your money. In this game the $10,000 represents an (arbitrary) penalty for the damages caused by dangerous climate change and the money you are willing to give up represents the cost of mitigating policy. How much of your $100,000 would you be willing to give up in order to spin the "policy" wheel?

I emphasize that the uncertainty represented by the "no policy" wheel is not a sound argument for inaction. The fact that there is some probability for small amounts of warming is countered by comparable probabilities for dangerous amounts of warming. I emphasize that the exact odds of various amounts of warming depicted in the two wheels are not as important as the qualitative differences between them. Indeed, more recent research at MIT,[5] and other work reported in the IPCC Fourth Assessment,[1] implies that the probabilities of large amounts of warming may be underestimated in these wheels.

WHAT ARE THE RISKS?

The projected warming of the Arctic and Antarctic regions in the MIT "no-policy" case are about 2.5 and 1.8 times greater respectively than the quoted global average warming (this uneven warming is evident from past observations and is seen in essentially all other climate model simulations). Also, the warming in the "no-policy" case is accompanied by projected sea-level rises of 0.2 to 0.84 meters due to warming (and hence expanding) oceans and melting of mountain glaciers. The IPCC Fourth Assessment reviews forecasts from a large number of other more comprehensive climate models revealing qualitatively similar asymmetry in warming, and sea level rises of 0.18 to 0.59 meters (1990 to 2095) depending on the emission scenario used. These sea level estimates are conservative since they do not include the possibility of significant melting of the Greenland and Antarctic ice sheets.

These conclusions and many others in the literature point to the great vulnerability of coastal and polar regions to global warming. The Greenland and West Antarctic ice sheets together contain the equivalent of 12 meters of sea level rise. It

is therefore significant that the IPCC Fourth Assessment[1] concludes that "the last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 meters of sea level rise." Also vulnerable are Arctic tundra and frozen soils which contain the equivalent of about 80 years of current fossil fuel carbon emissions,[6] and Arctic summer sea ice cover (a cooling influence) that is already decreasing.[1]

Other expected consequences of global warming include increases in heat waves and high latitude precipitation. There are also expected to be some benefits of warming, for example increases in the length of the growing season in cold regions, that also need to be considered. Recent research has suggested a significant connection between increasing sea surface temperatures and the duration and wind speeds in typhoons and hurricanes.[7] If further research confirms this, the increased storm damages, which typically rise as the cube of the windspeed, could be very costly. There are other thresholds and vulnerabilities in the climate system that, added to those discussed above, make it prudent to attempt to limit the amount of future global warming by lowering greenhouse gas emissions.[8]

CONCLUDING REMARKS

Regarding the needed emission reductions, it is important to note that it matters very little where the long-lived greenhouse gases are emitted and that, according to our emissions projections,[3] very substantial reductions will require ultimate participation by all nations, not just the currently rich countries. Another important point is that the predicted warming in 2100 is sensitive to the total emissions up to that time but relatively insensitive to the temporal pattern of the emissions. Hence higher emissions in the near term can potentially be offset by lower emissions later on.

To better calibrate the policy response, we need to improve the accuracy of estimates of the impacts of climate change on natural and human systems. Here the research is less mature, but we need to better understand and quantify these effects. Some of these effects, specifically impacts on human health, agriculture, forestry, water supply and quality, and flood-prone coastal and riverine settlements, can be potentially mitigated or avoided by adaptation. Natural terrestrial, coastal, and oceanic ecosystems may not be able to adapt. We also need to address the environmental impacts of future potential renewable energy sources operating at the multi-trillion watt scales needed for them to make a significant contribution to future total energy demand (e.g. billions of acres of land for biofuels, many millions of wind turbines). It goes without saying that quantitative studies of all of these issues will require significant improvement in the accuracy of climate predictions at the country and regional level. The challenges here are great, but accurate quantification of impacts is essential to define the appropriate balance between the costs of policies to lower greenhouse gas emissions and the impacts avoided by these policies.

Finally, I emphasize that we should not wait for perfection in either climate forecasts or impact assessments before taking action. The long-lived greenhouse gases emitted today will last for decades to centuries in the atmosphere and the severity of the risk is obvious from the fact that scientists cannot presently rule out the rapid warming forecasts. Added to this is the multi-decade period needed to change the global infrastructure for energy and agricultural production and utilization without serious economic impacts.

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Chairman RANGEL. Thank you, doctor.

Dr. Schneider is a professor at the Department of Biological Sciences. He has served over half-a-dozen presidents and certainly brings to us an international reputation.

We are honored to have you present among us, and we are anxious to listen to your testimony.

STATEMENT OF STEPHEN SCHNEIDER, Ph.D., PROFESSOR, DEPARTMENT OF BIOLOGICAL SCIENCES, STANFORD UNIVERSITY, STANFORD, CALIFORNIA

Dr. SCHNEIDER. Thank you very much, Mr. Chairman.

As a point of personal preference, I can remember back in the mid-1970s, as a 31-year-old, when I first testified in the House and also in the Senate, and I recall your sitting up there, too, when we were discussing this problem cordially, as an interesting curiosity in science.

In fact, in the mid-1970s, we were just beginning at that point in the research community to recognize the greater likelihood of warming versus cooling from human activities, and some people were beginning to talk about long-term concerns for policy.

If I had to summarize, as I'm sometimes forced to do in a 20-second sound bite in a TV program, so what have you all learned in the last 30 years since you've all been discussing this in Congress and elsewhere, I guess my single fastest quip would be that "nature has cooperated with theory," that most of what we predicted, not precisely, but warming, increased heat waves, decreased cold waves, increasing intensity of tropical cyclones, hurricanes, those kinds of events would occur, and indeed they have.

Now, it's often said that the science is settled, and indeed, with regard to warming of the last century, an incredibly unusual word for scientists was used by the Intergovernmental Panel on Climate Change when they said it was unequivocal.

However, what fraction of that global warming was due to nature, what fraction was due to us is not completely unequivocal, but I believe the words they used, also very strong language for scientists, was "very likely" that at least the last several decades could not be explained without the buildup of greenhouse gases in the atmosphere; and I personally concur with that.

The first slide suggests that, despite the fact that our confidence in the observed trends, both occurring as a reality and at the same time having a deep underlying cause that's both natural and human-driven, scientists can't explain it all without either one. Moreover, we still have substantial work left to do in figuring out precisely how much we'll be warming in the future.

There are, in fact, two fans of uncertainty.

One is human behavior. If you look at this figure—and this is one of those unfortunate figures we scientists love so much.

I tell my students that a figure is supposed to save 1,000 words, not take 1,000 words. I fear this one may be in the latter category. Fortunately, it's in my written testimony.

The main point that it conveys is there's a large fan of uncertainty in the colored bars. Those are primarily related to assumptions of how many people there will be in the world, what standards of living we'll have, and what technologies we're going to use to get there—highly polluting or lower polluting. It makes a big difference.

Then there are bars on the right-hand side of the figure. That represents a second fan of uncertainty, which is the uncertainty in the internal dynamics of the bio-geophysical system.

All together, it gives you a very daunting range of projections for warming by the end of this century, somewhere between 1.1 Celsius and 6.4—1.1 is larger than we now have, which is around 0.7, when we've already experienced increased intensity of hurricanes and fires and heat waves and ice shrinkage, and therefore, you could argue that we'd rather not warm up 1.1 degress more.

On the other hand, 6.4 degrees Celsius would be, as Ron Prinn said, a warming that I don't know any serious scientist who has studied the problem would advise that we risk. It's the temperature difference between an ice age and an inter-glacial cycle occurring not in five to ten thousand years, but in one to two centuries, would probably represent a massive extinction crisis and many, many difficult outcomes.

So, what is it that we have to be concerned about? It's risk management.

I do not believe the scientific community will anytime in the near future be resolving precisely that range of uncertainty, and just like anyone who buys insurance, invests in deterrence, or makes any strategic hedge, you have to consider the balance between the price of the premium and the benefit of the policy, and that's precisely what we will be doing here, because I do not think that you can rule out substantially dangerous change, nor can we precisely pin it down in the foreseeable future.

The next picture, which I promise you we won't go over here, but it's in the written testimony, basically says that it isn't just happening to our thermometers, it's happening to nature.

What those three panels show you, in a few phrases, is that plants are blooming earlier in the spring by a week or two, that birds come back earlier on migration, and the problem is, they don't all do it together, so you tear apart the fabric of ecological communities, and that's occurred at something like six tenths of a degree Celsius warming in the past 50 years, and we shudder to imagine what would happen if we were unfortunate and came out at the 6 degree warming end with ten times more change than in the past 50 years.

Finally, I want to stress an aspect that's very significant.

There are two issues.

One is, it's perceived in the world now that climate policy is on the track and is no longer just an issue for conversation.

Therefore, there will be elements who will try to sneak in under the wire and build in—what the economists call "lock in"—the largest emitting plants they can get away with before they're controlled.

What I would suggest to the Committee is to consider whether the rules that you set up would prevent anybody from having a perverse incentive to do the wrong thing.

If the baseline data against which they have to compare their emissions were in the past and not in the future, there would be little opportunity for chicanery to sneak in under the wire, and those again are the kinds of issues I think that you'll have to carefully address as you look at the policy.

Finally, let me conclude with this figure, which is complicated, but I can summarize it simply.

A former friend of mine was the astronomer, Carl Sagan, and he used to always get made fun of from his accent when he talked about billions and trillions of stars and galaxies.

We have a bit of a billions and trillions problem in dealing with climate change, as well.

There are all sorts of groups that will tell you how many billions or trillions it might cost to have one mitigation option or the other, and even if they were accurate—and trust me, I've read a lot of this literature; there's a wide range of uncertainty in that literature, as well.

Even if they are accurate, it's not adequate to say that we will lose 1 percent of GDP in the future when the economy will be eight times larger, and therefore that's trillions of dollars, and then take that trillions of dollars lost in 2100 and compare it to the present economy, where it looks like a Great Depression, because almost all models project something like a 2 percent per year growth rate in the economy.

What that means is, if there were a loss of 1 or 2 percent in GDP associated with mitigation policy, as many models suggest, what would it mean in terms of a delay to be a given percentage richer?

Well, this is work explained in the text, and it's just one set of examples. Please do not take these numbers literally. The framework is what it was designed to look at.

I'll conclude by saying, almost every study shows that even a loss of a few percent in GDP, which can translate into staggering numbers of trillions of dollars, is only a year or two delay in being, say, 500 percent richer by 2100.

So, what we learn is that the growth rate in the economy, which nearly everybody projects, makes up for the extra cost of mitigation in somewhere between 6 months and a few years, and I just submit to you whether it's a good insurance policy to avoid the more dangerous aspects of climate change to stay under the 3 degrees that my colleague, Ron Prinn, has said is a dividing point for dangerous effects by being 500 percent richer in 2101 with mitigation per capita, rather than 2100 without it, and avoid most of that climate risk.

Thank you very much.

[The prepared statement of Dr. Schneider follows:]

Statement of Stephen Schneider, Ph.D., Professor, Department of Biological Sciences, Stanford University, Stanford, California

Honorable Chairman and Members of the House Committee on Ways and Means, I respectfully submit the following testimony in response to your invitation of February 14, 2007.

Introductory Remarks

In 1976 I had the honor as a 31-year-old of appearing before the Congress for the first time, testifying in support of the establishment of a U.S. National Climate Program Office to coordinate activities in the government dealing with the then fledgling discussions of climate change. At that point the research community was just recognizing the greater likelihood of warming versus cooling from human activities, and the various agencies responsible for climate related research and management needed to coordinate their many independent activities. That Office was established and climate change work became a major feature of the efforts of several agencies and the Congress. Since that time, I have personally participated in some two dozen hearings in the House and Senate (as well as many Parliamentary hearings in several countries) on climate variability and change, dealing with both climate science and related policy implications (please refer to my website for more information on my work and views on the vast range of climate issues I can only touch on today: climatechange.net).

If I had to summarize in a phrase the major advance since that early interest in climate in the Congress three decades ago, it would simply be that since the mid 1970s, "Nature has cooperated with theory." The warming typically projected then was primarily based on the theory that additional heat trapping associated with the known increases of human-produced greenhouse gasses in the atmosphere would drive warming. In fact, recent studies have shown that most of the mainstream projections since the mid-1970s in the peer reviewed literature and in National Research Council reports that projected up to one degree Celsius warming by 2000 were accurate to about a factor of two. Impacts such as increased heat waves, decreased cold snaps and increased hurricane intensities were all projected in the 1980s, and such expectations have been largely supported by subsequent data. The many uncertainties in climate science—in particular how clouds might affect the sensitivity of the climate to heating produced by increasing greenhouse gasses—were always openly acknowledged, leading to roughly a threefold uncertainty in estimates of how much warming there would be from a doubling of CO_2 in the atmosphere above a pre-industrial benchmark concentration of 280 parts per million: roughly 1.5 to 4.5°C warming over a few centuries if CO_2 were to double. I wish I could report to the Committee that advances in climate science have substantially narrowed that range. But despite the dramatically increased scientific confidence we now express in the *observed* warming of the past 30 years, and the high likelihood that much, if not most, of it is a result of human activities, we are still not able to produce a substantially narrowed range of potential warming over the next hundred years. As Figure 1 shows, the likely range of warming for 2090 projected in the mainstream literature and summarized by the recently released Intergovernmental Panel on Climate Change (IPCC) Working Group 1 Report, covers a very large range: 1.1 to 6.4 degrees Celsius. About half that uncertainty is due to geophysical issues like how clouds will govern climate sensitivity, and the other half results from uncertainties in human behavior: how many people will be in the world, what standards of living they will demand and to what extent development goals will be achieved through greenhouse gas-emitting energy systems and land clearing activities. Such choices can, as the figure shows, make a major difference in climate change risk.

So What if the Climate Changes?

The bottom end of that 1.1 to 6.4°C range on Figure 1 would still be problematic for many regions and sectors, but the top end estimate is virtually certain to be very highly impacting for nearly all sectors and regions, and particularly devastating to nature. Note in Figure 2, that already—with about 0.6°C observed warming—that plants and animals are showing a discernible response to warming from human activities (see the lower two panels of the Figure). If that amount of warming increases by a factor of ten to the 6.4°C upper limit suggested by IPCC as possible by 2090, then most ecological estimates suggest a major extinction crisis for species—with some 50% of all existing biodiversity either going extinct or becoming endangered. These species would have to move substantial distances to find suitable new climate space, and in the process be forced to confront highly disturbed landscapes fragmented by factories, farms, freeways and urban settlements.

Over the past two decades, research has intensified on the impacts of projected warming on coastlines, agriculture, ecosystems, human health and cultures near coastlines and in high mountains—where warming can significantly contribute to sea level rise and the melting of ice systems. Again, if forced to summarize this work in a sentence: some systems might benefit in aggregate dollar terms from up to a few degrees of warming (in particular agricultural productivity in higher latitudes), but even small amounts of warming can have detrimental effects to agriculture in warmer regions, can increase the intensity of hurricanes or wildfires, and can alter ecological balances. Scientific assessments based on the literature have shown that even small amounts of warming would negatively affect more people and systems than would be benefited. Warming beyond a few degrees is generally found in the scientific literature to have a vast preponderance of significant negative effects on food production, forests, species, coasts, human health, wildfires and the delivery of such services as water supplies and flood protection. Figure 1 suggests that this level of warming is considered likely unless major mitigation activities are undertaken.

In short, a continuation of "business as usual" raises a serious concern from the risk-management point of view, given that the likelihood of warming beyond a few degrees before the end of this century (and its associated impacts) is a better than even bet. Few security agencies, businesses or health establishments would accept such high odds of potentially dangerous outcomes without implementing hedging strategies to protect themselves, societies and nature from the risks—of climate change in our case. This is just a planetary scale extension of the risk-averse principles that lead to investments in insurance, deterrence, precautionary health services and business strategies to minimize downside risks of uncertainty.

Portfolio of Options: Efficiency, Learning, Adaptation and Mitigation

Fortunately, many studies over the past decade and a half have shown that there is a portfolio of options to deal with the risks of climate change. First of all, since we are already committed to some level of further climate change regardless of our actions to mitigate emissions, it makes sense to invest in adaptation strategies to reduce the negative effects. This could involve research and/or extension activities such as the development of more climatically tolerant crops, coastal protection measures, and creating interconnections and improved migration pathways for species forced to relocate in response to warming. In particular, as the world's largest economy—and CO_2 emitter—we in the U.S. will be increasingly called upon to be a partner in helping less developed countries to improve their adaptive capacity via targeted development activities. Given that hotter and poorer regions and groups are less well able to marshal resources for adaptation, increasing global attention will be paid to those vulnerable regions as the globe sees accelerating warming (now projected with high confidence by nearly all mainstream climate scientists and reported in many National Research Council reports and by the IPCC). And not only poor countries will be vulnerable to extreme climatic events that ride on top of warming trends, demonstrated all too well by the aftermath of the 2003 European heat wave that took an estimated 50,000 lives prematurely and the still dire straits for most of the victims of Hurricane Katrina.

But adaptation is most effective for less than a few degrees of warming, and is virtually ineffective against harm to natural systems like ice sheets, ecosystems or those social systems with little resource base to adapt. For warming beyond a few degrees, the scientific literature suggests that adaptation becomes a very questionable prospect and the safer strategy is to avoid the risk of warming beyond a few degrees. This requires mitigation policies that reduce the emissions that cause the warming in the first place, and here is another area where a portfolio of strategies have been proposed. The sequencing of such strategies will be a major occupation of the governance of climate change risks. I often suggest that the first element in this sequence should be actions already prevalent in many counties, states and at the federal level: mandatory performance standards for energy efficiency of buildings, automobiles, air conditioners, refrigerators, energy supply systems and other technologies. Other strategies could involve capturing greenhouse gasses from smokestacks and sequestering them underground, a potentially promising entry in the portfolio of options, but one whose cost and efficacy at the gigantic scale needed (some trillion tons of carbon to be sustainably and safely buried for centuries or more) is not yet assured at all. Therefore, what is called for, in my view, is another step in the sequencing of actions: public/private partnerships to foster learning-by-doing projects to make renewable energy systems cheaper and more available and to explore other options from both cost and safety aspects. It is not just R&D, but R, D & D—the second D being "demonstration"—as deployment of prototype systems to compete for future market share based on their improved performance

gained from the demonstration investments is the key to learning-by-doing. And there can be little learning-by-doing without the "doing." Similarly, there can be little return on investment until there is investment, and the policy debate thus will need to focus on incentives to promote such investments.

Ultimately, reduction of greenhouse gas emissions by some 60–80% by mid century and to near zero by century's end (what is needed to have a fighting chance to stay below a few degrees more warming globally) is increasingly called for (by California, Illinois, South Australia and the UK among others). To achieve such admirable sustainability goals for climate protection, most studies suggest that we need both "carrots and sticks," and that carrots alone (like public support of private ventures in cleaner technologies) will not suffice—and that a penalty must be implemented for dumping our tailpipe and smokestack wastes into the atmosphere as if it were a free sewer. With no clear disincentives, this dumping is likely to only continue to increase. Such a "dumping fee" is essential over time as an incentive both to reduce emissions and to stimulate private investment in greener alternatives.

Avoiding High Emissions "Lock-in"

The recent attempts of some power producers to try to rush into service—and thus "lock in" high emitting power plants for 50 years—seems a clear attempt to "sneak in under the wire" of climate policy, and to pre-empt the likelihood of coming controls on emissions. Emissions baselines against which reductions will be scaled need to be set in the past, not the future. This strategy may send a signal to investment bankers that the sneak-in-under-the-wire game carries the high investment risk of a substantial future carbon liability, and may thus blunt this "lock-in" concern.

Despite some claims to the contrary, a fee for emissions is *not* an interference in the free market, but in fact the opposite: having a price for a commodity that does not reflect all the costs (like coastal damages from sea level rise and stronger storms) is a violation of market principles: what economists call a "market failure" or "externality." The solution is for governments to act to protect our shared atmospheric commons via policies that impose a fee on polluters covering the full cost of emissions. For such a "shadow price on carbon" to be effective as a motivator to reduce pollution and to invest in cleaner technologies, it must be perceived by both consumers and producers as inexorable, unavoidable by hunkering down and waiting for a few years or sneaking in under the wire. However, some sectors might be especially burdened by a shadow price on carbon, and although I do not personally believe we should hold the sustainability of our life support system hostage to any special interest, at the same time we could sequence these emission fees over time—decades perhaps—and ramp them up at a rate that gives the particularly affected sectors some time to adjust—but not to escape or be grandfathered, as that would likely increase substantially the risks of warming beyond a few more degrees.

The Numbers Game

Finally, it is common for some opposed to climate policies to cite frightening absolute numbers: trillions of dollars of annual costs for climate mitigation policies; or a few percent of GDP lost. But let me report that there is a wide variance across economic models on how much mitigation might cost—and some estimates suggest that it could actually improve the economy at first by promoting the implementation of cost-effective efficiency actions sooner. But even if one accepts some of the seemingly staggering estimates like trillions of dollars of costs, let me add some perspective. Figure 3 shows the results that Christian Azar from Sweden and I (Azar and Schneider, 2002) produced based on conventional economic models that estimate the costs of climate policy. We found that a typical shadow price on carbon (a carbon fee or tax, for example) to prevent the concentrations of CO_2 from more than doubling was around $200 per ton carbon emitted. A fee twice that high could eventually keep concentrations near present values (though an overshoot of concentrations above present in the next half century seems unavoidable—see Schneider and Mastrandrea, 2005). Azar and I used typical economic models estimates of the costs of such policies, although we believe them personally to be too pessimistic. These models estimate between a half a percent and several percent GDP lost annually by century's end.

Let us reframe this for perspective. If the annual costs in the future were indeed a few trillion dollars lost from climate policies, and one compared that to today's level of GDP, it would indeed seem astronomically high—equivalent to a depression—some tens of percent loss of economic production. But that comparison would be totally misleading, if not pernicious. We can't legitimately compare potential *future* costs of climate mitigation policies to the *present* size of the economy. Nearly all mainstream economic analyses typically project GDP growth rates of some 2%

per year—barring pandemics, world wars or other unforeseeable catastrophes we all work so hard to prevent. A few numbers to illustrate this follow.

If the current economy of the world now were about $40 trillion and it grew at 2% per year, then in 100 years it would be about eight times bigger—about $320 trillion annually. So indeed, a 2% loss in 2100 from a century of shadow prices on carbon that reduced most of the climate change risks would be a seemingly very daunting figure: about $6.4 trillion—a major fraction of the economy today. But in 2100, that loss would be made up in only one year by economic growth! In other words, if our economy continues to grow as typically projected, that growth will swamp the costs of mitigation. In this simple demonstration, we would be about 500% per capita richer on average in 2101 with major climate policies to reduce risks versus being 500% per capita richer in 2100 having taken no climate policy action and thus faced with full risks of dangerous climate change. In the language of risk-management, such an investment in mitigation is a cheap insurance policy or hedging strategy to avoid significant threat to our planetary life support system. It is unacceptable to compare future costs to the present scale of the economy. Framing costs in terms of the delay time to be x% richer is much more understandable than frightening, but largely out of perspective, absolute dollar costs.

But just because overall costs of climate mitigation may not be a large number relative to projected growth in the economy, there will still be, as mentioned earlier, individuals and groups with more than average difficulties. Thus, the critical challenge to governance is to both protect the planetary commons for our posterity and the conservation of nature, while at the same time fashioning solutions to deal fairly with those particularly hard hit by both the impacts of climate change (via adaptation programs) or from climate policies (perhaps via job retraining, incentives for relocation of industries, side payments, etc.).

I am often asked if I am optimistic or pessimistic about addressing climate change. In a sentence: I am optimistic that we can affordably and effectively sequence a series of policy steps to deal with climate change via efficiency, learning, adaptation and mitigation, but I am also pessimistic that we will fail to prevent a considerable climate change risk while we debate and delay the implementation of such policies. When I testified on many occasions to this honorable body over the decades, I always was asked and offered the personal opinion that steps to anticipate and reduce risks via climate policies were already called for, as the sooner one starts, the lower the eventual risks and costs. Given that the scientific evidence now is overwhelming that global warming is a reality, that humans are responsible for a considerable chunk of it, and that in the decades ahead we will become the dominant factor in climate change and related impacts, a clear and effective portfolio of policies is now more urgently needed than ever.

I deeply appreciate the opportunity to address this Committee and look forward to seeing the outcome of your efforts in the form of fair and effective actions to reduce the risks of climate change that will certainly grow considerably in the decades ahead if we continue to increase, rather than reverse, our emissions of greenhouse gasses. Thank you very much.

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Stephen H. Schneider, Michael D. Mastrandrea, 2005: "Probabilistic assessment of 'dangerous' climate change and emissions pathways." Proceedings of the National Academy of Sciences, **102**(44), 15728–15735.

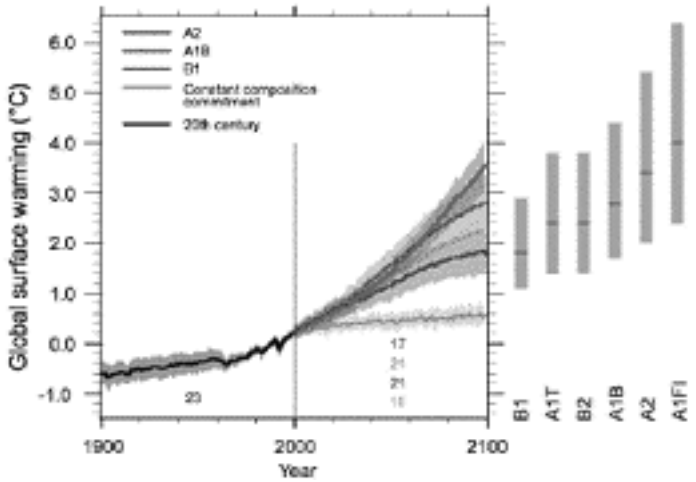


Figure 1. The figure shows clearly how dependent long term warming is on typically assumed emissions scenarios and that there is still a very broad range of projected risks from these standard scenarios—the lowest of which (B1) is still a doubling of atmospheric concentrations of CO_2 above pre-industrial levels and the highest (A1FI) is a tripling of CO_2 by 2100. Only via aggressive mitigation policies can emissions be brought to much lower levels than a doubling. The full range is 1.1 to 6.4°C warming. (Source: Intergovernmental Panel on Climate Change, Working Group 1, Fourth Assessment Report, in press.)

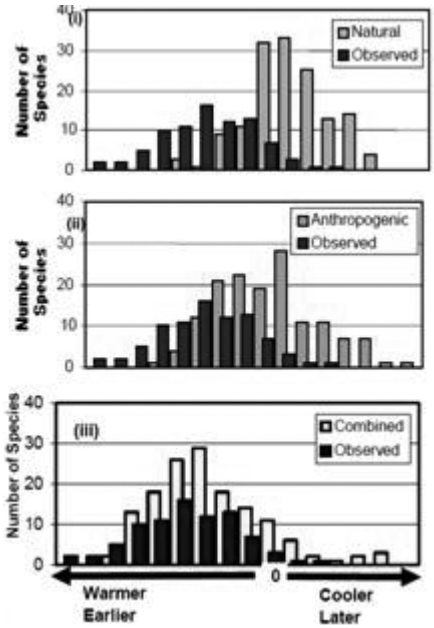


Figure 2. The study of causal connection by separation of natural and anthropogenic forcing factors compares observed temporal changes in animals and plants with changes over the same time periods in observed temperatures (dark blue bars) as well as modeled temperatures using (i) only *natural* climate forcing; (ii) only *anthropogenic* climate forcing and (iii) both forcings *combined*. The locations for the modeled temperatures were individual grid boxes corresponding with given animal and plant study sites and time periods. The agreement (in overlap and shape) between, the observed and modeled plots is weakest with natural forcings, stronger with anthropogenic forcings and strongest with combined forcings. Thus, observed changes in animals and plants are likely responding to both natural and anthropogenic climate forcings, providing a direct cause and effect linkage ("joint attribution") between observed species movements and modeled natural and anthropogenic forcing factors. (Source: Root et al 2005).

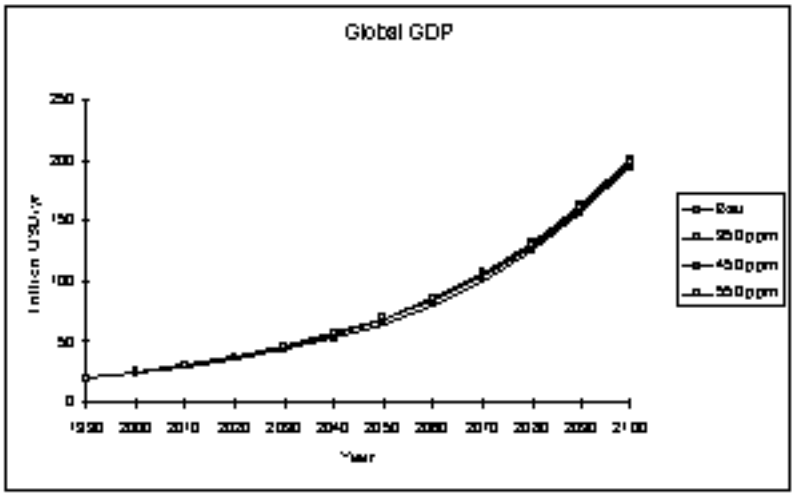


Figure 3. Global income trajectories under business as usual (top curve) and for the case of stabilizing the atmosphere at 350 (bottom curve), 450 and 550 ppm. Note that we have assumed rather pessimistic estimates of the cost of atmospheric stabilization (average costs to the economy assumed here are $200/tC for 550 ppm target, $300/tC for 450 ppm and $400/tC for 350 ppm) and that the environmental benefits (in terms of climate change avoidance and reduction of local air pollution) of meeting various stabilization targets have not been included. (Source: Azar and Schneider, 2002).

Chairman RANGEL. Thank you, doctor.

We will hear next from The Honorable Eileen Claussen, president, Pew Center on Global Climate Change and Strategies for the Global Environment.

She spends her lifetime studying climate change, and we are honored to have you present with us this morning.

STATEMENT OF THE HONORABLE EILEEN CLAUSSEN, PEW CENTER ON GLOBAL CLIMATE CHANGE, ARLINGTON, VIRGINIA

Ms. CLAUSSEN. Thank you, Mr. Chairman and Members of the Committee, for the opportunity to speak about the important issue of global climate change.

As you have heard from Doctors Schneider and Prinn, it is now well-established that climate change is occurring and that humans are primarily responsible.

The recently released summary of the IPCC's Fourth Assessment Report calls the evidence of climate change unequivocal, and expresses over 90 percent confidence that most observed warming is due to human influence.

Left unabated, climate change will have tremendous consequences for our country and the world.

The greenhouse gases emissions that contribute to climate change come from a wide variety of sources and sectors throughout the economy.

These include transportation, electric power generation, use of energy in our homes and offices, and manufacturing.

Just as there is no single sector or emissions source that is responsible for greenhouse gases emissions, there is also no single technology or policy that will solve global warming. We need a portfolio of policies and technologies to meet this challenge.

The Pew Center believes that there are three things we in the United States must do to reduce the real and growing risks posed by global climate change.

First, we must enact and implement a comprehensive national mandatory market-based program to progressively and significantly reduce U.S. greenhouse gases emissions in a manner that contributes to sustained economic growth.

Second, while taking the necessary first step of placing limits on our own emissions, the United States must also work with other countries to establish an international framework that engages all the major greenhouse gas-emitting nations in a fair and effective long-term effort to protect our global climate.

Third, we must strengthen our efforts to develop and deploy climate-friendly technologies and to diffuse those technologies on a global scale.

Only in this way will we achieve our environmental objectives and keep costs to a minimum.

Recently, the Pew Center joined with three other NGOs and ten companies, including BP, Caterpillar, Duke Energy, DuPont, and General Electric in announcing the U.S. Climate Action Partnership, or USCAP.

Together, we are calling for a combination of mandatory approaches, technological incentives, and support for demonstration projects.

The USCAP went into detail as to how we think these goals should be achieved.

Given this Committee's interest and jurisdiction, let me highlight only the recommendations focused on Federal technology research, development, demonstration, and deployment.

Let me reiterate that any solution to this problem will require a portfolio of technologies.

The United States will continue to burn coal and natural gas. We will continue to use nuclear energy. We will need to ramp up our use of renewable energy resources.

Transportation will be a key part of our future, but given our interests in both energy security and climate change, we will need to see far greater use of bio-fuels, advanced diesels, and hybrids in the short term, as well as continuing innovation in fuels and technologies over the longer term, including use of electric of hydrogen-powered vehicles.

The USCAP recommends the following key characteristics of a technology program:

First. A mix of deployment policies to create incentives to use low-greenhouse-gas-emitting technologies and address regulatory of financial barriers.

Such policies could include loan guarantees, investment tax credits, and procurement standards.

For example, tax incentives currently available to a limited number of hybrid electric cars and trucks could be extended to a larger number of qualifying vehicles.

Second. Stable, long-term financing, for example, in the form of a dedicated revenue stream or other means not reliant upon annual congressional appropriations.

Third. Joint public/private cost sector cost sharing and oversight.

The Department of Energy's FutureGen project is an example of a joint public/private initiative, with costs shared between the Government and the companies in the projects's Alliance.

The USCAP believes, however, that we need more demonstration projects to demonstrate the potential for long-term sequestration in a variety of geologic structures.

Fourth. Establishment of performance criteria and a technology roadmap to guide RD&D and deployment program investment decisions.

Finally. Establishment of a public/private institution to govern the administration of the RD&D and deployment program fund.

From our own work on technology policy, the Pew Center has found that Government has not always been good at picking technology winners, so it is best to have programs and incentives that serve to promote a variety of technologies and approaches.

The Committee could also consider incentives for energy efficiency measures in businesses, homes, and vehicles; for capture and sequestration of carbon that would otherwise be emitted from coal-burning power plants; for energy efficient transmission and distribution systems; and for transportation planning measures that reduce miles driven.

I thank the Committee for considering steps to address global climate change and look forward to your questions.

Thank you.

[The prepared statement of Ms. Claussen follows:]

Statement of The Honorable Eileen Claussen, President, Pew Center on Global Climate Change, Arlington, Virginia

Mr. Chairman and Members of the Committee, thank you for the opportunity to speak to the Committee about the important issue of global climate change. My name is Eileen Claussen and I am the President of the Pew Center on Global Climate Change.

The Pew Center on Global Climate Change is a non-profit, non-partisan and independent organization dedicated to providing credible information, straight answers and innovative solutions in the effort to address global climate change. Forty-two major companies participate in the Pew Center's Business Environmental Leadership Council (BELC), making the BELC the largest U.S.-based association of corporations focused on addressing the challenges of climate change. Many different sectors are represented, from high technology to diversified manufacturing; from oil and gas to transportation; from utilities to chemicals. These companies represent $2.5 trillion in market capitalization, employ over 3.3 million people, and work with the Center to educate the public and policy-makers on the risks, challenges and solutions to climate change.

As you have heard from Drs. Schneider and Prinn, it is now well established that climate change is occurring and that humans are primarily responsible. The recently released summary of the IPCC's 4th assessment report calls the evidence of climate warming "unequivocal" and expresses over 90% confidence that most observed warming is due to human influence. Left unabated, climate change will have tremendous consequences on our country and the world.

The greenhouse gas (GHG) emissions that contribute to climate change come from a wide variety of sources and sectors throughout the economy. These include transportation, electric power generation, use of energy in our homes and offices, manufacturing, and many others. Just as there is no single sector or emissions source that is responsible for greenhouse gas emissions, there is also no single technology or policy that will solve global warming. We need a portfolio of policies and technologies to meet this challenge.

The Pew Center believes there are three things we in the United States must do to reduce the real and growing risks posed by global climate change: First, we must enact and implement a comprehensive national mandatory market-based program to progressively and significantly reduce U.S. greenhouse gas emissions in a manner that contributes to sustained economic growth. Second, while taking the necessary first step of placing limits on our own emissions, the United States must also work with other countries to establish an international framework that engages all the major greenhouse gas-emitting nations in a fair and effective long-term effort to protect our global climate. Third, we must strengthen our efforts to develop and deploy climate-friendly technologies and to diffuse those technologies on a global scale. Only in this way will we achieve our environmental objectives and keep costs to a minimum.

Recently, the Pew Center joined with 3 other NGOs and 10 companies, including BP, Caterpillar, Duke Energy, DuPont, and GE in announcing the U.S. Climate Action Partnership (USCAP). Together, we are calling for a combination of mandatory approaches, technological incentives and support for demonstration projects.

We chose emission reduction targets with technology in mind: to allow for capital stock turnover and for the development and deployment of new technologies. In five years, emissions should be between 100 and 105% of today's levels, in other words, no more than 5% above current levels. In ten years, emissions should be 90–100% of today's levels. By 2050, we would like to see emissions cut 60 to 80% from current levels. It is the considered judgment of the U.S. Climate Action Partnership that these cuts are both technologically achievable and economically sound.

The USCAP went into detail as to how we think these goals should be achieved. Given this Committee's interests and jurisdiction, I will highlight only the recommendations focused on federal technology research, development, demonstration, and deployment. But let me reiterate that we will need a portfolio of technologies. The U.S. will continue to burn coal and natural gas; we will continue to use nuclear energy; and we will need to ramp up our use of renewable energy sources. Transportation will also be a key part of our future, but given our interests in both energy security and climate change, we will need to see far greater use of biofuels, advanced diesels and hybrids in the short term, as well as continuing innovation in fuels and technologies over the longer term—including use of electric—or hydrogen-powered vehicles.

The USCAP recommends the following key characteristics of a technology program:

- A mix of deployment policies to create incentives to use low-GHG technologies and address regulatory or financial barriers. Such policies could include loan guarantees, investment tax credits and procurement standards. For example, production tax credits currently available to some categories of renewables could be extended to other zero-GHG electricity sources. Likewise, tax incentives currently available to a limited number of hybrid-electric cars and trucks could be extended to a larger number of qualifying vehicles.
- Stable, long-term financing (for example, in the form of a dedicated revenue stream or other means not reliant upon annual congressional appropriations).
- Joint public/private sector cost-sharing and oversight. The Department of Energy's FutureGen project is an example of a joint public/private initiative, with costs shared between the government and the companies in the project's Alliance. The USCAP believes, however, that we need more demonstration projects to demonstrate the potential for long-term sequestration in a variety of geologic structures.
- Establishment of performance criteria and a technology roadmap to guide RD&D and deployment program investment decisions; and
- Establishment of a public/private institution to govern the administration of the RD&D and deployment program fund.

It is important that incentives be consistent enough to provide the certainty needed for large-scale investment decisions. For example, the short-term nature of the production tax credit for wind power has resulted in a boom and bust cycle in which investments have been strong while the credit is in effect but drop quickly as it expires, hampering consistent growth in this sector.

From our own work on technology policy, the Pew Center has found that government has not always been good at picking technology winners, so it is best to have programs and incentives that serve to promote a variety of technologies and approaches. Projects could be selected via a reverse auction, allowing proposals for reduction projects to compete on a level playing field for funding. An auction could specify technology categories as well as offer a broad competition to elicit new, as-yet-unknown technologies.

The Committee could also consider incentives for energy efficiency measures in businesses, homes, and vehicles; for capture and sequestration of carbon that would otherwise be emitted from coal burning power plants; for energy efficient transmission and distribution systems; and for transportation planning measures that reduce miles driven.

Many of the companies we work with have set voluntary targets and reduced their GHG emissions significantly. The majority have done so by finding efficiency opportunities in their operations and most have had no net cost to implement those reductions. This is not to say that all reductions will be free, or that a regulatory scheme alone would be a sufficient response to climate change. But it does suggest that moving forward with both a push (through technology incentives) and a pull (through a price signal) could allow us to meet a series of emission reduction objectives such as those recommended in the USCAP proposal.

Here are some examples of what companies have been able to achieve.

DuPont used seven percent less total energy in 2004 than it did in 1990, and has lowered its GHG emissions by 70% during that time despite an almost 30 percent increase in production. Compared to a linear increase in energy with production, this achievement has resulted in $2 billion in cumulative energy savings.

From 1990 to 2002, IBM's energy conservation measures resulted in a savings of 12.8 billion kWh of electricity—avoiding approximately 7.8 million tons of CO_2 and saving the company $729 million in reduced energy costs.

The pharmaceutical company Baxter reduced its process-related GHG emissions by 99 percent between 1996 and 2002 by phasing out the use of certain solvents. These process changes resulted in reductions equivalent to over 3 million metric tons of carbon dioxide. Alcoa's aluminum smelters reduced generation of PFC's (powerful greenhouse gases) by 75% from 1990 to 2002.

These leading firms are curbing their contributions to climate change, but their voluntary efforts are not enough to achieve the comprehensive reductions in greenhouse gases needed across the economy. To achieve that goal, we need to enact the measures discussed above.

I thank the Committee for considering steps to address global climate change and look forward to your questions.

Chairman RANGEL. Our next witness will be Dr. David Montgomery, who is the vice president of Environmental Practice.

We are thankful that you've taken time to share your views with us. You may proceed.

STATEMENT OF W. DAVID MONTGOMERY, Ph.D., VICE PRESIDENT, ENVIRONMENTAL PRACTICE, CRA INTERNATIONAL

Dr. MONTGOMERY. Thank you, Mr. Chairman.

I'm honored by your invitation and the opportunity to be here.

Since the starting point of this discussion is climate science, I thought I should outline briefly a bit of my understanding of that subject.

I'm an economist, but anyone who works on climate economics and policy has to have some understanding of the science, and just a few words on mine.

There is clear evidence that the Earth is warming. The amount of warming that's been caused by human activity is open to debate, but there is no question that the human race can play a role in slowing or stopping that trend. Clearly, something should be done.

The questions are, what will the alternatives cost, what will be effective, and where to start.

Two points that were mentioned by Professor Prinn in his written testimony I think shed a great deal of light on these questions.

He stated, and this is my paraphrase, that it does not matter where greenhouse gases originate, they're all mixed in the atmosphere and contribute equally to warming everywhere.

This observation implies that the costs of meeting any climate goal can be reduced by ensuring that emission reductions occur in the countries where they're least costly.

Professor Prinn also mentioned that it's pretty much irrelevant when emission reductions occur.

This observation implies the decision about how much to abate now and how much to abate several decades in the future can be based pretty much exclusively on the relative costs, because either way, we can achieve the same reduction in long-term temperatures.

So, let me return to the three questions of cost, effectiveness, and where to start.

First, cost:

Limits on greenhouse gas emissions will impose a cost on the U.S. economy, and the cost will be larger for tighter targets.

In previous studies of proposals for U.S. emission limits, my colleagues and I have estimated annual losses that range from about three-tenths of a percent of GDP to about 1.9 percent of GDP in 2020, for proposals actively under consideration.

In every case, exactly the same mechanisms are at work:

The need to adopt more costly methods of electricity generation, to invest in producing more expensive low-carbon fuels and to undertake investments to increase energy conservation, divert resources that would otherwise be available to produce the goods and services that make up GDP.

Higher energy costs raise the cost of U.S. manufacturing relative to competitors in countries that do not adopt limits on greenhouse gases emissions and they lead to a flow of jobs and investment out of the United States toward those countries.

Emissions reductions achieved at these costs in the United States or even other industrial countries are also unlikely to make much difference in global temperatures over the next century. There are two fundamental reasons.

First, virtually all projections agree that the vast majority of emissions over the next century will come from developing countries, in particular China and India.

Second, with today's technology, it's simply not economically feasible to achieve emission reductions on the scale required to stabilize global temperatures.

These two points suggest to me that the highest priorities for climate policy have to be developing countries and R&D. Both require immediate action and are immense challenges.

Without involvement of developing countries and a dramatic new commitment to R&D, it strikes me that it will be nearly impossible to reduce emissions sufficiently to manage climate risks effectively.

Halting the growth of emissions from developing countries will not be an easy task.

These countries have consistently opposed any attempts to initiate discussion of limits on their emissions in international negotiations. They fear that such limits would condemn them to continued poverty.

They also gain competitive advantages from having industrial countries go first and take the lead in reducing emissions, but this creates additional resistance on their part to limits on emissions.

Finally, developing countries generally have such poor legal and market institutions that it's pretty clear they couldn't implement efficient policies to reduce emissions, even if they desired to do so right now, without much more deep economic reforms.

Nevertheless, some solution must be found. If developing countries continue on their current course, it would not be possible to stabilize temperatures.

I think it is possible to reconcile their desire for improved living standards with lower emissions, but what it takes at the start is much more rapid and deeper economic reforms to release the market forces that lead to energy efficiency and that set the stage for the kind of market-based policies that can reduce emissions effectively and efficiently.

I think the Asia-Pacific Partnership is a start in this direction.

R&D is also an absolute necessity. Stabilization of greenhouse gas concentrations requires that, at some point, our net emissions fall to zero on a global basis. That is, the rate at which we put emissions into the atmosphere has to be balanced by the rate at which they are removed.

R&D to create new technological options is a necessity if that stabilization goal is to be economically feasible.

One study estimates that to get on a path toward stabilization, within the next 50 years, the world will require twice as much energy from carbon-free sources as the total amount of energy we produce today.

I don't think that could be done at affordable cost with today's technology or with incremental improvements. A massive program of R&D focused on breakthrough discoveries leading to new approaches and technologies is required.

Even mandatory limits on emissions over the next decade or two, I do not believe will provide sufficient or credible incentives for that kind of R&D.

Development and transfer of new technology is also critical to the role of developing countries. If we can reduce the cost of reducing their emissions, transfer technologies that help their economic growth as well as reducing their emissions, we can reduce their resistance to doing something.

What does all this imply for near-term emission limits?

The choice of how much to do today and how much to plan on doing tomorrow to reduce emissions involves balancing the high costs of immediate reductions against the potentially much lower costs of achieving reductions of exactly the same magnitude in the future with new technologies that we can produce through a commitment to R&D today.

One way of striking this balance between what to do today and what to do once new technologies are available is by considering modest financial incentives for reducing greenhouse gases in the near term that are designed to rise at a rate that would be sufficient to provide an incentive for the adoption of new cost-effective technologies once they become available.

Thank you, Mr. Chairman, for your invitation.

[The prepared statement of Dr. Montgomery follows:]

Statement of W. David Montgomery, Ph.D., Vice President, Environmental Practice, CRA International

Mr. Chairman and Members of the Committee:

I am honored by your invitation to appear today, as the Committee addresses issues of climate science and its implications for climate policy. I am Vice President of CRA International, and an economist by profession and training. Much of my work for close to 20 years has dealt with the economics and policy of climate change. It is impossible to do climate economics and policy without some understanding of the state of climate science, and I am particularly honored to sit here because I have known Professor Prinn for most of the time that I have worked on climate policy and I have relied on his writing and presentations as the clearest and most objective account of the state of climate science. Having said that, I should also add that any errors are my own and should not be blamed on him.

Since the starting point of this discussion is climate science, it might be helpful if I begin by stating my understanding of some key aspects of that subject. There is clear evidence that the Earth is warming. The extent to which human activity has had a role in that warming is open to debate, but there is no question that we can play a role in slowing or stopping the trend. But we must do so with a clear understanding of the benefits as well as the costs of various approaches, and what difference specific actions can make in the consequences of climate change.

Key Points

My testimony contains five key points.

- Mandatory U.S. greenhouse gas controls and any version of the Kyoto Protocol will impose a significant cost on the U.S. economy and will lead to a shift of investment away from the U.S. and toward countries like China and India that are not willing to undertake similar efforts.
- By creating these competitive advantages, unilateral policies adopted by industrial countries will actually strengthen the incentives for countries like China and India to resist controls.
- Since China, India and other developing countries will be responsible for the majority of global emissions over the next century, any prospect for halting global warming depends crucially on inducing these countries to cut their emissions.
- Even if all industrial countries met the emission targets set in the Kyoto Protocol, the emission reductions bought at these costs would not be sufficient to prevent most of the temperature increases now projected for the next century.
- Effective R&D is a necessity, in order to develop new technologies that will make it possible to reduce greenhouse gas emissions sufficiently to stop climate change at costs that do not exceed public willingness to pay, here and abroad.
- Minimizing the costs of achieving climate goals requires making sure that the timing of emission reductions matches with the availability of these new technologies.

Summary

Limits on greenhouse gas emissions will impose a cost on the U.S. economy, and the cost will be larger for tighter targets. In previous studies that have looked at a range of proposals for U.S. emission caps set at varying levels, my colleagues and I have estimated annual losses that range from 0.3% to about 1.9% of GDP in 2020. In every case, we see exactly the same mechanisms at work. The need to adopt more costly methods of electricity generation, to invest in producing more expensive, low-carbon fuels and to undertake more intensive energy conservation measures diverts resources that would otherwise be available to produce the goods and services that make up GDP. Higher energy costs raise the costs of U.S. manufacturing relative to competitors in countries that do not adopt limits on greenhouse gas emissions.

Due to these higher energy costs, there will be an even greater shifting of investment from the United States (and other industrial countries) into countries like China and India. Emissions in the United States will fall, especially as our share of energy intensive industries shrinks, but they will grow even faster in China as factories rise there that would otherwise have been built here. Moreover, given the much lower level of energy efficiency in countries like China, the leakage of emissions will be much greater than the leakage of investment.

The relative share of the United States and other industrial countries in global emissions is rapidly shrinking, and over the next century the vast majority of greenhouse gas emissions will come from developing countries. China's emissions are expected to exceed the U.S. in the next year or two and then to move far ahead.

Mandatory limits on emissions in the United States, or even in conjunction with other industrial countries, will not be sufficient to achieve stabilization of greenhouse gas emissions at any reasonable level. Emissions from developing countries are growing too rapidly. Moreover, due to their relative technological backwardness, investments in reducing emissions from developing countries could have a much bigger "bang for the buck" than in the United States.

Adopting mandatory limits will not automatically lead developing countries to follow our lead. Instead, limits on emissions from industrial countries will cause a shift in investment toward those developing countries, so that our emission reductions will be offset by greater increases in emissions outside the United States. Once they build industries based on energy cost advantages, developing countries will be even more unwilling to adopt policies that would threaten those industries.

The implication of these observations is not that the United States should do nothing. It is that gaining the participation of developing countries is probably the highest priority for climate policy, because without that participation it is impossible to prevent large temperature increases.

Immediate funding for R&D is also required. Stabilization of greenhouse gas concentrations requires that at some point we achieve zero net emissions on a global basis—that is, the rate at which emissions are put into the atmosphere must equal the rate at which they are removed. R&D to create new technological options is a necessity if that stabilization goal is to be economically feasible. One study estimates that in order to get on a path toward zero net emissions, within the next 50 years the world will require twice as much energy from carbon free sources as the total amount of energy produced today.[1] That cannot be done at affordable cost with today's technology or with incremental improvements in that technology. A massive program of R&D focused on breakthrough discoveries leading to new approaches and technologies is required. Even mandatory limits on emissions over the next decade or two will not provide a sufficient, credible incentive for that R&D.[2]

Again, the correct implication to draw from this analysis is not that we should do nothing until new technologies somehow become available. An immense effort will be required to develop those technologies, and it must start now. Congress should give high priority to the design and funding of an effective R&D program that relies heavily on the private sector that will have to adopt and use the technologies.

Since climate change is driven by the sum total of emissions over long periods of time, it is possible to greatly reduce the costs of climate policies and achieve greater benefits by adjusting the timing of emission reductions to match with the availability of new technologies that provide emission reductions at lower cost. Thus, incentives for the deployment of cost-effective greenhouse gas-reducing technologies could be provided through a modest financial penalty on emissions that balanced the costs and benefits achieved.

Climate science and climate policy

There are two conclusions from climate science that I think are broadly accepted and that are critical to the comparison of costs and benefits. The first is that warming is caused by concentrations of greenhouse gases in the atmosphere, and that those concentrations build up slowly as greenhouse gases are added to the atmosphere. The time scales involved in this accumulation are long, since net annual emissions are only a small fraction of the total stock of carbon dioxide in the atmosphere.

The second conclusion is that it does not matter where a greenhouse gas is released, it will make the same contribution to concentrations in the atmosphere—and all other climate effects—whether it originates in California, Virginia, Germany or China. This leads to the notion of *where* flexibility, that costs of achieving any climate goal can be substantially reduced by policies that ensure emissions are reduced in the geographic regions where it is least costly to do so.

Another implication that I draw from these robust conclusions is that to a first approximation it is also pretty much irrelevant when emissions enter the atmosphere, since concentrations grow so gradually over time. There is some disagreement on how irrelevant the timing of emissions is to temperature increases, but I think all would agree with some notion of *when* flexibility, that the costs of achiev-

[1] M.I. Hoffert, et al. "Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet" Science, Vol. 298, November 1, 2002, p. 981–7.

[2] W.D. Montgomery and A. Smith, Price, Quantity and Technology Strategies for Climate Change Policy," Chapter 27 in M. Schlesinger, H. Kheshgi, et. al, eds. Human-Induced Climate Change: An Interdisciplinary Assessment, Cambridge University Press, forthcoming 2007.

ing any climate goal can be substantially reduced by choosing the best timing for emission reductions.

The nature of climate processes also implies that the more immediate and irreversible an impact is found to be, the less relevant it is to the decision about what to do. The limited ability of the industrial countries to influence emissions from developing countries, and the slow effect of changes in emissions on greenhouse gas concentrations suggests that changes that can be observed today are likely to be unavoidable. The benefits of action to reduce greenhouse gas emissions take the form of avoided damages. If certain damages cannot be avoided, then they do not play a role in the balancing of the costs and benefits of action. In the language of decision analysis, we call a bad outcome that cannot be avoided a "worry"—something we fret about but cannot change—as opposed to a "risk" that can be managed and reduced through actions still available to us.

With this as background, I would like to discuss the question of what various kinds of policy approaches can achieve in reducing the risks and consequences of climate change, and what they will cost.

What can emission limits on industrial countries accomplish?

The Kyoto Protocol is frequently cited as a standard for effective action on climate change. Unfortunately, even if all the countries that originally signed the Protocol were to meet those targets, the result would fall far short of what is required to stabilize global temperatures. MIT researchers have estimated that the Kyoto Protocol, if all its signatories were to continue forever to keep emission at or below its targets, would produce a reduction of 0.5°C in global average temperatures by 2100 (about a 14% reduction from uncontrolled temperatures).[3] Other mainstream climate scientists have estimated that it would take 30 Kyotos to achieve what they consider acceptable concentrations of greenhouse gases in the atmosphere,[4] and that the targets for the 2008–2012 period would produce a reduction in global average temperatures in 2050 of just 0.07°C.[5]

All these estimates assume that all parties to the Protocol actually meet their targets. It is not just the United States that will have emissions in excess of the Kyoto Protocol target. At this point, Australia, Japan, Canada, and the European Union itself appear likely to fail to reduce emissions sufficiently to meet their targets. The European Union may be able to comply with its obligation, but only if it purchases large quantities of "hot air" from Russia, an action with leads to no net decrease in global emissions.

It is not the lack of U.S. participation that makes the Kyoto Protocol fall short of achieving sufficient reductions in emissions to achieve climate goals. The reason for the ineffectiveness of the Kyoto Protocol—and this would still be the case if the U.S. were to undertake unilaterally a standard equal to or tighter than Kyoto—is that developing countries are not only outside of the agreement but are benefiting from the competitive distortions that it creates.

Any industrial country that sets a mandatory cap on carbon dioxide emissions will have to incur higher energy costs to meet that cap. The tighter the cap, the greater that cost will be. In previous studies that have looked at a range of proposals for U.S. emission caps set at varying levels, we have estimated annual losses that range from 0.3% to about 1.9% of GDP in 2020.[6] For proposals that apply a constant or declining cap, or provide for a rising carbon tax, these costs would increase over time. In every case, we see exactly the same mechanisms at work. The need to adopt more costly methods of electricity generation, to invest in producing more expensive, low-carbon fuels and to undertake more intensive energy conservation measures diverts resources that would otherwise be available to produce the goods and services that make up GDP. Higher energy costs raise the costs of U.S. manufacturing relative to competitors in countries that do not adopt limits on greenhouse gas emissions.

This is the key to the problem of the Kyoto Protocol and any other form of unilateral action by industrial countries to limit their emissions. Due to these higher energy costs, there will be an even greater shifting of investment from the United States (and other industrial countries) into countries like China and India. Emissions in the United States will fall, especially as our share of energy intensive industries shrinks, but they will grow even faster in China as factories rise there that would otherwise have been built here. Moreover, given the much lower level of en-

[3] J. Reilly et. al., "Multi-Gas Assessment of the Kyoto Protocol," Nature 401: 549–555 (1999).
[4] D. Malakoff, Science 278, 2048 (1997).
[5] T.M.L. Wigley, Geophys. Res. Lett. 25, 2285–2288 (1998).
[6] Prepared statement of Dr. Anne E. Smith before the Committee on Energy and Natural Resources, United States Senate, Washington, DC September 20, 2005.

ergy efficiency in countries like China, the leakage of emissions will be much greater than the leakage of investment.

Finally, the competitive advantage that China and India would gain from unilateral emission limits in the United States makes those countries even less likely to agree to future limits on emissions. Once they build industries that depend on a difference in energy cost to succeed, developing countries will be even more unwilling to undertake policies that threaten those activities.[7] Thus far from providing a moral example that will bring countries like China into an international agreement, naïve unilateral action will create economic disincentives for those countries to limit their emissions.

This is particularly important because developing countries will replace the industrial world as the largest source of greenhouse gas emissions over the next century. These countries are expected to continue rapid population and economic growth which, combined with essentially wasteful energy use, leads ultimately to emission far surpassing our own. China is a good example. Its rate of economic growth has exceeded 8% per year for the past decade, and every added dollar's worth of output in China increases greenhouse gas emissions by double the amount associated with a dollar's worth of output in the United States. Energy-related technology used in most of China still lags far behind the United States.[8] Thus China's greenhouse gas emissions are expected to exceed ours within the next year or two, and to keep on increasing from there. India is a similar story, though at this time a smaller economy.

Promoting cost-effective emission reductions in developing countries

The remedies are not easy to find, but it is clear they are not being provided by the Kyoto Protocol or its Clean Development Mechanism. China, again, is claiming most of the money going into the CDM, by building factories that produce exotic greenhouse gases and then earning CDM credits for destroying those same gases. All of the major developing countries have expressed their opposition to any form of mandatory cap on their carbon dioxide emissions, because of valid concerns that in their current state of institutional development such caps would interfere with their industrial growth.

Paradoxically, there are in fact immense opportunities for reducing emission in these countries in ways that would improve their prospects for economic growth—if the governments of China and India can muster the political strength and will to end market distorting policies even though these policies may have the support of important constituencies.[9] If they are able to meet this challenge, a dollar spent in developing countries could be expected to create much larger emission reductions than the same dollar spent in the United States or any industrial country. These opportunities exist because of the outmoded technology used in China and other developing countries, and the lack of market institutions to create effective incentives for efficient energy use. Thus large emission reductions can be achieved in developing countries through introduction of technologies that are now the standard in industrial countries, and at the same time improve their productivity and prospects for economic growth. The situation is exactly the opposite in the United States, where our generally efficient markets and advanced technology means that we must incur substantial additional costs to reduce emissions.

Finding approaches to engaging these developing countries is therefore critical to managing climate risks, and these approaches must directly address technology transfer and institutional reform. Although the Kyoto Protocol offers little hope of doing so, the Asia Pacific Partnership has had a promising beginning along these lines but it requires more adequate funding and greater emphasis on institutional reform if it is to achieve its potential.

R&D to make reduction of climate risks feasible

One of the clear implications of climate science is that stabilization of atmospheric concentrations of greenhouse gases will require the world (not just the U.S.) to reduce greenhouse gas emissions intensity to near-zero levels. Halting climate change is possible only if large-scale greenhouse gas emission reductions can be implemented at costs that are both politically and economically acceptable. The magnitude of possible reductions in the next decade or two achievable with today's tech-

[7] H.D. Jacoby, R. Prinn et. al., Kyoto's Unfinished Business, Foreign Affairs Vol. 7, No. 4.

[8] P. Bernstein, W.D. Montgomery and S. Tuladhar, "Potential for Reducing Carbon Emissions from Non-Annex B Countries through Changes in Technology," Energy Economics, 2006.

[9] W.D. Montgomery and S.D. Tuladhar, "The Asia Pacific Partnership: Its Role in Promoting a Positive Climate for Investment, Economic Growth and Greenhouse Gas Reductions." International Council for Capital Formation, June 2006.

nology is dwarfed by the magnitude of reductions that are required and that successful innovation would supply.

Hoffert *et al.*[10] identify an entire portfolio of technologies requiring intensive R&D, suggesting that the solution will lie in achieving advances in many categories of research. They conclude that developing a sufficient supply of technologies to enable near-zero carbon intensity on a global scale will require basic science and fundamental breakthroughs in multiple disciplines. This kind of R&D effort appears to be the only way to hope to achieve meaningful reduction of climate change risks. Emission limits that do not simultaneously incorporate specific provisions that directly support a substantially enhanced focus on energy technology R&D will not effectively reduce climate risks.

Development and transfer of new technology is also critical to preventing increases in emissions from developing countries. Although there are large present opportunities to reduce emissions in China and India through application of technologies that do not require either R&D or emission limits to be economic in industrial countries, preventing future growth in their emissions requires new, low cost technologies suited to their use.

Designing such an R&D program is a huge challenge for Congress, because it takes not a single vote but a sustained commitment over many Congresses to provide stable, growing funding for R&D aimed at breakthrough technologies for zero carbon energy. That requires a consistent commitment to funding, design of effective incentives to motivate private sector investment in R&D, tolerance of the failures that inevitably come with serious research, and most of all, avoiding the temptation to fritter the money away on large scale demonstrations of current technology that may provide jobs for a members' districts but contribute little or nothing to providing the radically different technologies that will be required to stabilize global temperatures.

The notion of when flexibility is closely connected to R&D policy. It suggests that it is possible to reduce the costs of climate policies and achieve greater benefits by adjusting the timing of emission reductions to match with the availability of new technologies that provide emission reductions at lower cost. The choice of how much to do today and how much to plan on doing tomorrow to reduce emissions involves balancing high costs of reducing emissions with today's technology against the potentially much lower costs of achieving reductions of the same magnitude in the future. One way of striking this balance is to consider modest financial incentives for reducing greenhouse gas emissions in the near term, designed to rise over time at a rate that would be sufficient to provide an incentive for the adoption of new, cost-effective technologies as they become available.

Chairman RANGEL. Let me thank this entire panel.

You have not made experts out of us, but you've certainly made us aware that we have to join in with our colleagues in Government and the private sector to arrest this climate change that is so dangerous to humankind.

I assume in your studies, when you refer to tax incentives, that that has not really been a part of your studies, that you just know that we would have to somehow provide ways for people to use alternative fuels.

Have any of you come across any readings that you might suggest to us, since our primary responsibility will not be to determine the alternative, but to provide the tax assistance to encourage people to use it? Have you done any studies or had discussions in that area?

Dr. Prinn.

Dr. PRINN. I'm a climate scientist, primarily, but I do co-direct a program at MIT that includes a significant economics component.

There is a lot of debate among economists about the relative roles of a simple tax to send a price signal through the system to

[10] M.I. Hoffert *et al.*, p. 981.

lower emissions, to providing tax incentives for the development of alternative energies, all the way to cap and trade ideas where you put a limit on the emissions and have permits that would be traded.

From my view, just as somebody watching from the side, that debate continues among the relevant community of academics, at least, as to which of these ways, or what combination of them, will work best.

So, I personally can't give you some very highly focused advice, particularly on the value of tax incentives relative to these other possibilities.

Chairman RANGEL. Thank you.

Dr. SCHNEIDER. Yes. Thank you, Mr. Chairman.

I, too, am a climate scientist, but have for the last 15 years been working very closely with economists and we've written a number of joint papers on just exactly these questions.

I guess I could characterize the bulk of the comments I hear from my economics colleagues as they generally tend to have preferences for carbon taxes to other factors on the grounds of simplicity and reduced transaction costs, but those are still debated within the community.

Nearly all of them would agree with David Montgomery's statement that you have to look both across time and in other places for the lowest-cost option.

In my own personal work, one of the things that we did is we tried to take a look at how using, in the context of a very simple economic model, how a range of carbon taxes imposed in this model would affect emissions and then how that affects the probability of dangerous climate outcomes. Well, you have to define that according to how many degrees of warming there is.

There is absolutely no question that if we don't have some price on carbon, that you end up with a much higher probability of being in the upper range of risk and if you do have controls on carbon, then you substantially lower that likelihood.

It's just like Ron Prinn's wheel. Without some form of policy incentive, whether it's cap and trade or taxes, that's important.

One final remark that I have heard in these debates, and not just from economists, more likely from political scientists or sociologists or people in the political world, is that whatever the policies that we implement, they will have impacts differentially on different groups.

We know that it was not the richest people who were harmed in Katrina in the aftermath of the floods, just as we know it was not the younger people, but the elderly, that were hurt in Europe in the heat wave of 2003, and we also know that there's a differential impact on people according to each policy.

So, not only do we have to look to reducing the overall magnitude of our footprint on the Earth through a variety of possible policies that you will examine, but we also have to take a look at the distribution of either the impacts of climate or the impacts of policy on special groups and see what side payments we may need to do to get them to participate more willingly.

Chairman RANGEL. Thank you.

Ms. Claussen.

Ms. CLAUSSEN. Let me try to explain a little bit about the Pew Center.

We work very closely with 42 major corporations, and they cover a wide range of sectors.

We have utilities that are primarily gas-fired. We have utilities that are primarily coal-burning. We have forest products, chemicals, a lot of energy-intensive industries.

As a group, both based on the analytical work we've done and from their own analyses, I think there is a clear preference for a cap and trade system rather than a tax, carbon tax.

There are a number of reasons for that, the most important being that in the cap and trade system, it is the market that sets the price, whereas in a tax system, it is the Government that sets the price, and it is not clear exactly what the right price should be to draw new technologies into the market.

So, as a group, they much prefer a cap and trade.

The second reason they prefer a cap and trade system is because there are cap and trade systems in Europe, and they extend into parts of the developing world, and the larger the market, the cheaper it is to find inexpensive reductions.

So, were we to go one route and the rest of the world to go another route, I think we would not realize the kinds of cost savings that we might if we all did the same kind of thing.

So, there is clear preference for a cap and trade.

That said, we also agree as a group that you not only need rules that set limits, and you can be modest in how you start and become more stringent as time goes on, but that you also need tax incentives and carrots to help get the technology developed and into the marketplace.

Neither one of these by themselves will do what we need to get done, but the combination is probably where we need to go.

Chairman RANGEL. Thank you.

Dr. Montgomery.

Dr. MONTGOMERY. Thank you.

There are, I think, three points I'd like to make on this.

The first one is on the use of prices, like carbon taxes, versus quantity caps. Prices and taxes are market based instruments just like cap and trade, but a carbon tax for example has much lower cost risks than a mandatory cap.

Although Ms. Claussen and I work with many of the same businesses, I find that there are some very strong economic arguments for considering the price approach rather than the mandatory cap approach.

We have done some studies, where we have looked at various uncertainties that would affect the price of carbon and the cost of meeting an emission cap.

We can never be sure what's going to happen, for example, to electricity demand over the next few years. It's driven by all sorts of things we don't know—economic growth, temperatures. Therefore, we don't know what the cost of meeting mandatory caps will be.

What we find is that, with a rigid cap on emissions, you can have very large volatility in the price of emission allowances, which then reflects itself in potentially destabilizing influences on the economy.

That can be avoided by a price approach or by hybrid policies, such as a safety valve which limits how high the price of an allowance can go under a cap and trade system, all of which can be very important to reducing overall costs.

The second point, in which I agree with Ms. Claussen, is that the analysis that we've done in looking at the effect of long-term emission caps or announcements of future carbon prices suggests that they will not provide an effective or a credible incentive for R&D today.

Therefore, we really need to think about how to put in place current incentives and programs to provide encouragement for the kinds of long-term R&D that are necessary to give us new technology. We're not going to see that without active money put into it today.

Chairman RANGEL. Thank you so much.

Mr. McCrery.

Mr. MCCRERY. Thank you, Mr. Chairman.

I want to thank the panel. You've provided some excellent testimony today, not all of which is in the jurisdiction of this Committee, but certainly you contribute to our broader understanding of the problem and how we might fit into the solution.

Dr. Montgomery in his testimony brings up some very important questions, and I think his testimony is most relevant, frankly, to the operations of this Committee.

I think most of us are convinced that the scientific evidence presented by the three scientists on the panel, or the two scientists and the Pew Foundation, which I'm sure has scientists on board, is accurate, and we don't quarrel with that.

The question, though, for this Committee is, how do we use tax policy to help with the human effort to allay this, or delay or overcome potentially this dangerous increase in the Earth's temperatures?

Dr. Montgomery talks about how, if we impose some solutions, either from a tax standpoint or from a general cost standpoint, we shift competitive advantages from the United States to other nations, and this is something that another of your Boston colleagues, Michael Porter, has written about the advantages of nations and how those create jobs or opportunities for job creation, economic growth.

We certainly don't want to do anything, I think, that unduly shifts those competitive advantages to other nations that would have an impact, a negative impact on our economic growth and job creation here in this country.

So, the question, I guess, that we have to ask ourselves is, how far can we go in terms of implementing policies here in this country without some kind of comfort level that other nations are going to participate in this effort to bring down global warming?

It's kind of a chicken-and-egg thing, I guess. How to get to agreement unless we agree?

Certainly, I'm concerned about the United States moving forward with punitive measures such as that suggested by the U.N. yesterday, which calls for a carbon tax here in the United States of something in excess of $50 per ton, and I question whether we should go unilaterally in that direction.

Dr. Montgomery also offers, I think, some direction for us, supported by Ms. Claussen, in terms of encouraging the development of new technologies that could help us deal with the problems associated with the increasing use of carbon fuels in our society and around the world.

In fact, I'm optimistic that if we appropriately develop those technologies, that could actually become an economic bonus for us, but we've got to figure out how we do that without micromanaging that development here from the Federal Government, because we don't have a very good track record of industrial policy from here in Washington.

So, I'm encouraged by the testimony that you've given us today. I hope you will help us sort through these questions and develop with us some approaches that provide the greatest opportunity for both addressing the global climate change challenge and not diminishing and perhaps even increasing economic growth here at home. That's the challenge they we face.

So, thank you all very much, and we look forward to working with you as we move forward in this.

Thank you, Mr. Chairman.

Chairman RANGEL. Thank you.

Mr. Levin, you may inquire.

Mr. LEVIN. Thank you, Mr. Chairman.

Welcome to the panel.

Let me ask you a question that I think a lot of us have been pondering for some time.

Mr. McCrery mentions that there is increasing consensus that there is climate change, global warming.

I want to ask you this, because it relates to the issue of urgency which relates to what we do.

Why do you think there's been such disagreement? What has caused it?

In the work with other people, all of you have done so broadly, in addition to perhaps views of science, there seems to be something at work.

Why has there been such a process of denial for so long? What's been at work here, do you think?

Dr. SCHNEIDER. Well, I'll be happy to try a stab at that.

Mr. LEVIN. Be as blunt as you can.

Dr. SCHNEIDER. That's not usually a problem for me.

Back in the 1970s, as I referred to in the oral remarks, it was very easy to have debate.

We were just sorting out the cooling effect of dust and smoke from the warming effect of greenhouse gases, and it took a lot of studying.

By the mid to late 1970s, the warming became the clear winner.

We were uncertain about the effects of clouds. If you increase heating, you evaporate more water, you make more clouds. That could cool the Earth back down. It's what we call a stabilizing feedback.

On the other hand, if you make the clouds taller, they trap more heat, they make it worse.

That's part of the reason why we've had that uncertainty.

So, there's been a lot of those kinds of arguments, and naturally, scientists enjoy looking at the cutting edge, trying to make their reputations by finding a new way to see it.

However, over the last 30 years, the preponderance of evidence has become virtually overwhelming that the warming is real, that at least the last several decades of it are preponderantly due to us, and that there will be substantial change in the future, though as I showed you it still has a wide range of uncertainty built in.

Mr. LEVIN. Let me ask you, the one issue, though.

Why has there been the lineup there has been as to whether there is or there isn't? What's been motivating, what have been motivating forces beyond?

Dr. SCHNEIDER. Clearly there are interests in the world, and those interests or ideologies have very different perspectives on their personal worldviews about whether it's more important to protect the planetary commons, to deal in long-term risks, or to protect nature, or whether it's more important to maintain market share for selected clients or protect entrepreneurial rights.

So, what's happened is that the climate problem has also partly gotten mixed up with ideological politics to where somebody from the deep ecology groups grabs out of context the worst case, the end of the world case, and somebody from an enterprise institute grabs out of context, oh, it's good for you, so you get end of the world and good for you extremes, the two lowest probability outcomes, getting big play, and the media then proceeds with that, when in fact the vast bulk of the knowledgeable community believes them to be low probability and everything else in the middle is of more concern.

I guess that's not a foreign concept in this town, as well, that we have that tendency to polarize.

Scientists find it very distasteful, frankly, getting engaged in that.

We like to fight with each other over the nuance of the details of the theory or the data rather than link it to ideology, but unfortunately, when you're in a science which has a lot of public involvement and has stakeholders with very opposite views, it's never surprising that you get some conflict and some selective inattention to inconvenient information——

Mr. LEVIN. Okay. Anybody else?

Yes, Dr. Prinn. The yellow light is on.

Dr. PRINN. I think the root of the debate, if you like, or at least the legitimate debate, is the obvious uncertainty in simulating and forecasting climate.

You can look at that wheel that I showed and you can look at a little sliver there that shows almost no warming with no policy, and you'd say, if you're comfortable with that, then you can argue from that little sliver that it's not an issue.

You can argue from the other side of the wheel, where it says that there's some probability of even much greater than 5 or 6 or 7 degrees Centigrade or almost double that in Fahrenheit, and you can make a case that we are facing the greatest threat to human——

Mr. LEVIN. Why do some people say one thing and some people say another? Why do people line up on the two camps or the two attitudes?

Dr. PRINN. I think there's been a difficulty for some scientists to decide to look at this as an issue of just working out the odds.

It happens to be that Steve Schneider and I agree very strongly in the need to embrace the uncertainty and to see this as a decision-making process, if you like, under that uncertainty.

The uncertainty is such that it's a double-edged sword. You can look at it and say, on one side, the possibility that there may be very little warming, arguing for inaction, then on the other side, lots of warming, arguing for action.

I think the truth lies largely in the middle, and that's the point that I tried to make in my presentation here, and I think also Dr. Schneider is making the same point.

I personally have evolved in my own views.

I mentioned that 10 years ago I was not convinced that the human signal had arisen out of the noise with the observations available to that point, and the techniques available. Now my conclusion has changed.

Scientists do change. We change our minds based on more evidence.

I think that process is going on, it looks like a glacial pace to some, but slowly but surely, the opposition to the notion that humans are making a very significant impact on climate, and particularly in the future are likely to make a very dangerous impact unless we do something, is now a debate that many think, or consider to be, largely complete.

Mr. LEVIN. Thank you. The red light is on.

Chairman RANGEL. Mr. Herger.

Mr. HERGER. Thank you very much.

I can understand why people would be concerned, and that people might change.

Dr. Prinn, you just mentioned that your opinion changed in the last 10 years.

Archaeologists tell us we went from a, over a long period of time, over millions of years, from a dinosaur stage where it was very warm, to an ice age, back to where we are now, and I remember just 30 years ago scientists, some of you, were telling us it was cooling. Remember? We weren't going through a warming, it would cool. This is just in 30 years.

I think if you look, as I, in at what limited information I have, you look over a period of hundreds of years, you actually have several hundred year periods where it will be colder, then it will be warmer, and really, to really understand what's going on, you really need to take several thousand years to really look at it.

That's not really the focus of my question.

Ms. Claussen, I would like to ask you, if I could, you suggest that the United States must take the lead in addressing climate change by unilaterally imposing a mandatory emission reduction program in the United States after taking this initial step, you suggested we should then work with other countries in encouraging them to reduce their emissions.

This view is contrary to Mr. Montgomery's testimony where he argued that unilateral action by the United States actually increases the incentives for China and India to resist controls.

In addition, the Financial Times reported just yesterday that, quote: "China's surge of investment in heavy industry and power capacity since 2000 has seen energy efficiency levels retreat and pollution measurements soar. China added power capacity last year equal to the entire grids of the U.K. and Thailand combined, 90 percent of it coal-fired.

To feed its growing stack of steel, aluminum, and cement plants and the like, China is home to 16 of the world's 20 most polluted cities." Close quote.

Ms. Claussen, based on this recent history, what is the basis for your belief that if the United States acts unilaterally, countries such as China and India will follow?

Ms. CLAUSSEN. Let me try to answer that by putting it in a little bit of context.

There are 20 countries who account for about 85 percent of the world's greenhouse gas emissions, and if we're going to find a real solution to deal with this problem, at least those 20 have to be engaged. That's point number one.

The second point is that there are other countries who have actually taken steps to reduce their emissions. Most of them are in Europe, and they do not include the large developing countries, as you point out.

We have been absent from the global table to try to talk about what the framework should be over the past eight or more years, and I think that's a problem.

I do not think that we have sufficient credibility to design a framework that would include those 20 major emitters unless we at least take some steps on our own.

Don't forget, we are still the world's largest emitter. We are still responsible for most of the concentrations of greenhouse gases that are in the atmosphere.

Mr. HERGER. That's changing, is that not, and just within a few years, China would grow to be number one?

Ms. CLAUSSEN. Well, they'll be number one in current emissions, but looking historically at it——

Mr. HERGER. Even a few years after that, at the rate they're going, they will become number one.

Ms. CLAUSSEN. I'm not arguing with you that China's emissions aren't really important here. I'm just saying that I think we have a responsibility to take some actions.

Now, I do not agree with the assumption that——

Mr. HERGER. Should it be unilateral, as you pointed out——

Ms. CLAUSSEN. I do not agree with the assumption that if we take some action, we are necessarily going to cause great economic harm to the United States, and I would like to just suggest that the Committee take a look at some of the actions that major companies have taken to reduce their emissions.

There are 20 or 30 big corporations that have set targets for themselves, on a voluntary basis, and that have reduced significant amounts of emissions, much more than the kinds of levels that are being talked about either in the House or in the Senate at the

present time, and not one of them has found that to result in a cost.

Most of those reductions have taken place because of efficiency improvements. Most of those have actually been beneficial to the bottom line.

So, taking some steps here, I believe, will give us the credibility to work with the big emitters in the developing world, because you need them, you can't solve it without them, and to try to design a framework that moves everyone in the right direction.

I think without some leadership from us, it won't happen, and without some action in the United States, we will not have the ability to lead.

Mr. HERGER. Well, I agree with what you've just—your last comment, but I think it comes down to common sense, it comes down to not bankrupting our economy by unilaterally going out, when we look at what the rest of the world is doing, and doing things that do make sense, and when we do that, I think it's a win-win, but not if we do it the other way.

Thank you, Mr. Chairman.

Chairman RANGEL. Mr. McDermott.

Mr. MCDERMOTT. Thank you, Mr. Chairman.

It's always amazing, when we have a panel that all agree that something needs to be done.

What we're really talking about here is the rate at which we're going to move.

Mr. Herger just used the word "bankrupt" which I think is not helpful in the discussion when we get out on those ends.

The question that I want to ask, and I'd like to reframe what Mr. McCrery said. He talked about the problems if we led and all this, and what it would do to our economy.

I would like to talk to you or hear from you about what happens if we do not lead in this world change. Let me give you the example.

It's a tiny one. It's really a minor one, but it's instructive, I think.

We had wind incentives here in this Congress which were allowed to expire, and now if you go and look at wind generators across the face of the Earth, almost all of them are made in Denmark, a country of six or eight or nine, ten million, I'm not sure exactly, population.

They took the lead and ran with it, and left us in the dust.

My feeling is that there is a cost to not taking hold of this. Since we all agree across the panel that something must be done, really, there is going to be a cost.

I'd like to hear you talk about the other areas in which we are behind the rest of the world in terms of our moving, whether it's solar paneling in Germany or whether it's the—well, there are many places that some of us are aware of.

I'd like to hear you talk about it in terms of the places where we, our industry is losing jobs and losing opportunities because we have not taken the incentive and used the Government.

I happen to think that the answer to Mr. Levin's question about why change was never made was because people were afraid, and our industrial concerns that if we admitted there was a need for

reaction to climate change, the Government would get involved, and they didn't want to disrupt the laissez faire system. Clearly, we're beyond that.

I'd like to hear you talk about what directions we ought to be going in, and who is ahead of us now.

Any one of the three of you.

Or Mr. Montgomery, Dr. Montgomery.

Dr. MONTGOMERY. Thank you.

Let me start with a thought, which is that what I am really concerned about the United States being behind is something the rest of the world is equally far behind, which is the scale of investment that's required in R&D at a fundamental stage to create the kind of breakthroughs that are needed to give us, 20 or 30 years from now, technologies that we can't conceive of today, but which are absolutely necessary if we're going to get on a path to really managing the dangers of global warming.

Providing subsidies for wind power in the near term——

Mr. MCDERMOTT. Don't get hung up on wind power, because that's really a minor issue. There are much larger issues than that. I only used it as an illustrative indicator of what we've done before.

Dr. MONTGOMERY. No, no. I understand, and I agree with you.

I think that there's a difference between providing subsidies for low-carbon technologies available now, which is really just buying current emission reductions, versus providing incentives for R&D which set the stage for much larger emission reductions in the future, which can take off on their own.

That's where I think we're far behind. I don't think we're losing much if we do not subsidize current technologies. Putting a price on carbon can bring current technologies into the market and bring about reductions in emissions, but the real investment for the future is in the R&D side.

Mr. MCDERMOTT. The rest of the panel?

Ms. CLAUSSEN. Let me try to make a couple of points.

If we look at where the greenhouse gases emissions come from, they come from electricity and transportation. That together is about 70 percent of the problem.

Mr. MCDERMOTT. Right.

Ms. CLAUSSEN. We aren't going to find a technological solution unless we tackle those two big things, because when you look at something like manufacturing, and if there is a price on carbon, you're going to get efficiency improvements and process changes, and I think those industries are going to go ahead and do that.

So, the big issues we really have to deal with are electricity and transportation.

On electricity, I do not think there is a single solution. I think we are going to use nuclear, I think we are going to go into more renewables, I think we are going to burn coal.

Actually, coal is the thing that concerns me the most, and because we have vast reserves of coal, China and India have vast reserves of coal, they are industrializing, they are all going to burn coal.

So, the real question is, how do you find a way to burn coal that doesn't harm the climate, and what does it take to get you there?

There are some technologies being developed that are going to make it easier to capture the carbon stream. We have done very, very little work on exactly how to do it from the range of technologies, and even less on how you might sequester that carbon stream and keep it in deep geologic formations for a long, long period of time.

So, I would say if we were going to concentrate on anything, it would be both demonstrating those technologies in a major scale, not just one demonstration here that will give you some results in 15 years, but a lot of demonstrations that could both prove that it works, assuming we can make it happen, and bring down the cost, because the cost now is actually very, very high, and then dealing with transportation.

Again, I think there are lots of things to do there. I wouldn't put all my money on one particular technology there.

It may be that hydrogen fuel cells will be the answer to this, but I'm not convinced.

I think we need to make sure that there's some competition and that money goes into a variety of these technologies so you can actually get the beset one to deal with the problem.

Now, when you look at other countries, a lot of them are starting to move along those same lines. I think if we were to do this in a vigorous way, put in a certain amount of money, create the incentives, get a price on carbon, we could really do the job that needs to be done here and get our industries to be the most successful at it.

If we just wait, others will find the space out there, and they'll do it before we do it.

Chairman RANGEL. Mr. Camp.

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

I appreciated just the remarks you made, because I do think we need to go beyond just implementing Kyoto, which is often what we get to when we talk about global warming or climate change, now, I guess to take into account that we had a hearing canceled because of the ice storm, on global warming, in Congress.

I think that there is an economic cost to Kyoto, and the geophysical research letters published about 10 years ago estimated that if every nation on Earth lived up to the U.N.'s protocol on global warming, it would prevent no more than a 10th of a degree of warming, Fahrenheit, every 50 years.

So, if we really want to alter the warming trend significantly, would we have to cut emissions by larger amounts than called for by Kyoto, and if so, do we have the technology to be able to do that, to reduce greenhouse gas emissions?

I guess Dr. Prinn, do we have the technology to go beyond that?

Dr. PRINN. Well, I'm optimistic that we do.

The issue of coal in the United States was brought up by Eileen Claussen, and I think there is a major challenge for the Nation regarding coal-fired power plant. Going into the future, the way in which those can work and also keep emissions down to essentially being non-existent, is to look very carefully at carbon capture and sequestration to be accompanied by the burning of the coal.

I personally think that one way or another, significant effort has to be put in to see if this is economically feasible?

I think it's technologically feasible, but is it geologically feasible with the capacity of these reservoirs, to go down about seven, eight miles deep in some places. Can they take all of this carbon dioxide, and keep it there? A small leakage is all right, but if the answer to that is yes, and if the economics works out, and the technology, as I say, I think is largely there, then coal can continue to be an important source of electrical energy for the Nation.

The utilities right now are faced with a dilemma. They need to perhaps build a few more power plants. What are they going to do? Are they going to continue to build conventional coal-fired power plants that may be, with great difficulty and cost, converted to carbon capture, or not at all, or do they look at nuclear power, do they begin to think that renewables, bio-fuels will power utilities into the future?

They, I think, have got great difficulties in front of them, and the more that there's some leadership on this issue for the Nation, to say this is where we're going, we're going to reduce emissions, it will help utilities make those very, very expensive decisions——

Mr. CAMP. Well, and there has been a lot done, particularly in the auto industry.

The automakers have, a majority of them have already committed to achieving at least a 10 percent reduction in greenhouse gases by 2012, and that's from a baseline of 2002.

We had some testimony about the 1970s, and I will just say that vehicles today are 99 percent cleaner than they were in the 1970s, and that's just one particular industry.

Looking at another industry, in the refrigeration industry, for example, home appliances, they're much more efficient than they were just a few short years ago.

However, I do think the economic cost of Kyoto is something we should look at. The estimates show it could cost 2.4 million U.S. jobs, double the cost of electricity, raise the cost of gasoline by an additional 65 cents a gallon, reduce the U.S. output by 300 billion, which is greater than the total expenditure in primary and secondary education.

So, I do think we have to look at the costs and tradeoffs, and my question would be, is the cap and trade program a viable program to reduce emissions?

I guess I would just ask each of you quickly to answer. I know I don't have much time left.

Dr. PRINN. Potentially, yes. I realize the debate I think is going to be between taxes versus cap and trade.

Dr. SCHNEIDER. The short answer is yes, but like anything that complicated, the devil is in the details and how it's structured, from the point of view of incentives, or fairness, it will matter both politically and from the efficiency point of view.

Mr. CAMP. All right.

Ms. Claussen.

Ms. CLAUSSEN. Yes, widely supported by those in the industry who would like to see us take on some kind of requirement here.

Mr. CAMP. Dr. Montgomery?

Dr. MONTGOMERY. No, if the purpose is developing the new technologies and bringing down radically the costs of technologies like carbon capture and sequestration.

A cap and trade system can get the technologies we have available off the table and into use, but it can't get the new technologies onto the table that we're going to need in the future.

Mr. CAMP. All right. I do agree with my colleague that we need to take a longer view of the warming issue.

I want to thank the Chairman for his time. Thank you.

Chairman RANGEL. Mr. Neal?

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

In my former life, I was much involved, as you know, with issues that are pretty mundane, in the level of local Government, like taking the pressure off the landfill, so we constructed at the time, in Springfield, Massachusetts, the largest regional recycling facility in America—103 communities participated. As part of an integrated approach, we did waste to energy. It shortly worked.

Now we're sitting back, and we're looking at what's next and what's new.

For you, Dr. Prinn, I'd like to ask, it's difficult, even based upon the hearing that we've had this morning, as we look at alternative energy, it's hard to gauge what the next great breakthrough is going to be in terms of innovation. Isn't that true?

Dr. PRINN. I certainly agree.

I think that most of us believe that we're going to have to have about 10 or 20 solutions, that there's not going to be a single one. Depending on the part of the country or, indeed, the Nation, the various nations around the world, they will choose among these 10 or 20 options, so there isn't a single one.

Ones where I think some breakthroughs would be very nice to see is on the renewable side, on the issue of bio-fuels, an efficient way in which you can take cellulose and convert it into the chemicals necessary to produce alcohol for fuel.

In principle, it can be done, but breakthroughs are needed to produce alcohol as a bio-fuel.

There are limits to bio-fuels, because it is going to take land that we presently use for growing food, and there will be a competition.

So, it has to be looked at, and said, will it work at the very large scale?

Certainly for bio-fuels, cellulosic alcohol, as it's called, it's something where we would like to see a breakthrough.

I would also say for solar energy, that increasing the efficiency of the solar panels will make a very, very big difference, and lowering, of course, their cost.

Mr. NEAL. With the exception of the Clinton health care plan, the most strident debate that I've participated in during this Committee's—my time on this Committee was the debate between ethanol and oil.

I don't have to tell you, it brought out the worst in some of the Members of the Committee.

We have moved beyond that, haven't we? I guess the specific question, Dr. Prinn, that I'd like to raise with you is, how would you suggest that we proceed with tax policy based upon, as you've indicated, the next round of innovations?

Dr. PRINN. I would certainly see this as an area where tax incentives could work, because initially, companies, private entities that would want to do the necessary research to make these break-

throughs are putting up large capital, and with perhaps some chance that they'll make nothing, because they don't make the discoveries.

So, tax incentives I think would help certainly for the development of new inventions, if I can call them that.

Getting those new inventions, once they are there, from off the lab bench as it were, and then beyond that, is an issue, that involves seriously looking at economics and so on, that would be there—I'm not sure what tax incentives do, and I think there are others on the panel that could comment much more intelligently on that.

Mr. NEAL. I'm going to ask Ms. Claussen that right now.

The nature of the tax policy here at the Committee level has been really to do temporary tax incentives.

Do you think that's the way that we ought to proceed, or do you think that we ought to be doing something that's much more consistent with the future?

Ms. CLAUSSEN. Yes, I do, because I actually think things that go into effect and then are gone in a year or gone in 2 years are very disruptive.

They do not get you to the longer-term investments that you actually need to make the difference.

So, if there is some way to do these things over a long period of time in a consistent way, I think we're going to see a much different picture coming out of companies and the private sector in the kinds of technologies that we need for the future.

Mr. NEAL. Dr. Schneider and Dr. Montgomery, feel free to comment as well.

Dr. SCHNEIDER. Yes. I think if we look back at history, the degree to which people believe something is inexorable is really very important to whether they take a long-term reaction or hunker down and wait it out.

When the OPEC oil embargoes took place in the 1970s, most people believed that was real, and that's when the United States turned to a combination of efficiency standards in automobiles, air conditioners, refrigerators, which has given us indelible benefits ever since. You can calculate in the many billions the dollars we saved from those.

When we have short-term fluctuations, people wait it out, and they just go for business as usual.

So, a signal from the Congress that they were serious and that even if the start was slow, it was going to ramp up inexorably, I think would lead to substantial performance change.

Mr. NEAL. Dr. Montgomery?

Dr. MONTGOMERY. Yes. I think that permanent tax incentives, especially for R&D, are critically important.

The difficult part is they really need to be very broadly defined rather than targeted to specific activities, and I think there may actually be general agreement on that, that we don't want even the Committee on Ways and Means picking exactly which technologies should be developed and how.

Of course, the problem with that, as you know, is it makes the tax incentives very expensive, because it makes it easier to qualify.

You may end up giving some money to something that would have happened anyway.

That's the risk, I think, of getting the kind of broad try everything out and see if it works R&D that's necessary.

Mr. NEAL. Thank you, Mr. Chairman.

Chairman RANGEL. Mr. Weller.

Mr. WELLER. Thank you, Mr. Chairman, and I commend you and Mr. McCrery for convening this hearing this morning.

I believe that climate change is real. I also believe it's caused by human activity.

If you look at the maps of the 15th century used by the European explorers when they came to our own hemisphere, you see Bahaman Cays that are no longer above water.

So, clearly, so-called global warming has been occurring for a long time.

However, if you look at the data, it's occurring much faster today.

So, I, for one, believe human activity is clearly having an impact on the climate, and causing climate change.

I also believe, Mr. Chairman, that the solution requires a global solution. We can't go alone in addressing the issue of climate change.

As my friend, Mr. Herger, noted, China will soon eclipse the United States in emissions, so clearly, they need to be involved, as well.

I also want to commend my colleagues who noted there is an economic impact to this, as we look at what policies we may want to adopt.

Manufacturing is important in my district, and some policies advocated by some would drive the jobs, manufacturing jobs currently in my district to China and Asia, because they'll move to places where these policies don't exist as a place to do business. So, we need to take that into account.

I also hope, Mr. Chairman, as we move forward, that we consider energy independence as part of our strategy to complement our goal of addressing the issue of climate change, and I hope we'll build on what I believe are the successful policies that were included in the 2005 Energy Policy Act, what many of us call the energy bill.

I've seen in my own district the tax incentives for promoting alternative sources of energy, such as wind and bio-fuels, the impact they've had, and clearly, rural Illinois and rural America were the winners of that energy bill, because we've had hundreds of millions of dollars in new investment in wind energy in the district I represent.

There's five new ethanol and bio-diesel plants in the works, moving forward with construction, and there's over $1 billion in additional wind energy investment alone in the district that I represent planned and moving forward over the next couple years.

So, clearly, the energy bill of 2005 has made a difference in promoting renewable and alternative sources of energy, and I hope as we move forward that we do look at making permanent the renewable production tax credit and look for tax incentives that reward investment in new technology, such as marrying the hybrid and

flexible fuel technology vehicles that soon will be coming on the market, and encouraging consumers to buy those.

I guess my first question is for Dr. Montgomery.

Dr. Montgomery, you talked about the need for R&D being a key part of our effort to address CO_2 gas emissions.

Ways and Means of course has jurisdiction over tax. A lot of discussion today has been fairly broad, well beyond the Ways and Means jurisdiction.

As we look at energy independence initiatives, climate change initiatives, and I hope we can do both, that a lot of us advocate renewable and alternative sources of energy as part of that solution, how would you structure tax policy when it comes to that area, as attracting greater investment that will be part of our effort on climate change?

Dr. MONTGOMERY. I tend to think about this question in terms of the continuum of activities from basic laboratory research, development, demonstration, and commercialization.

I actually see the role for the Committee on Ways and Means and tax incentives of the kind you're talking about mostly at the front end, where we're talking about basic research and R&D.

I think that after making the scientific breakthroughs, creating the technological options, at some point in that process—and the really hard part of designing anything is figuring out where that point is—I think it becomes the private sector's responsibility, that the technology is never going to be developed or deployed effectively if it continues to be owned and pushed by the Government.

So, there we need to be thinking about market-oriented incentives for giving an incentive to deploy the technology.

Mr. WELLER. Doctor, is nuclear power part of the solution?

Dr. MONTGOMERY. Absolutely.

Mr. WELLER. Do others in the panel agree that nuclear power is part of the solution?

Dr. PRINN. Yes, I certainly do. We need to look at it and regard it as a possible significant solution, particularly for utilities.

Mr. WELLER. The other two on the panel, do you support nuclear power as part of the solution?

Ms. CLAUSSEN. Nuclear power is now about 20 percent of our electricity source. I don't see any way that we can address climate change without it.

Dr. SCHNEIDER. I guess I'll give a comparable answer to what I said before. It all depends on how you do it. Questions of cost and safety are there.

I certainly am not an idealogue who has ever said "No nukes." I just want to compete it against all the other alternatives, and that also has to include costs for how you're going to deal with wastes, particularly wastes that might go to countries that we may not be so anxious to have access to those wastes, and that's part of the cost cycle.

The other question is, there are legal, federally mandated limitations to liabilities on their insurance risk, which is a subsidy, and I'm not arguing the subsidy is wrong, but I'm arguing it's all part of the cost factor.

So, I think if we competed it with all the other things, including the R&D, we'll see what emerges. However, I would certainly not rule it off the table.

Chairman RANGEL. Mr. Doggett.

Mr. DOGGETT. Thank you, Mr. Chairman.

Thanks to each of you for your testimony.

I've been in and out of your testimony this morning because of a hearing where the Chairman of the Federal Reserve is testifying in the next building over, in the Budget Committee, and I had a chance to ask him questions about the topic you're here testifying on, and was encouraged by his response on the cap and trade system.

Indeed, it seems to me that the number of true global warming deniers is shrinking by the day, and more and more responsible businesses are coming forward, way ahead of this Congress, and suggesting that we need prompt action to deal with the realities that you've described to us.

We need more to come forward and we need more to not only admit there's a problem, but encourage us to take meaningful action about it.

Unfortunately, in my home State of Texas, we have one of the most irresponsible corporations that is out of the mainstream, and that's Texas Utilities, which has gotten a great deal of attention in its desire to use outdated technology and get in, as Dr. Schneider said in his earlier testimony, I think, as a good example of—you used the term "chicanery," and that's certainly applicable to Texas Utilities, in sneaking under the wire.

Even with the encouraging developments of the last few days, that prospective new purchasers of Texas Utilities would go forward with only three of the 11 plants that it originally proposed, just the Oak Grove plant alone would burn 2.5 million pounds per hour of the dirtiest Texas lignite that I think we've got, and on its first day of operation, as projected, it would suddenly become the fourth largest emitter of mercury in the country.

Together, the three plants that are proposed for online would emit approximately 22 million tons of carbon dioxide annually.

Texas Utilities, under old or hopefully better, though it could hardly get worse, management, is not the only company that is proposing to build for the past instead of for the future.

There are other companies in the utility industry that are still in the wrong direction, though many, many more are taking the approach that you suggest.

I think my question is first to Dr. Schneider, about whether it isn't necessary—we've had various members ask about carrots, but there's also the stick side of tax policy, and don't you think that we need some immediate and serious action to stop a probable race to the bottom where the irresponsible try to sneak in under the wire and engage in what you've called chicanery?

Dr. SCHNEIDER. Thank you very much, Congressman, and I applaud your stand in your own State.

We want to try to make certain that what we do, as I said earlier, has a degree of inexorability in it, because when you say that the United States is not a party to the Kyoto Protocol, in irony, through the capitalist system, we in a way already are, that many

investment banking companies believe there's a fairly high probability that there will be a shadow price on carbon, which therefore means carbon emissions is a liability against the balance sheets of companies, whether it's from cap and trade, taxes, or other policies, and therefore, they're already affecting the loan rates to carbon emitters.

I think that might be a way that the Committee could consider dealing with people in that "sneak under the wire" mode, which is if you have a retroactive date at which the baseline is set, that not only rewards the people who had the courage to be early adapters, but it prevents the idea of trying to maximize your emissions so that you can then have a baseline that's high and cut below it.

So, I think there may be ways that you could do that, because then, if they had a high liability, their own investment banking community may not be very wiling to give them the kinds of loans at the costs that they'd be willing to pay.

So, I think there are instruments that you could use short of direct command and control that probably would take advantage of market forces and reduce the likelihood of the "sneak in under the wire" that we're going to see not just there but in many other places.

Mr. DOGGETT. These businesses are competitive. They're not interested in having a competitor have an unfair advantage, and they need some certainty.

You believe that taking some action now, perhaps even before we can get the Administration to agree to a cap and trade system, to provide a little of that certainty, that you can't sneak in under the wire while you lobby for inaction, that that would be something that would be helpful to the forward-looking businesses that want to address climate change?

Dr. SCHNEIDER. Yes. As our Chair knows, we actually talked about doing those kinds of things 20 and 30 years ago, and now that the evidence is so abundant, we're finally moving to do it.

What's unfortunate is, had we taken small steps earlier, it would be cheaper and easier to do it now, so we're rushing and looking at more costs than we otherwise would have had, but the more we delay, the most costs will build on top of that [continuing]. So, I think that your strategy to send inexorable signals is admirable.

Chairman RANGEL. Mr. Linder.

Mr. LINDER. Thank you, Mr. Chairman, and thanks to each of you. Dr. Montgomery, is it clear that we are talking mainly about carbon emissions here?

Dr. MONTGOMERY. Yes. Well, we are all referring to carbon emissions. Carbon dioxide is clearly the most prevalent of the greenhouse gases. It is really important for——

Mr. LINDER. Isn't water vapor more prevalent?

Dr. MONTGOMERY. That is a question I am going to defer to Professor Prinn, because he really knows about water vapor.

Dr. PRINN. Water vapor is, indeed, the most important greenhouse gas in the atmosphere. It, however, has a very short lifetime. It lasts maybe the order of a week or so, once it evaporates, before it condenses and gets back to the surface. So, it is short-lived. It's budget in the atmosphere is largely—totally, I would say totally—

unaffected by the direct emissions of water vapor by humans. In other words, we are not controlling that.

What we are worried about in the climate issue is that we are beginning to indirectly control the levels of water vapor in the atmosphere. When the oceans warm up, that does increase the water vapor, at least in the lower part of the atmosphere.

So, water vapor is, indeed, very important as a greenhouse gas. It is incorporated in all of these climate models that you heard me talking about. It is a source of some of the uncertainty that you see in these forecasts, and so on, but it is there, it is important.

What we are considering now for the climate issue that is being discussed here today, is the long-lived greenhouse gases, whose emissions are being dominated by human activity. That is the big difference between the two.

Mr. LINDER. What role does precipitation play in your model?

Dr. PRINN. What role does——

Mr. LINDER. Precipitation play in your model.

Dr. PRINN. It is very important, because it removes the water vapor from the atmosphere, and keeps the atmosphere a lot cooler than it would otherwise be, but there are many other complexities as well.

Evaporation and condensation and all of these complex processes that you think of to do with a water cycle, we try to encapsulate in these climate models—with imperfections, of course.

Mr. LINDER. Dr. Schneider, you said you testified here in 1976 and the consensus was that warming was going to be a bigger problem than cooling. Is that correct?

Dr. SCHNEIDER. By 1976, it had tipped, and 5 years earlier it was much more confusing.

Mr. LINDER. In 1975, we—Newsweek wrote an article called, "The Clean World," which was a—the article stated that scientists were "almost unanimous in the view that the trend will reduce agriculture productivity for the rest of the century. If the climatic change is as profound as some pessimists fear, the resulting famines could be catastrophic."

What clicked between 1975 and 1976?

Dr. SCHNEIDER. Well, I would guess that Newsweek was probably a few years behind in reading the scientific literature. Because when we write things, it takes a while for them to get out.

Back around 1970, it really was not clear whether the increase in hazes was going to reflect more sunlight away and cool the Earth down, relative to the amount of warming from increasing CO_2.

What happened—in fact, I personally thought that cooling was more likely in the first paper I ever wrote in 1971—but I was proud that by 1975 I changed my mind, and the reason was two facts. One is that we found out that those hazes were largely concentrated in industrial and agricultural burning areas, only one sixth of the world, whereas the greenhouse gases were global, so therefore, the aerosols had less total impact. The second thing we discovered was it wasn't just CO_2, but methane and chlorofluorocarbons that were greenhouse gasses.

So, I would say by 1975 those inside the scientific tent had already pretty well switched over to warming. By 1976, I think that

was the dominant theme in most of the hearings in this body. Of course, with media, some lag behind that.

Mr. LINDER. Recently there has been an article about research at the University of California that said that 300 million years ago there were 2,000 parts per million of volume of CO_2 in the atmosphere. How do you explain that?

Dr. SCHNEIDER. Well, it is a very important thing to study the history of the Earth's climate, not to find analogies to today—I don't think we could, because the continents were in different positions, the concentrations of the atmosphere were different, different plants and animals—but it's the backdrop against which we calibrate our understanding of how the system works.

Way back then, there was a change in the rate at which the ocean floor was spreading. There are mid-ocean ridges, and there is lava going on under there. This was discovered in the fifties, when we had an explosion of scientific research that went out and found it. When that floor spreads more rapidly, then it puts up more CO_2.

So, the geologic timeframes of 100 million years ago, 200 million years ago, saw that very much larger sea floor spreading. The consistency in that is if you're making all that lava come up, you're putting all the rubble in the oceans. Therefore, the oceans have a smaller volume, and the sea levels would be higher.

In fact, most of the geologic evidence is 100 million years ago, for example, sea levels were something like 300 meters higher. All the ice in the world today couldn't give you more than 70 meters. It had to be something else.

So, then what we do, is we take the same computer models that we use to project the future, and then we try to move the continents around, we change the CO_2, and we try to see if we can get anywhere near agreement to the kinds of scanty data we have from ancient history. It's a mixed bag, but by and large, when the models projected it would be a lot warmer it was a lot warmer. They don't get the numbers right, but they get the basic directions.

Mr. LINDER. Thank you very much. Thank you.

Chairman RANGEL. Mr. Pomeroy.

Mr. POMEROY. Thank you, Mr. Chairman. I want to thank you for holding this hearing. For years, I aspired to the Committee on Ways and Means, only to find when I got here, we really weren't talking about important stuff. I appreciate the leadership you brought to this Committee, when we do get to have these hearings exploring the depth of the problems, and then the role tax policy might apply in addressing those problems.

Dr. Montgomery, I found your comments very interesting. I was just going to see if I tracked them through, because they don't entirely strike me as consistent. You indicated that marketplace dynamics will incent new technology innovation above all other things, but you indicate that steps we might take, relative to global climate change, unless embraced across the developing world, would simply drive activity into developing countries and damage our competitiveness.

It seems to me, the only thing you assert by way of pressure we can create, driving technological innovations which may save us from this problem, would be the R&D tax credit. I agree with you,

it's critically important, and I agree with you, it ought to be broad-based, and I agree with you, it ought to be permanent, but it seems to me to be a bit of a slender reed to say this is it, in terms of responding to global climate change.

Have I understood you correctly, or would you care to clarify where I am not complete?

Dr. MONTGOMERY. I think there—let me try to clarify three parts of it. I certainly don't think that R&D alone will lead to stabilization of greenhouse gas concentrations or temperatures.

We need three things. We need R&D incentives and funding in order to create the technologies and put them on the shelf. At an appropriate pace, and over time, we need market-based incentives that could be provided by cap and trade systems, by a carbon tax, by a safety valve, by a number of approaches, to get those technologies off the shelf.

We need to think about the timing of when we want to do those two things, because I think it's very important that we not have financial disincentives for CO_2 emissions, until the technologies are available that make it possible to reduce emissions effectively and cheaply. We don't want to get the targets ahead of the technology.

Mr. POMEROY. I agree with you in part—but in part, necessity is the mother of invention. So, if this is kind of an abstract undertaking, "Gosh, it will be neat when we get this technology," you've got one dimension of urgency versus, "Holy cow, the new deadline is approaching."

Dr. MONTGOMERY. The general thinking among economic theorists—and my thinking, and what I was publishing on since the 1970s—was if we can just get a cap-and-trade system out in the market, we don't have to worry about anything else. I think that was overly optimistic.

The problem is that in order to create incentives for R&D and the development of new technologies, we have to look at market conditions 10 to 20 years from now. I am now convinced that it's not possible for the congress to create a credible enough incentive, because of your inability to lock in future congresses and future Administrations to this policy, to think that what is enacted today, in terms of the cap-and-trade system, will be convincing enough to the private sector about what's going to happen 20 years from now to their investments, to induce the massive amount of R&D we need today. I wish I didn't think this, but I——

Mr. POMEROY. I'm sorry, I do apologize, I keep interrupting, but I'm just in a dialog sense here.

Dr. MONTGOMERY. Yes.

Mr. POMEROY. Do you really think that the business community is betting on the heat coming off of global climate change, that the concentration of this congress may abate in a future congress?

Dr. MONTGOMERY. No, but I do not think that they are willing to bet that future congresses will be taking a hard enough line to put the scale of resources that are needed into R&D today.

The reason I don't think the R&D is a slender reed is because we are probably talking about 10 times as much R&D investment as is taking place today across the board. It is a very difficult task and the Committee on Ways and Means's job is to try to figure out where in the world all this money is going to come from.

Mr. POMEROY. Thank you for that. I—my remaining time, just a tiny bit of time, Dr. Prinn, I would ask you. You talked about carbon sequestration, putting CO_2 under ground. By the way, North Dakota hosted a fabulous demonstration of that, with the gasification plant and the CO_2 shipped to Canada, pumped into their oil wells, enhancing oil recovery.

Are there other credible technologies under development? I have heard about an algae capture technology. Is there other things, when we talk about carbon sequestration, that are under development, other than what plants absorb, or what we pump into oil wells?

Dr. PRINN. Yes. There—well, sequestration in geological reservoirs is certainly one. There has been quite a lot of discussion about the possibility of putting carbon dioxide in the deep parts of the ocean.

Generally, it is considered difficult, and may be, in fact, politically impossible, because of the law of the sea, and other concerns about its permanence. So, I don't think the ocean is going to play the role that people might hope it would.

Mr. POMEROY. Okay.

Dr. PRINN. There has been some talk about fertilizing the ocean with iron, to increase the production of phytoplankton, and therefore, some small fraction of those sink down and become a carbon loss. My view on that is also that it's not of the scale that is useful. Again, it runs into issues to do with dumping of stuff in the ocean.

So, I would come back and say what are the things that are worth pursuing right now? Or at least should be on the table. The geological reservoirs—very big saline aquifers that, of course, the western states have vast volumes of, and also sequestration in soils and forests, as viable places where we can store carbon in ways that we can have some control over in the future.

Chairman RANGEL. Thank you so much. Mr. Blumenauer.

Mr. BLUMENAUER. Thank you, Mr. Chairman. I appreciate your continuing this effort. I feel like we might apply for college credits in the economics of poverty and trade. Today's hearing was, I thought, really very helpful. I deeply appreciate it.

I want to pursue the notion there is this expectation that somehow there is a lot of high-tech solutions. I appreciate, Dr. Montgomery, your talking about there is probably some stuff out there on the horizon that we should be looking at, and we might accelerate the progress.

It seems to me that, for all intents and purposes, there is an awful lot that we can do right now. The reference from several of our experts 75, 80 percent of this is transportation, electricity, and agriculture.

If we were to get serious—and I am from a region in the northwest, where I have—I represent a city that actually is about at its 1990 emissions level right now. For the last 25 years, the largest single source of energy has been conservation. It has been achieved at, I don't know, 3,000—at half the price of a coal-fired plant. We haven't scratched the surface, it seems to me, in that area.

I want to just throw a couple of ideas past the panel, and maybe get a little feedback. If we were to establish an oil import fee that would set a figure for oil in perpetuity at $50 a barrel, escalated

with inflation, if we were to move in an area of carbon tax, if we were to have the Federal Government's carbon footprint's reduced—I think it's safe to say we are the largest generator of greenhouse gases of any entity in the world, and if we were to set aside one percent of our energy bill for conservation, if we would commit not to purchase any vehicles that did not meet a specific level, absent some sort of waiver, if we committed to have renewable portfolio standard for the Federal Government, these are little things that are within our power.

I won't even talk about the farm bill that is up for reauthorization, with an opportunity through the farm bill and the legislation, that we could use on this Committee to change the carbon footprint of agriculture in this country, both to reward the right stuff, and penalize some of the things that we don't want.

Aren't there lots of simple, common-sense things that we can do that will make a difference now, over the next five or 6 years?

Ms. CLAUSSEN. Let me try first to answer. Absolutely, yes. There is absolutely no question about it. Do we have a need for long-term technology in R&D? Yes, but can we do a lot in the short term? I think there is no question.

I think the easiest way is not only to look at the City of Portland, or some states that have done these things, but just to look at what private industry has done, because virtually all of the companies that have set targets—and many of them are much more stringent than the U.S. target was—have found that they could meet those targets by efficiency improvements.

They were, in many cases, just sort of things that I would consider silly things that were turning off the computers at night, changing the lighting. Doing all of these very simple things, which actually are great for the bottom line, and can result in significant reductions.

That is why we, and a lot of the companies we work with, would like to see a price on carbon, because that would really motivate that kind of behavior, and in fact, we could make significant reductions without significant cost.

Dr. SCHNEIDER. Yes. In California, we have had bipartisan support over the last 30 years for a whole series of performance standards in houses, in machinery, and so forth.

In fact, Art Rosenfeld, with the California Energy Commission, then spent about a half-a-million dollars of taxpayer money in a competition that led to the invention of the electronic ballast that made the compact fluorescent possible. When I asked him what was the payback, he spent all lunch thinking about it, and then came up with a number like $1 trillion. It was a pretty good return.

Why does California do it? It does it because it adheres to what I like to call the 7–11 principle. If you can do better than a 7 percent return on investment—typical of a mortgage rate—or an 11-year payback, it's something to consider, a mandatory control, because you have a win-win associated with that.

That, in fact, is why, in California again, about 15 percent of the electricity demand has been reduced by these actions, including about half of that in utilities in private sector, and the estimate is

about $5 billion a year saved. Again, it eliminates bipartisan bickering a great deal, when everybody wins.

I also think that in the end, though, while we have a lot we can do to start—and the sequencing should certainly be on performance standards first; we have heard that from everybody, and I think we're in agreement—but we also should remember the learning by doing, which means getting the costs and the prices down for available alternatives, not just exotic, uninvented technology, but hot tower solar, and batteries that you could use for plug in hybrids. The technology is here, it's just not here at the cost we would like. Learning by doing first takes doing, just as return on investment takes investment.

So, finding the ways to encourage the investment and the doing is what will bring these online cheaper, sooner.

Chairman RANGEL. Mr. Thompson, please.

Mr. THOMPSON. Could I just ask a question, Mr. Chairman, for a request from——

Chairman RANGEL. Yes.

Mr. BLUMENAUER. Ten seconds. I just—if you have ideas of where the Federal Government can emulate what you are talking about in the private sector, or the State of California, I would welcome a little brief note, or something of that nature. Thank you for your indulgence, Mr. Chairman.

Chairman RANGEL. Mr. Thompson.

Mr. THOMPSON. Thank you, Mr. Chairman. I want to thank all the witnesses for being here for your testimony today.

Ms. Claussen, if you would, please, I think we all know that forests have a certain benefit of absorbing CO_2. Up in my district—I represent a district in Northern California—there is an organization, The Pacific Forest Trust, and they registered the state's first forest carbon project with the California Climate Action Registry. They have got about 2,100 acres of working forest land that they have designated as this project. I highlight the fact that it is working forest land.

I am told that that one project is expected to curb about 500,000 tons of carbon dioxide CO_2 emissions through sequestration. This seems like a pretty promising program. I would like to know what, in your view, what role projects of this nature can play, and if you believe that—this is the tax Committee—if you believe that, in our effort to deal with this, any comprehensive plan should take into account and include incentives for these types of programs.

Ms. CLAUSSEN. I am not familiar with the very specific project you mention, but should sequestration in forests and soils play a role in this? I think the answer is yes.

Now, it is—I'm not exactly sure whether this is a solution for the long term—and I suspect it is not—but while we move forward in other areas, and while we deal with new technologies that can be more permanent——

Mr. THOMPSON. Why do you say it's not a solution for the long run?

Ms. CLAUSSEN. Because I think it is very hard—although in some cases, you can do it—it is very hard to guarantee the life of the forest over a really long period of time.

Mr. THOMPSON. It is certainly a part of any solution——

Ms. CLAUSSEN. It is certainly a part of the——

Mr. THOMPSON. —short run or long run.

Ms. CLAUSSEN. You bet. It is certainly part of the solution. It can do a lot in the short to medium term. It should be a part of any comprehensive program.

Mr. THOMPSON. How do you quantify the value of the tax incentive? Is that——

Ms. CLAUSSEN. Off the top of my head, I can't give you a good answer. If you would like us to provide one for the record, we would be happy——

Mr. THOMPSON. Would you, please? I would appreciate that. Thank you.

Dr. Schneider? Can you—and I had to step out for a little bit, and you may have touched on this, and indulge me, please, if I am being repetitive—but what are your long-term estimates on the impact of global climate change, and a water supply for everybody, for municipal, agricultural, and natural resource priorities? On the West Coast, in western states?

Dr. SCHNEIDER. I will start with California and the west, because there is probably a legitimately larger concern there than in some other areas. That is because when you have a Mediterranean climate, where the bulk of the rain comes in in the winter, and not in the summer, if you end up with warmer seasons—and a lot of our water is stored in snow pack, not just in reservoirs, something like half—and you start melting them sooner, then you have a flood management problem earlier in the spring, and you have less water availability downstream in the summer, when you need it.

If you are several degrees warmer, you need it even more, and you increase substantially the risk of wildfire. If there has been any unifying factor in California—and I think in Oregon and Washington—in concern about not wanting to warm up more than a few degrees, it has to do with the risk of wildfire associated with that kind of Mediterranean climate, and the reduction of water supplies. It is less clear in other places.

The IPCC collected the results from 20 models, and—roughly—and while there was disagreement about many parts of the world, where it rained more or less, there were a few areas where they were all in relative agreement for obvious reasons.

First, you are going to get more precipitation in the high latitudes, both north and south, because the atmosphere holds more moisture when it's warm. Second, the Mediterranean climates, the Mediterranean itself, South Australia, South Africa, California, West Coast, Mexico, will probably have substantial water resource problems because they are already stressed, and they are already dry in the summer, and adding heat is not a good thing.

Mr. THOMPSON. So, do these studies look at things such as increased insalination levels, because of increasing water and effect on agricultural products, and things of that nature?

Dr. SCHNEIDER. Well, there are studies that look at water quality, as well as water quantity. There are not thousands of them. We are still trying to collect the literature on this.

Everybody admits that there are uncertainties, from how many people in the world, to the emissions, to what it means in those water sheds. The one thing we know is we are going to change the

drought/flood frequency, probably going to increase the extremes, pretty much everywhere, but the West looks like a particular problem, because of its Mediterranean climate.

That would affect water quality, as well, because if you have run-off of pesticides or herbicides, or other things, at a time—in the summer, at a time when you have less actual run-off, then the concentrations would go up. That can also be controlled by local rules, so it will require a combination of Federal and local action to protect those systems.

Mr. THOMPSON. Thank you very much.

Chairman RANGEL. Thank you. Mr. Nunes.

Mr. NUNES. Thank you, Mr. Chairman. Mr. Schneider, you, in your written testimony, you proposed a $400 billion tax on carbon. We're producing about $1.7 billion U.S. tons. Simple math shows that that $400 billion per ton tax would be about $700 billion a year, and $7 trillion over 10 years.

So, I have two questions for you. The first is that CVO has determined our GDP in 2007 will be about $13 trillion. Given that tax collections are already at a historical high, do you believe that this tax, a tax of this type, is economically sustainable? That is my first question.

The second question I would like for you to answer is how do you suggest—being that we are a tax-writing Committee—how do you suggest that we apply this tax to the American people, in what form? Gas tax, and so forth, and so forth.

Dr. SCHNEIDER. Thank you very much for that question, because I can clarify that I certainly would never advocate a $400 a ton carbon tax snapped on the day after tomorrow.

What I was doing in that study was showing that even a tax that large, which was presumably ramped up over time, and using the standard growth rates that would be calculated in most economic models, even a number that large—and I acknowledged in the testimony that costs would be trillions of dollars—you still—when you look at it play out over a century—again, if you believe that we will have a 2 percent per year growth rate in the economy—even a $400 per ton carbon tax only delays our getting 500 percent per capita richer per year or two 100 years from now.

I also said in the testimony that it would be very important to take a look not just at who might be differentially injured by climate change—such as I had said earlier, people living on coast lines and high mountains—we also have to take a look at who would be hurt by any policy, and deal in fairness to help them through the transition.

Mr. NUNES. Doctor, if I may, though—because I have limited time here—if not $400, then how much? We are—we need to know if we are serious about writing this into law, and taxing the American people with this carbon tax, if it's not $400, is it $200? Is it $300? Is it $150? Where do you start, and how do you apply the tax?

Dr. SCHNEIDER. Well, what I would do personally—and, of course, you are calling for my values of the relative merits of these—and in my value system, I want to try to send an inexorable signal that we are going to slow emissions down. I don't believe that starts with a very, very high number, because of the disloca-

tion it would have for people who are currently locked in to the kinds of work for which those taxes would be really very critical.

Just as a way of perspective, several people had made comments, politically and otherwise, that Kyoto, or some other similar type policy, would have bankrupted the United States. Yet gasoline price went up 2 years ago by $1.50 a gallon, which is the equivalent of $270 a ton carbon tax, and didn't do very much damage to the economy, though it hurt individuals.

So, I am a believer in ramping things up slowly, announcing it, and giving people time to adjust. In the end, the models themselves suggest if you want to control to 350 ppm—that is near current levels of CO_2—that the numbers are somewhere on the order of $400 a ton. I would not personally advocate it—it is not in my talks or my articles to say that—it was just simply scaling.

Mr. NUNES. So, if we are going to stick with a number, though, what would you think it would be?

Dr. SCHNEIDER. What would I—well, the market is all over the place these days, from 10 to 50 dollars per ton, depending on where you are. I think you start small, and you say, "I am going to crank the knob up every year, higher and higher, and then when we get new studies to find out if we're lucky and we are coming out at the low end of climate change, we might crank it back. If we find out we're unlucky and we're coming out at the high end, let's crank it up more."

I will be surprised if it doesn't, in decades, settle somewhere well over $100 a ton, as an incentive to do both the R&D and to discourage wasteful use.

Mr. NUNES. Thank you, Dr. Schneider. Thank you, Mr. Chairman.

Chairman RANGEL. Mr. Kind.

Mr. KIND. Thank you, Mr. Chairman. I want to thank our panelists for, not only their testimony, but your patience here today, on an incredibly important topic. I just returned from a few days over in Europe, to meet with the European parliament and the European Union, discussing this very topic, along with some other matters. They are absolutely obsessed, as you can imagine.

Because whereas Al Gore says it's an inconvenient truth for us, it's a matter of survival for them, in regards to climate change, and the impact it's going to have throughout the region. They're wondering what we're going to do in this session to step up, and start assuming some of the responsibility that we have to share on a global level.

With that in mind, let me ask you just two questions, for each or any one of who that want to address it. What is the most important thing that we should be doing right away to help us reduce the CO_2 emissions in this country? Secondly, what is the most important thing we can be doing to help the emerging and developing world, to try to leapfrog over a lot of the mistakes that we have made in the past, so that they don't become a significant problem for the rest of us?

Let me just leave it open to any of you that want to——

Dr. PRINN. I think it is very important to put a price on carbon emissions, even if it starts out at a very modest level. I think that needs to be done, one way or another. The issue of whether it's a

tax or it comes under a cap-and-trade, is something that I think is not my area of expertise to comment on.

I think it is extremely important that we work together with the other major developing countries, that the United States works carefully with China and India, and these other big, emerging economies, to see the ways in which we can help them develop their economies—we are not going to stop them doing that—but in a way that is looking very carefully at lowering the emissions that would otherwise occur from those developing economies, and with a clear understanding that, at some point, they take on restrictions to their emissions. They may not start in that direction initially, but at some point there is an agreement that they join in, along with us and the other OECD countries, to make a global effort at lowering emissions. The point——

Mr. KIND. I have——

Dr. PRINN. —is that it doesn't matter where the gases are coming from.

Mr. KIND. Right.

Dr. PRINN. We all live here, it's a global common problem.

Mr. KIND. Dr. Schneider, do you have any thoughts?

Dr. SCHNEIDER. Yes. As I had said in my written testimony, I think that a lot of this is a sequencing problem. It is probably easiest to start smart, start where you get the lowest cost and the highest paybacks, which is performance standards, not just have them selectively distributed around states, but take a look, federally.

A Congressman made the comment which I agree with, that we also had better look at Government procurement. Because it's always better to get your kid to believe you when you tell him to turn out the lights when you turn off the TV when you walk out the door. So, I think the Government being involved is a part of it—not just symbolic—but a good way to also have a learning-by-doing experiment, and send market signals to producers of those efficient products.

Part of performance standards is CAFE, part of it is appliances, bulbs, and housing. I think next in the chain, which we have heard from everybody—and I hear no disagreement here, though we might have nuances about how we do it—is public/private partnerships, so that we can get that learning-by-doing experiment going. President Bush (the father) once said, "Let 1,000 flowers bloom." I don't think we need 1,000. A dozen, maybe.

Mr. KIND. Sure

Dr. SCHNEIDER. We have to have that competitive market of learning by doing, and it is not going to happen just on private investment returns. It will take the public partnerships. After all, there is a public benefit, which is——

Mr. KIND. Let me go to Ms. Claussen and Dr. Montgomery real quick, before my time expires.

Ms. CLAUSSEN. The answer, I think, a price on carbon—and I would advocate through a cap-and-trade system—would be number one. In terms of the developing world, I think we have to engage with them in a constructive way, so that they can follow cleaner development paths. Because, obviously, they're going to develop.

They obviously need electricity and transportation, but there are ways to do it better, and I think we can be helpful.

Mr. KIND. Yes. Dr. Montgomery?

Dr. MONTGOMERY. I would make my first priority creating a stable and growing source of funding for effective R&D, and sending it through an effective organization that is outside existing executive departments, and outside the appropriation process. We can expand on that one.

Second, for the developing world, I think it is absolutely clear the developing world is not going to be able to make a big reduction in its growth in emissions without much stronger economic, legal, and market institutions. I would start with pushing that reform.

Mr. KIND. Let me just say—and it really hasn't been delved into in any great extent, but I don't know how we can get there quicker or faster, unless we have a mature nuclear energy policy, as well, in this country, and it's something that we can share globally with non-proliferation concerns in mind.

Because everything else sounds great, but that seems to be the most obvious direction to get the biggest bang for our buck, in short term. Thank you all.

Chairman RANGEL. Mr. Pascrell is recognized for 5 minutes.

Mr. PASCRELL. Thank you, Mr. Chairman. Thank you, each of the four of you. You did a great job on this panel, and we need more dialog, we need more discussion.

Mr. Montgomery, I want to start off asking you a first question. You are an economist, you have testified before this Committee about the economic impact of various ideas that have been proposed to address climate change. It's kind of like a warning, "Better watch out what you're getting yourself into, because this is going to cost a lot of money, that is going to cost a lot of money." I have a question for you.

If we fail to respond to global warming, if we fail to respond, would there be economic costs associated with higher temperatures, higher sea levels, and changes in weather patterns? Would you answer that question, Mr. Montgomery?

Dr. MONTGOMERY. Yes, there would be economic costs.

Mr. PASCRELL. Why don't you tell us about those?

Dr. MONTGOMERY. The economic costs we need to take into consideration in designing policies are the economic costs that we can avoid because of those policies.

Changing the direction of the climate is going to be a slow process, no matter how rapidly we start doing things. Therefore, we have to think about time scales on which we can accomplish something, given that we need the whole world to do things—and which costs that allows us to avoid.

Mr. PASCRELL. On that——

Dr. MONTGOMERY. The costs we're looking at avoiding certainly are all of those things, and they are going to be occurring over the next century.

Mr. PASCRELL. Well, it appeared from what you all said today, and what others have been writing lately, that we have come a long way in 6 years, the last five or 6 years. We seem to be all on the same page, that now we are dealing with sound science.

Now, Ms. Claussen, you talked about conservation. You gave us some very specific examples about how we can reduce emissions, and so forth, and so forth. In May of 2001—I want your response to what the Vice President of the United States said about conservation. He said that, "Conservation may be a sign of personal virtue, but it is not a sufficient basis for a sound, comprehensive energy policy." Would you please respond to that statement by the Vice President of the United States?

Ms. CLAUSSEN. It's too easy, your question here. I actually think conservation is a good basis of a sound energy policy. It is the number one thing we can do. It is a win-win. It is not the whole game, but there is no question that that is where we should start.

Mr. PASCRELL. By the way, he said that just a little while after—a second here, Dr. Schneider—he said that just a little while after the President reneged on a campaign promise that he made to all of us that he would cap emissions for coal-powered plants. Dr. Schneider?

Dr. SCHNEIDER. I do agree with the Vice President, that it gives you personal virtue. The point is, it does more than that. The best example I can give you is that initially California started performance standards on refrigerators from 1975, in the OPEC embargo, that were then picked up by many states, and eventually the Federal Government.

It has been calculated out that the amount of electricity saved alone through those performance standards is not only substantial, it is twice the maximum potential of the energy production of the Alaska national Wildlife Refuge, which I think is something the Vice President might note.

Mr. PASCRELL. Thank you, Dr. Schneider. Dr. Montgomery, I want to get back to you. Utilizing—I believe utilizing conservation efforts, we can retrofit the Tax Code to help us encourage conservation. Do you think that that is hyperbole? Do you think that is pie in the sky? Or do you think it's achievable? Then I have one other question to ask you.

Dr. MONTGOMERY. Okay. Then I will try to be brief. I think you get what you pay for. If you are prepared to pay for energy conservation through tax incentives or subsidies—that means taking resources away from other uses, because you're collecting taxes—and by expending those resources, it's certainly possible to bring about conservation.

I think that is the experience in California, too. California has incurred economic costs, it has chosen a particular path of industrial development, and it has—by expending those resources, it has accomplished something in reducing its energy consumption.

Mr. PASCRELL. You said on page three of your testimony, when you were talking about developing nations, and why should we ask this of ourselves if we're not going to ask this of others, you said the implication of these observations is not that the United States should do nothing, it is that gaining the participation of developing countries is probably the highest priority for climate policy, because without that participation, it is impossible to prevent large temperature increases. That's what you said.

Are you implying, or would you accept, or would you support this idea, that with participating countries—and whether they are de-

veloping or they have been developed—that you could actually deal with trade agreements with those countries to work on these climate changes? Would you accept something like that, that we—it be part of our trade deal with countries around the world?

Dr. MONTGOMERY. Yes. I think that trade negotiations are an important route to doing something about climate policy. Global trade negotiations are tricky enough. We have immense problems in dealing with things like the Europeans' insistence on subsidizing agriculture, which is impoverishng developing countries.

I would be more inclined to go with regional trade agreements. I think that bilateral or Pacific rim negotiations, where we talk about trade, we talk about climate, we talk about technology transfer, we talk about maybe even incentives for U.S. investment in countries, if they will change their behavior, I think that's a very important route.

Mr. PASCRELL. Thank you.

Chairman RANGEL. Thank you. Mr. Porter.

Mr. PORTER. Thank you, Mr. Chairman, and thank you all for being here today. As you know, I represent the State of Nevada, as does my colleague to my right, Congresswoman Shelley Berkley. A huge issue for us is, of course, Yucca Mountain and opposition to Yucca Mountain.

We have heard, for probably 20 years, that the Federal Government and all of the scientists, who have spent $12 billion or $13 billion, have told everyone that that site is safe for burial of nuclear waste. I said jokingly the other day, "If it was a Saturday Night Live skit, it would probably be pretty funny, but it's actually too serious of an issue, the Yucca Mountain."

It's a problem, it's broken, and I know that you, I believe, support nuclear energy, as do I, but I please ask, as you look at that as an option, that when we use sound science, it's not happening at Yucca Mountain.

Now, I would also like to add, I guess, the food chain of this debate is huge. There is millions, if not billions, that have been spent on both sides, and which makes it very difficult for the average American to cut to the chase of the debate. I'm not questioning your expertise today at all, but I know that the American people are in question.

What can we tell the American people who are residents in Nevada, right now, one thing that they could do to help? Because I believe there is a problem, and we need to find the solution. What's one thing a family can do to make a huge difference? I may be oversimplifying, but I have been asked that question by schoolchildren, by businesses, by individuals.

The second part of it is geothermal, of course, is huge for the country, one of the largest in the world. Nevada is number two in production. I hear constantly from the business community that they need more incentives, more incentives for solar and geothermal. So, I guess the third part of this is what can we do to encourage that? Can we start with Dr. Prinn?

Dr. PRINN. Yes. Beginning with the issue of geothermal that you brought up, I think it is there with great potential, particularly in the western states, because you don't have to drill down so far to get to the hot rock. I have not seen a careful consideration of

the cost of getting very large amounts of energy from geothermal, and I think that has to be looked at very carefully.

Obviously, in your State, you could look at wind energy as an important source, because you have got lands that nobody looks at, right?

Mr. PORTER. We have lots——

Dr. PRINN. You've got lots of land, and you don't have to worry about what we worry about at the Cape Wind project, where rich people don't like to see these windmills in their horizons.

On the issue of what the individual person can do, well, the way I answer this in the many public talks I give when that comes up, is about every four or five or 7 years, depending on how frugal you are, you buy a new vehicle. This is one way where people can, I think, make a very significant difference. They can go for a vehicle that gets twice the mileage, and that will half their gasoline cost, right, in doing so, but in doing so they will have made an important contribution, particularly if it then becomes a popular thing to do. That's something everyone can do.

The way we run our households, of course, the ways we waste energy, and we waste money in doing so, and that would apply in Nevada and in Massachusetts, and everywhere else. I would now leave it to others to——

Mr. PORTER. Thank you.

Dr. SCHNEIDER. Yes, I too get asked that question all the time. One young lady said, "I can't negotiate with the Chinese. What can I do?" Of course, I said, "Do you turn your light out when you walk out of the room?" She said, "Well, most of the time, not all of the time." "How about the computer?"

So, you begin with the things that you can control. You can control the number of trips that you take. Do you bother mom and dad to drive you downtown the second you want, or with a little bit of planning can you do two trips instead of four? It's not just simply that those acts are symbolic. They are, but when a billion people do them 10 times a day, they go beyond symbolic. Plus, they also create the mindset for being efficient.

I agree with Ron Prinn, that you have to take a look very carefully at the labels of the air conditioners, the refrigerators, the automobiles.

When you remodel your house, do you build to the minimum of the building code, or do you build to a payback criteria, like 7–11? You need to get some help to try to do that. So, I think there are a lot of things we can do.

Finally, we need to get into organizations. We need to talk to people of like mind, or even differences, but who agree in a conservation ethic. We talk to each other, we learn from each other, and then we network to other groups, because that's what makes it politically more possible for leaders to act when they have supporting constituents. So, I think there is a whole hierarchy of steps.

Of course, then, from the top down there are the taxes and the caps and trades.

Ms. CLAUSSEN. I think we are all asked this question. I usually give a three-part response. When you make a purchase, make it with carbon in mind, and that could be whether it's your vehicle or your refrigerator or your washing machine.

I think it is important, if you are going to invest your money, that you invest your money in companies that are taking steps in the right direction here, and that are advocates for good public policy.

I know I shouldn't probably say the third in hearing, but I always say it's important who you vote for, because we need a national policy. I would say you should vote for people who are going to come up with a sound one.

Mr. PORTER. Thank you.

Dr. MONTGOMERY. Mr. Levin started the questioning by asking us about why there was such a huge divide in opinions on climate policy. I actually think the advice I would give everyone in their homes and their families is to study the subject seriously, think critically about the extreme statements that you hear from any side, read everything Ron Prinn has ever written for general consumption, understand the subject.

This really gets to the question of long-term incentives for businesses, as well. The expectation of what climate policy is going to be, and what businesses need to do in order to prepare for it, is driven less by what this congress votes than by business's expectation about what the electorate is going to expect and demand over 20 years.

Businesses are not going to be confident of that until we have much more consensus among our citizens about what the climate problem is, and how you can address it. So, I would say study it, and encourage your children to study hard and do science and engineering, because we need them in order to get R&D to create the future that we are going to depend on.

Chairman RANGEL. Ms. Berkley.

Ms. BERKLEY. Thank you, Mr. Chairman, and thank all of our witnesses for being so patient and staying the extra 45 minutes.

Whenever I hear anybody talk about a nuclear energy as a possible part of a solution, and part of our future energy portfolio, I get a little bit nervous. I would like to echo some of the things that Mr. Porter said. A nuclear energy has a very nasty byproduct, and that nasty byproduct is nuclear waste. This nation's only solution for its nuclear waste problem is to store—ship and store—77,000 tons of very toxic radioactive nuclear waste across 43 states to be buried in a hole in the Nevada desert, where we have got groundwater issues, seismic activity, and volcanic activity.

When people talk about nuclear energy being clean and cheap and safe, it is—I would like to disabuse everybody of that myth. If it is so cheap, it costs $2 billion, minimum, to build another nuclear power plant—that's why there hasn't been one in the last 20 years—I don't think that sounds very cheap. If it's such a great cheap source of energy, how come the taxpayers, me included, have to keep subsidizing this energy source?

We are already 20 years behind schedule, after the so-called "Screw Nevada" Bill, and nothing much has been done, other than we have spent a fortune studying it.

It requires gazillions of gallons of water for nuclear waste. We don't have any water. You may have noticed that Yucca Mountain is in the middle of the Nevada Desert. We are now in the middle of our seventh year of a 5-year drought, and we don't know how

long this 5-year drought is going to last. There is no water resources in the State of Nevada for the storage of nuclear waste.

We know—and actually, Congressman Porter was the Subcommittee Chairman when they were—when we did an investigation that found over 1,000 e-mails in—well, I don't have a direct quote, let me paraphrase what some of these e-mails were when we are talking about so-called sound science for Yucca Mountain. "I don't know any of the numbers, so I just make them up." That was one of the better e-mails, but there are hundreds of others that said exactly that. I don't—"Whatever they ask me for, I give them," and I don't know—"I just make it up." That's not exactly sound science.

The U.S. Circuit Court of Appeals, as you know, overturned the EPA radiation standards that were at 10,000 years. They said they were short by 290,000 years, and that the EPA is yet to come up with adequate radiation standards, because radioactive nuclear waste has a half-shelf life of 300,000 years.

There is water at Yucca Mountain. Originally—and I was a youngster, just out of law school when the "Screw Nevada" Bill was passed—but they told us that it was so dry that they would store the nuclear waste, and the mountain would collapse over the nuclear waste, and it would be encased in there for gazillions of years. The reality is the last time I took a tour of Yucca Mountain there was water dripping. It is not as dry as people say it is, as our so-called scientists say it is.

In an era of terrorism, why would we be generating more nuclear waste, when we know there are terrorists out there that would love to get their hands on the nuclear waste and use it? Why? To harm our country.

Then last—hardly last, but another issue is transportation. There is no safe way to transport nuclear waste across this country. For the 77,000 tons that currently exist throughout the United States at the nuclear reactor sites, it would take 108,000 truck load shipments over a 35-year period to now transport the nuclear waste that currently exists. Now we're proposing to rely more on nuclear waste and nuclear energy?

Perhaps the most important thing to me is Senator Harry Reid, and I have already publicly said that if any nuclear waste gets transported to the State of Nevada, we will lay down on that railroad track. I am sincerely hoping he is in front of me.

Nonetheless, I can assure you that nuclear waste is not an option for this country. It is 20th century technology in a 21st century world, and we better start figuring out how we're going to make up the extra 20 percent of our energy needs that, currently, nuclear energy satisfies. Thank you very much. Anyone have a comment?

Chairman RANGEL. What timing. The record will remain open for the response to that. We are about to conclude the hearing. Mr. Becerra is recognized for 5 minutes.

Ms. BERKLEY. Thank you.

Mr. BECERRA. Thank you, Mr. Chairman. I will be brief. I want to thank you all for your patience and your wonderful testimony. I think it is refreshing to have a discussion where we don't talk about whether there is global warming, but what we can do to address it.

So, I hope this will be the last time we have to come before Congress to have a discussion about whether there is such a thing as global warming, and what we have to do to address it. So, thank you for that.

I hope, as you go on and continue to give your expert opinions and your great advice and counsel on these matters, that you will also help us formulate policies that will address some concerns that I have, that as we try to move toward cleaner energies, alternative energies, and alternative methods of implementing these new approaches, that we don't forget that there are a lot of folks in America, modest income folks, who will have a tougher time making the switches over to these new energies, or the new methodologies, because it will cost them to do so.

I think everyone in America would love to drive one of these fuel-efficient hybrids, or would love to have their hands on an electric vehicle. The reality is, for a lot of folks, they can't even afford to get a newer, cleaner burning engine car, and they have to deal with the 10-year-old vehicle that they can afford, which is spewing out much more emission than would be a new car. They don't have a choice. So, please, please, please, as you are coming up with these ideas, don't forget that we have to make amends and make do for modest income Americans.

The other thing I would mention is that I hope we will continue to talk about our responsibility, as a nation. Because while we talk about the polluters that we see—and every time I go to one of these developing countries, you see these large municipal buses that are transporting people—Mr. Chairman, I will try to be brief.

Chairman RANGEL. There is a vote on the floor, and Ms. Jones wants to be recognized, and I want to say so long to the panel.

Mr. BECERRA. I will conclude, then, by just finishing that remark, and leaving a question for you to answer, if you can, for the record.

As much as we see these big buses that are spewing pollution in these developing countries, the reality is that we are the biggest polluters per capita, as a nation in the world. I hope that we will continue to focus on the fact that we need to be the leaders, to make sure the rest of the world follows.

Finally, the question I would have is, please let us know in your written comments the importance of predictability. If we want to have the private sector invest in these large scale projects to get us more energy efficient, what—how can we provide them the predictability to make these investments, to know that there will be a return on these investments into the future? So, the more you give us on that, the better off we are.

With that, I will yield, Mr. Chairman. Thank you very much.

Chairman RANGEL. Ms. Tubbs Jones.

Ms. TUBBS JONES. Mr. Chairman, thank you very much. Committee panelists, thank you for coming. Two questions I am interested in. Coal. Ohio is a big producing coal State, I want to know what you think about coal.

Secondly, about wind power, the first inventor came from Cleveland, of turbo-power. So, I would ask you about wind power. Mr. Chairman, thanks for being such a great Chair, and giving me a

chance. I would like to get some answers back in writing from you. Thanks.

Chairman RANGEL. I cannot tell you how impressive your testimony has been with this Committee. I have just advised staff that I would like to consolidate your testimony, and distribute it to the House for us to have, as a guideline, for the things that we have to learn in order to do the things that we have to do.

I also want to thank you for your patience for a very long hearing that we have had today. Take my word for it, your investment in time has made us better Members of Congress. Mr. McCrery.

Mr. MCCRERY. Amen.

Chairman RANGEL. Thank you again.

[Whereupon, at 12:55 p.m., the Committee hearing was adjourned.]

[Questions submitted by the Members to the Witnesses follow:]

Questions Submitted by Ms. Tubbs Jones to Ms. Claussen, Dr. Montgomery and Dr. Schneider

***Question 1: Coal Energy*—Almost 90% of Ohio's electricity comes from coal and Ohio has an enormous coal reserve. Coal production has been increasing in recent years, with production growing by 1.7% from the Appalachian region since 2004.**

- **What place does coal have in the low-carbon emission future of this country? Does it have a place?**
- **If so, what kind of further research must be done and what can this Committee do to support that research?**

Response from Ms. Claussen: The United States has significant coal reserves and likely will continue to burn coal well into the future. However, coal is inherently higher polluting and more carbon intensive than other energy alternatives. Large-scale implementation of carbon capture and sequestration (CCS) projects will be needed if climate change is going to be addressed in a meaningful way.

The first step is to fund research, development, and demonstration of technologies to separate and capture carbon as well as tests of carbon storage in a variety of settings. The United States has the geological capacity to store the emissions from its coal-fueled plants in depleted oil and gas reservoirs for several decades. Capacity in other geological reservoirs is estimated to be in the hundreds of billions of tons (500 billion tons of capacity); enough to store current levels of domestic emissions for over 300 years.

Once developed, these CCS technologies will need to be deployed to demonstrate their feasibility and to determine the costs associated with the various options. This would entail some 10–30 demonstrations, at scale, of commercial coal plants of a variety of configurations capturing and storing their CO_2 as well as multiple demonstrations of CO_2 injection in a variety of geological formations and geographic regions across the country. The estimated cost per CO_2 storage project (not including the acquisition of the CO_2) is estimated to be $15 million/year for a ten-year period.[1] This could be generated through public support, such as tax incentives or feebate programs.

Beyond research and early demonstration projects for commercial viability, the development and deployment of CCS technology will require a national, economy-wide policy—such as "cap-and-trade"—that provides the incentive for greenhouse gas reductions from all sectors, including electric power. Most recent estimates indicate that a price of at least $25 to $30 per ton of CO_2 would be needed to drive coal-based electric power plants to install CCS. Because states have substantial authority over electricity generation and environmental protection, they can play an important role in demonstrating, incentivizing and requiring CCS. However, they are no substitute for a nationally consistent program that promotes CCS for all large sources of emissions. Policies beyond cap-and-trade (such as performance standards) may also be needed to stimulate the development of CCS technology.

[1] Katzer, Doug, ed. 2007. *MIT Study on the Future of Coal—Options for a Carbon-Constrained World.* Cambridge, MA: Massachusetts Institute of Technology.

Finally, a regulatory framework for carbon storage is needed. This framework should include proper site selection, permitting processes, monitoring requirements, and public participation.

Response from Dr. Montgomery: Coal will continue to be used for many decades as a fuel for power generation in existing facilities under all but the most extreme proposals for carbon emission limits. However, unless carbon capture and sequestration technologies are developed and prove successful, the amount of coal production and use is likely to fall dramatically from current levels over the next few decades.

The recent MIT report on "The Future of Coal" lays out the R&D needs for carbon capture and sequestration in detail. I would emphasize two points: 1. that current research funding and plans fall far short of what is needed and 2. regulatory oversight and liability rules for carbon sequestration must be clear, realistic and flexible if there is any chance of sequestration technology succeeding.

Response from Dr. Schneider: Coal-burning is the most carbon dioxide emitting per unit electricity produced major system and thus expansion of coal as currently practiced is inconsistent with major reductions in greenhouse gases over time. However, the key is to transform the "as currently practiced" part to include end to end management of CO_2—probably by a crash R&D program to develop safe, long-term underground storage in saline aquifers or other suitable formations to keep the CO_2 sequestered and thus harmless from a climate point of view. It is not assured that the promising start with underground CO_2 storage in the enhanced oil recovery business (tens of millions on tons sequestered so far) will "scale up" if anything like business as usual emissions occurs over the twenty-first century (i.e. over a trillion tons of CO_2 would have to be safely and permanently stored).

As noted above, a major R&D program to evaluate the safety and permanence of massive scale carbon capture and sequestration is needed, along with efforts to lower the unit costs per ton CO_2 stored. This clearly will involve public/private partnerships and thus a clear role for the Ways and Means Committee in setting up tax or other incentives to spur such partnerships.

***Question 2: Wind Power in Northeast Ohio*—A Cleveland inventor, Charles Brush, was the first person to use a wind turbine to generate electricity as far back as 1888. Today, we have a power-generating wind turbine at the Great Lakes Science Center in downtown Cleveland and there are plans for more turbines in the works. Just last month, the Cuyahoga County Energy Task Force met to move forward with a wind farm off the coast of Cleveland in Lake Erie.**

- **What can we do to continue to encourage the development of wind technology? Are there any policies in place today that we can build upon to make this technology a central part of our alternative energy plan?**
- **Most importantly, what can this Committee do to help cities and programs like the Energy Task Force continue to support this technology?**

Response from Ms. Claussen: To encourage the development of renewable energy, including wind technology, a mix of policies to encourage generation and production and to reduce barriers for distributed sources is needed. Policies in place today, such as the federal production tax credit (PTC), have helped provide an incentive for additional investments. Our work suggests that creating a uniform system to track renewable energy credits (RECs) in a consistent manner could facilitate trading these credits across the country. In addition, incentives for uniform grid interconnection standards at the state level would also help to reduce the barriers to further development of wind technology.

Response from Dr. Montgomery: When wind generation is economic, it will be brought into the mix by electric generators and utilities who are motivated to obtain energy from the lowest cost sources. Putting a price on carbon emissions will provide that incentive for wind power and other forms of generation with zero carbon emissions. This Committee has jurisdiction over tax matters, and could investigate the adoption of a carbon tax as an alternative approach to managing carbon dioxide emissions that would increase the profitability of wind generation and aid all cities and programs that support the technology.

Response from Dr. Schneider: Similar to my answer for carbon capture and sequestration above, public/private partnerships to create incentives for innovation in technology and lowering of unit costs of electricity are also needed for renewable energy systems like wind power. In particular, storage systems to deal with the

intermittency of wind and very efficient transmission lines are still in the early development stages but could get a big boost by tax or other incentives to potential developers of these important energy alternatives.

Clearly, working with them on a balanced program of "carrots and sticks"—incentives for R&D exploration as well as penalties for dumping tailpipe and smokestack wastes in the atmosphere—clearly can move our development program forward.

***Question 3: National Standards on Renewable Energy*—Almost half the States of the Union, twenty-four, have enacted some sort of state-wide standard for renewable energy. These standards range from a certain percentage of power usage to a set number of megawatts produced from renewable sources. My home State of Ohio is one of those currently without a standard on renewable energy.**

- **Do you believe that a national standard is needed to curb the release of carbon dioxide or should we continue to pursue policies state-by-state?**
- **If a national standard is needed, are there any state policies or aspects of state policies that we should implement on a federal level?**

Response from Ms. Claussen: As you have correctly pointed out, various states have established standards for renewable energy. These state standards include targets ranging from modest to ambitious and their definitions of renewable energy vary. Though climate change may not be the prime motivation behind some of these standards, the use of renewable energy does deliver significant GHG reductions. For example, Texas is expected to avoid 3.3 million tons of CO_2 emissions annually with its RPS, which requires 2000 MW of new renewable generation by 2009. Increasing a state's use of renewable energy brings other benefits as well, including job creation, energy security, and cleaner air.

The Pew Center's preferred approach to federal policy is a cap-and-trade program that covers all major sectors of the economy. However, there may be a role for complementary programs to promote reductions in key sectors such as electric utilities. One potential role for the federal government would be to establish a uniform platform for defining renewable energy and establishing a uniform trading mechanism. Although the states may be in a better position to craft a portfolio tailored to their unique local resource mix, the current variation in state programs makes linkage across states difficult, so federal involvement in creating a platform is desirable.

Response from Dr. Montgomery: Managing climate risks requires reducing carbon dioxide emissions in the most cost-effective fashion. Renewables have a role to play, but they are not the only option and they frequently are not the most cost-effective option. Our research finds that a Renewables Portfolio Standard can increase the cost of achieving climate goals under a comprehensive cap and trade program or carbon tax. The RPS forces adoption of specific renewable technologies, and these technologies supplant more cost-effective options such as coal-fired generation with carbon capture and sequestration. We find that basing climate policy on an RPS alone could cost four times as much as achieving the same emission reductions through a comprehensive carbon tax or cap and trade program that allowed free choice between renewables and other zero emission technologies such as carbon capture and sequestration from coal fired generation. An RPS is a solution in search of a problem, and it is not a cost-effective solution to the problem of carbon dioxide emissions.

Response from Dr. Schneider: Yes. But, if enough states adopt such standards, it will have a major impact on the reduction of greenhouse gas emissions and lowering unit costs regardless of whether there is national policy. However, in homogeneity in both obstacles and opportunities makes it more difficult for the private sector which develops the technology—or the investment banking community that backs them up—to play on a level field. National scale rules do indeed provide more predictability to industries on how to invest. While I would never advocate denying states the opportunity to have tougher standards—California has led the nation and the world on this in pollution control for decades—I certainly think that some minimum national standards will make it easier for the business community to function in more cost-effective ways as they help us "invent our way out of the problem."

A study of the experiences of various states or nations in renewable portfolio standards might be useful to the Committee in assessing any minimum national standards and avoiding potential pitfalls and encouraging demonstrated opportunities. California has long insisted on performance standards for buildings and appliances and now automobiles and their experience shows it not only reduces pollution, but if carefully crafted, provides a return on investment for the average consumer

better than the mortgage interest rate—and thus can lower their effective monthly cost of living. That partially explains the strong bipartisanship in California on climate policy and energy efficiency—not only does it work for the environment, but it saves money too.

[Submissions for the Record follow:]

Statement of John A. Fees, The Babcock and Wilcox Companies

Chairman Rangel, Mr. McCrery and Members of the Committee:

My name is John Fees and I am the Chief Executive Officer of The Babcock & Wilcox Companies.

It is my privilege to provide this testimony on the combustion-based technology alternatives available today, and on the near horizon, that are designed to capture carbon dioxide emissions from electric power plants and to provide testimony on commercial nuclear power—carbon-free generation.

The Babcock & Wilcox Company has a rich legacy of providing reliable engineered technology solutions for efficient, base load electric generation throughout the U.S., North America and across the globe. We have sustained our business by developing and commercializing realistic solutions. Over many decades, we have successfully met the challenges of power generation and provided the technologies and equipment to resolve the associated environmental control issues. We provide commercially viable solutions to meet emissions control requirements of regulated pollutants. We will provide practical technologies to resolve the challenges of greenhouse gas emissions as well. B&W is a premier, comprehensive provider of clean energy.

The Babcock & Wilcox Company was formed in 1867. The first utility power plant in the United States had a boiler designed and supplied by B&W. B&W is the world's expert on steam which is still the most economic medium to generate electricity worldwide. B&W has literally written the book on "Steam." "Steam, Its Generation and Use" a text book produced by The Babcock & Wilcox Company, is the longest continuously published engineering textbook of its kind in the world, first published in 1875 and last updated in 2005.

Our manufacturing capabilities have also powered national security since the start of the last century. Teddy Roosevelt's Great White Fleet was primarily powered by B&W boilers. At the end of World War II, at the surrender of Japan, 395 of the 400 U.S. Navy ships in Tokyo Bay were powered by B&W boilers. In the 1950s, B&W became a major U.S. manufacturer and supplier of components for the U.S. Navy's fleet of nuclear powered ships and submarines.

Beyond defense, nuclear power is a route to carbon-free electricity generation for civilian purposes. We are the only U.S. manufacturer of the heavy nuclear components that will be required for the emerging civilian nuclear power plant build-up. As such we anticipate playing a critical role in the coming nuclear renaissance to provide clean, safe nuclear power.

Coal-fired and nuclear power plants provide the vast majority of the reliable and lowest cost electricity generation in this Country. Coal-fired and nuclear power plants combined comprise 41 percent of the Nation's electric generation capacity. Due to their cost effectiveness these plants generate 69 percent of all the electricity in the Country. These technologies are the foundation of our economic competitiveness, energy security, and increasing standard of living.

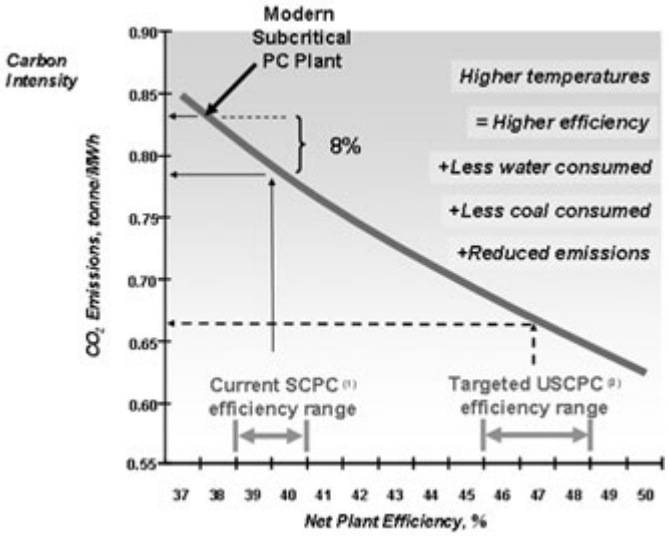
B&W's position as a premier developer and manufacturer of coal technologies and facilities is widely recognized. Thirty-eight percent of U.S. coal-fired boilers have been designed and manufactured by B&W. B&W supplies around one-third of all environmental control technologies and equipment to the U.S. coal power marketplace. We have been selected to provide many of the emission control technology solutions used by electric power generators to meet the strictest requirements under the Clean Air Act, the Clean Air Interstate Rule (CAIR) and various stringent air permitting requirements in the states. B&W has also been awarded a number of the new, highly efficient supercritical coal fired power plant projects, including the first high efficiency Ultra Supercritical Power plant in the U.S. in four decades.

Advanced Coal Power Technologies

Efficiencies

Efficiency at a power plant is measured by the ratio of the electricity generated compared to the energy in the fuel used. Increasing steam temperatures and pressures provides more energy to the steam turbine, enabling higher efficiency and allowing the same amount of electricity to be generated by burning less coal. This results in less production of CO_2 and pollutants derived by coal combustion, and reduced fuel costs.

Many existing U.S. coal-fired plants operate with relatively low steam temperatures and pressures (subcritical steam conditions). These old plants are generally used during high electricity demand periods because of the low generation efficiency, typically in the 30–35 percent range. When steam conditions exceed the combination of *both* 760F and 3200psi, the steam (or working fluid) is said to reach supercritical conditions. Efficiencies of these plants exceed 37 percent. Replacement of a relatively common 37 percent efficient sub critical unit with a 40 percent supercritical unit of same generating capacity would reduce CO_2 emissions by about 8 percent. Supercritical plants with efficiencies around 40 percent are already commercially available and being increasingly deployed. R&D projects with advanced materials and manufacturing methods are underway to permit increases of working fluid temperatures to 1200F, and then to around 1400F. When this happens efficiencies will rise above 43 percent toward 48 percent.



It is important to note when evaluating coal plant performance, that efficiency numbers, taken at face value, can be misleading. The U.S. convention for calculating efficiency, called "higher heating value (HHV)," is different from that used in Europe, "lower heating value (LHV)." One of the factors responsible for the difference is the way moisture in coal is treated in the efficiency calculation. There are other factors that enter into the calculation as well. The result is that, for virtually identical plant performance (coal fuel in vs. power out), the U.S. efficiency (HHV basis) would be reported as being 2 to 4 percentage points lower than European efficiency (LHV basis).

Pollutants

The emissions from pulverized coal-fired power plants have been reduced tremendously over the past three decades, with this achievement due in part to market based regulatory structures pulling technology forward for deployment. Great strides have been made in SO_2 and NOx reduction through scrubbing and selective catalytic reduction technologies. Fabric filters and improvements in electrostatic precipitators have reduced particulate emissions and more recently, technologies such as wet electrostatic precipitators and sorbent injection are capable of further reductions including fine particulates (PM2.5).

With technologies available to address regulated pollutants and major programs to retrofit the existing fleet in progress, public and industry attention turned to mercury. As a result, commercially available mercury control, for both eastern and western coals are being deployed. Now, concerns about climate change have intensified leading to the pressing need for the development of ways to address carbon dioxide emissions.

Carbon Dioxide Capture

There are several promising technologies to address capture of CO_2 from the use of fossil fuels and all are dependent upon development of a safe means of permanent storage. Assuming storage technologies can be commercialized and enabled, the challenge for coal combustion processes becomes one of extracting the CO_2 from the combustion process. A modern power plant using sub-bituminous coal will produce about 1,800 lbs of CO_2 per MWh. In an uncontrolled state, the CO_2 is diluted in the exhaust gas to about 15 percent of its volume; this creates a challenge to produce a concentrated CO_2 stream for storage.

Three approaches are presently seen as plausible carbon capture techniques:

(1) Oxy Coal Combustion for new and existing plants that burn coal,
(2) amine scrubbing and other CO_2 sorbents for new or existing plants that burn coal, and
(3) pre-combustion processes utilized by IGCC fitted with facilities designed to accommodate carbon dioxide capture.

Oxygen combustion produces a concentrated CO_2 in the combustion process by supplying pure oxygen instead of air for combustion eliminating nitrogen which dilutes the CO_2 concentration. Pre-combustion and amine scrubbing process extract the CO_2 from the gas stream using a regenerable solvent such as monoethanolamine (MEA). Some current studies now show oxygen combustion as the least costly while other studies lean toward pre-combustion or advanced amines, indicating that technology development is underway and competition is strong. None of the technologies has been demonstrated at significant size in an integrated full-scale system for electricity generation.

Oxy Coal Combustion

Only the Oxy Coal Combustion process is based upon equipment and systems that are already commercially available at the required scale. However, there are integration requirements, operating parameters and final designs that require verification at larger scale. Oxygen combustion and the major operational processes have been demonstrated at pilot scale and a new 300 MW commercial plant using this technology is being developed by B&W for the SaskPower Corporation to be located at Estevan, Saskatchewan.

In spite of the additional cost to concentrate a CO_2 stream for storage, recent studies show oxygen combustion to be competitive with the other capture technologies. Since this technology utilizes conventional equipment, it is likely to have a considerably lower deployment and operational risk, and has potential for retrofit to the existing fleet of conventional plants, where tenable.

Additionally, recent studies by the U.S. Department of Energy indicate oxygen combustion will be the lowest cost solution for coal and that the incremental cost increases of electricity using oxy combustion is less than the increase associated with amine CO_2 scrubbing.

Oxygen combustion provides a means of replacing the nitrogen in air with CO_2 gas exiting the combustion chamber. By recirculating a portion of the combustion stream the oxy coal combustion plant effectively replaces the nitrogen in a conventional system with CO_2 thereby inherently creating a concentrated CO_2 stream for permanent storage. The net effect is that the system looks and acts like a conventional power plant with which power plant operators are comfortable, but which is capable of near zero emissions given carbon storage. Additionally, by excluding air conveyed nitrogen from the combustion chamber there is a sharp reduction in nitrogen oxide emissions from this technology, which is likely to obviate the need for selective catalytic reduction facilities.

Although the properties of the flue gas differ from those with air firing due to the lack of nitrogen, it has been found that with the proper recycle ratio, an existing boiler can be converted to oxy coal combustion without changing heat transfer surfaces and only experiencing a small impact on fuel efficiency in the boiler island. For new units, optimized arrangements are being studied that offer some reduction in equipment size and improved performance.

The first generation of full-scale units is intended to require minimal change to the conventional power plant as reasonable to permit retrofit application and minimize risk. Advanced air separation technologies and optimization of the product gas specification and the cleanup/compression process are also expected to improve both performance and cost.

Radical Innovations

We see Oxy Coal technology as one of the potential carbon management solutions for the relatively near future. B&W is developing a portfolio of potential solutions,

including some that are radically different from any that are currently approaching readiness for full scale testing. One of these approaches involves destruction of carbon dioxide, using naturally occurring enzymes to catalyze the reaction. While clearly still at the research stage, this approach may bear the potential for greatly reducing the costs for carbon dioxide reduction in the longer term.

Closing Comments on Combustion-Based Climate Change Technologies

The first wave of near-zero emission coal plants will start operations around 2012. As industry learns from these early commercial deployments, we will make adjustments to improve efficiency and competitiveness. Technology development, economic and market incentives can accelerate the timeframe for implementing widespread carbon capture deployments on a commercial scale. This will only be successful if legislation does not favor one technology over another. Therefore, when considering any incentives for deployment, Congress should avoid provisions that provide marketplace advantages or disadvantages for any specific technology.

We are confident that our Oxy Coal Combustion technology can provide the most cost-effective solution for some power plants, while other technologies are better suited for others.

We are encouraged by indications that a consensus is building toward a market-based system for carbon management. A market-based system should encourage an efficient allocation of resources for reductions of carbon emissions both at new plants and, where tenable, at some existing plants. It is important to recognize that to significantly reduce our nation's CO_2 emissions, capture of CO_2 will have to occur at existing fossil-fired plants, where tenable.

We ask that the legislation support the acceleration of resolving and expanding Research and Development associated with carbon storage. In addition there is a need for clear policies regarding legal ownership of and liability for the injected CO_2, and concise communications to overcome local concerns with large annual injections at storage sites. We believe that unless the regulatory and technical obstacles to the long-term storage of carbon dioxide from electric power plants are resolved, these will become the limiting factors in reducing carbon emissions.

Commercial Nuclear Power

As the European Union recently realized with its decision to count nuclear power toward renewable energy goals, nuclear power will be central to any efforts to reduce our carbon dioxide emissions. Commercial nuclear power provides carbon-free baseload electric power. Approximately 20% of all electricity generated in the U.S. is generated from carbon-free nuclear energy. While European and Asian countries aggressively work to meet the demands of a growing commercial nuclear market, America is losing its industrial capacity, intellectual expertise, and competitive edge. For reasons of economy, environment and national security, this must change.

America's Nuclear Industrial Base is Insufficient

The unfortunate reality is that the United States does not have the domestic resources to build even one power reactor. Once the large, heavy forges and piping are acquired from overseas, we have the domestic capacity to manufacture about one and a half reactors annually. To construct enough reactors over the next twenty-five years to just maintain nuclear power's 20% contribution to America's total electricity production, we will have to triple that manufacturing capacity.

The Babcock & Wilcox Companies is the one domestic source of commercial reactor pressure vessels and steam generators. General Electric is the only U.S. manufacturer of commercial fuel assemblies. Meanwhile, foreign companies like Alstom, Toshiba, Ansaldo-Camozzi, Doosan, Equipos Nuclereas, S.A., Hitachi, Ishikawajima-Harima, and Mitsubishi are positioned to supply the vast majority of reactor vessels, steam generators and vessel heads that will go into the next generation of nuclear power plants.

The Nuclear Industrial Base: A Strategic Asset

Other nations understand the strategic and environmental significance of having a nuclear industrial base to support its nuclear activities. As carbon dioxide controls in whatever form, are legislated, nuclear energy will move towards being the lowest economic cost alternative. Furthermore, nations understand the vulnerability that they open themselves to by becoming overly dependent on foreign energy sources. The result is that many nations own and/or support their nuclear industrial base, make significant investments into their nuclear infrastructure, and artificially protect their domestic nuclear markets.

The only exception to this rule is the United States. Foreign firms, for the most part, compete openly and freely in the U.S, even if they are state-owned. On the other hand, unless the state makes specific provisions, most foreign markets are

very difficult for U.S. firms to access. This, along with the fact that no U.S. commercial nuclear power plant has been ordered in three decades, has caused major consolidation of the U.S. nuclear industrial base and a loss of our dominant position in the commercial nuclear industry.

Leveling the Playing Field

One of the problems with growing America's domestic commercial nuclear infrastructure is that the playing field is not level. Much of the global nuclear industry is either heavily subsidized, state owned, or enjoys other state-sponsored cost saving or risk mitigating measures. This environment makes competing very difficult for American companies. Some of the broad structural problems with the international nuclear market that perpetuate unfairness and U.S. disadvantage include:

- *Insurance and Indemnification*. Many countries provide insurance for nuclear firms or cap liability exposure. This non-tariff protection afforded to foreign companies disadvantages U.S. manufactures. It allows foreign, state-owned and supported companies to freely operate in the United States, but because U.S. firms do not enjoy the same protections, they often can not compete abroad. In cases where U.S. firms do compete abroad, they do so with increased risk or within the context of additional regulation. The Convention on Supplementary Compensation for Nuclear Damage (CSC) is a Treaty that the Senate ratified that would address this problem. Unfortunately, Congress has yet to pass the implementing legislation that the State Department requires before the instrument of ratification can be filed with the International Atomic Energy Agency. The CSC Treaty will establish an international indemnification regime that would commit the international community to common standards for handling nuclear facility accident claims, and provide for a supplemental international fund to pay victims. Without the Treaty, U.S. companies will not only be prohibited from competing for work overseas, but prevented from fully supporting the President's non proliferation agenda—ceding many of those activities to foreign suppliers. This is a serious trade/export issue.
- *Tariffs*. Many nations and international political groupings maintain significant tariffs on nuclear components. While the United States maintains tariffs on some components, it has in the past unilaterally waived the tariff on heavy nuclear components, placing domestic manufacturers of these components at a distinct disadvantage over established foreign competitors. The recently passed pension bill contains a provision that lifts the waiver after 2008 except for heavy nuclear components contracted for before July 31, 2006. This was a compromise position between industry and the utilities. Moving forward, the United States must assure tariff parity between the United States and its nuclear trading partners.
- *Domestic preferences*. While nations can compete openly with private U.S. firms in the United States, they often maintain domestic preferences for their domestic markets. The preferences include everything from raw materials to entire reactors and result in foreign states having much broader access to U.S. markets then the U.S. has to foreign markets. And given their ability to sell at discounted rates, private U.S. manufactures are severely disadvantaged in their own markets.
- *Overregulation*. The nuclear industry is inherently regulation heavy but some foreign states use gratuitous regulation to restrict foreign access to their markets. The additional cost for U.S. companies to transverse the regulatory environment is often too substantial to maintain competitiveness.

An Energy Policy Act for the Industrial Base

The Energy Policy Act of 2005 has successfully encouraged progress toward constructing the first new U.S. nuclear power plants in thirty years. While a critical first step, these efforts focus only on new nuclear power plant construction rather than on nurturing and building a robust domestic nuclear industry. Recent federal efforts only benefit a small portion of the nuclear industry, such as construction companies, reactor designers and utility firms. This approach ignores the broader domestic nuclear industrial base required to support a growing nuclear industry and its employment of highly skilled manufacturing jobs. As a follow on to the Energy policy Act of 2005, Congress should provide incentives to invest in America's nuclear supplier base. These are the companies that will manufacture the components, pour the forgings and extract the raw materials needed to support a nuclear renaissance. Such a program would help to offset the economic advantages of heavily subsidized foreign companies.

Similar programs are now needed to resurrect America's nuclear industrial base. American manufacturers need a tax incentive program geared to offset economic advantages of heavily subsidized foreign companies.

Congress should level the playing field. These efforts should focus on stimulating the production of those components that are either not available in the domestic commercial market or for which there is a single domestic supplier; new nuclear technologies; and nuclear workforce training programs. Loan guarantee should focus on facility capitalization and other capital growth investments. These incentives should go directly to companies that manufacture components as well as to utilities for buying domestically. This would provide the same sort of stimulus for the nuclear industry that existing efforts have provided to the commercial reactor design and plant construction industries. Congress should include a sunset clause that eliminates the incentives once domestic industry has had the opportunity to compete on a level playing field and reestablish itself.

Having a domestic supplier of these components to compete with the heavily subsidized international nuclear industry, not only provides jobs for American workers, but will be essential to keeping prices in check and quality high. Without such an incentive program, it will be difficult, at best, for American companies to reenter the commercial nuclear business. The U.S. could, thereby, be relegated to spectator status as nations such as Russia, France and China, lead the world through the emerging nuclear renaissance. Their control of the manufacturing base and fuel business could lead to secondary treatment in delivery priority for critical components and higher prices. In the end, the United States is in danger of shifting its foreign dependence from oil and natural gas to nuclear industrial components and technology supply and in the process weakening our participation in developing nuclear non-proliferation efforts.

Thank you for the privilege to provide testimony to the Committee on these critically important matters.

Statement of NGVAmerica

Introduction

NGVAmerica appreciates the opportunity to provide the following statement concerning America's energy policy. NGVAmerica is a national organization of over 100 member companies, including: vehicle manufacturers; natural gas vehicle (NGV) component manufacturers; natural gas distribution, transmission, and production companies; natural gas development organizations; environmental and non-profit advocacy organizations; state and local government agencies; and fleet operators. NGVAmerica is dedicated to developing markets for NGVs and building an NGV infrastructure, including the installation of fueling stations, the manufacture of NGVs, the development of industry standards, and the provision of training.

The Ways and Means Committee has indicated it will hold a series of hearings to address energy and tax policy. This effort also will address global warming and the climate change implications of energy use. The first hearing on this issue was held February 28, 2007. NGVAmerica's comments respond to the committee's invitation for interested organizations to provide statements for the record. Our statement also addresses the Bush Administration's goal for 2017 of using 35 billion gallons of non-petroleum fuels. NGVAmerica has submitted a similar statement for consideration by the Senate Finance Committee, which is holding hearings on the same issues.

NGVAmerica is pleased to provide the following statement to the committee as it considers these very important issues. NGVs can and will play an increasing role in replacing petroleum motor fuels and reducing emissions that contribute to climate change. Congress already has taken a number of steps to encourage greater use of natural gas and other alternative transportation fuels. These steps were enacted as part of the Energy Policy Act of 2005 and SAFETEA–LU. These incentives include tax credits for alternative fueled vehicles, alternative fuel infrastructure and alternative fuel use. Consumers and businesses alike are benefiting from the congressional action that was taken to encourage the increased use of alternative fuels. However, much more must be done if the U.S. is to begin the long process of transitioning away from the use of petroleum motor fuels—especially if America is to achieve the goal called for the President in his State-of-the-Union address of displacing 35 billion gallons of petroleum transportation fuels by 2017. This effort will require sustained and significant federal support since the risks associated with this effort are simply too great for private industry to undertake them alone in the timeframe needed. Moreover, this effort will require a mix of different transportation

fuels to fill the void provided by petroleum since no one single fuel appears likely to supplant petroleum.

The comments provided below discuss the potential benefits of increasing the use of NGVs and ways in which the committee can assist in achieving them. Increasing the use of natural gas vehicles (NGVs) can: (1) reduce America's dependence on foreign oil, (2) improve air quality in urban areas, (3) reduce emissions of greenhouse gases, and (4) pave the way for the more rapid introduction of hydrogen transportation technologies.

Summary of Recommendations

1. Extend and amend the tax incentives for purchasing natural gas vehicles, using natural gas in those vehicles and building natural gas fueling infrastructure.
2. Provide the same tax incentive for biogas converted to biomethane as currently exists for biogas used for electricity generation.
3. Provide tax incentives for natural gas use in off-road vehicles.

Rationale for Recommendations

Reducing Petroleum Reliance

There has been much discussion and controversy about the energy balance of various alternative fuels and their ability to reduce petroleum consumption. In the case of natural gas, each gasoline gallon equivalent of natural gas used for transportation displaces nearly 100 percent of the petroleum that would otherwise be used in the form of gasoline or diesel fuel. Furthermore, nearly 85 percent of the natural gas currently consumed in the U.S. is from domestic sources—produced right here in the continental U.S., the Gulf of Mexico, or Alaska. Most of the remainder is imported from Canada. The total U.S. natural gas resource base, including proved reserves, is more than 1,300 trillion cubic feet, over a 65-year supply of natural gas at current production levels.[1] Thus, U.S. supplies of natural gas are abundant and secure. With sufficient will, supplies of *conventional* natural gas will continue to grow as U.S. demand for this valuable fuel grows. And with the right incentives, non-conventional, renewable sources of natural gas also could increasingly be available to U.S. consumers. For example, an analysis previously conducted for DOE estimated that the U.S. could feasibly produce 1.25 quadrillion Btu *annually*. This is equivalent to 10 billion gasoline-gallon-equivalent of biomethane from landfills, animal waste processing facilities, and sewage.

Biomethane is pipeline-quality natural gas produced by cleaning up and purifying biogas. Biogas is a mixture of methane and other gases produced from the decomposition of organic materials such landfill waste. Thus, biomethane is a renewable source of natural gas. In the U.S., the production of biomethane has been overshadowed by the production of electricity from biogas. This is partly because the U.S. tax code encourages renewable electricity production but does not encourage biomethane production. In addition, many of the incentives recently adopted in the Energy Policy Act of 2005 (grants, loan guarantees, demonstration projects) favor bio-refineries that produce liquid fuels, or more specifically ethanol. If these incentives were expanded to be biofuels-neutral, the U.S. could more quickly realize the potential of this valuable fuel source. Other countries are moving forward with biomethane development even as they also move forward with increased ethanol use. In Sweden, twenty-five biomethane production facilities are in use and there are sixty-five fueling stations now dispensing biomethane for transit buses and other vehicles.[2] Some positive developments are occurring here in the U.S. California officials recently signed a memorandum of understanding to work with officials from Sweden to advance the use of biomethane as part of California's bioenergy initiative.[3] And just this year, Prometheus Energy, a Washington State-based company, began producing biomethane at the Bowerman Landfill in Irvine, California.[4] This facility will be producing 5,000 gasoline-gallon-equivalent of biomethane per day. The biomethane will be used to fuel low-emission, transit buses operated in Orange County.

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[1] See—American Gas Associations (U.S. Resource Base)—http://www.aga.org.

[2] See State of California Department of Resources Press Release June 29, 2006—http:// resources.ca.gov/press_documents/CaliforniaSwedenBioenergyMOURelease_06_29_06.pdf

[3] See Memorandum of Understanding Between State of California and Sweden; http:// resources.ca.gov/press_documents/CaliforniaSwedenBiofuelsMOU.pdf

[4] See GreenCar Congress (January 25, 2007)—http://www.greencarcongress.com/2007/01/prometheus_prod.html; or Prometheus Energy—http://www.prometheus-energy.com/whatwedo/bowerman.php

If fully utilized, biomethane could offset nearly all or most of the future demand for natural gas as a transportation fuel. As noted above, the potential exists to produce an estimated 10 billion gallons equivalent. This amount of fuel represents nearly a third of the President Bush's announced target for 2017 of achieving the production and use of 35 billion gallons of non-petroleum motor fuels.[5] Current demand for natural gas as a transportation fuel in the U.S. stands at about 200 million gallons per year. Thus, the increased use of natural gas for transportation could grow substantially in the coming years, offsetting a large amount of petroleum, and be supplied almost exclusively by renewable sources. Importantly, most of the fuel inputs that would be used to produce biomethane (e.g., sewage, landfill gas, animal waste) are currently underutilized or not used at all. Therefore, encouraging the production and use of biomethane would not harm other industries and would provide additional revenue stream for those industries that currently process and handle these feedstocks. Farmers and other operators of animal facilities can install anaerobic digester systems to convert their animal waste to usable biomethane—with valuable, sanitary fertilizer as a byproduct. Longer term, cellulosic crops could be used to produce biomethane. Currently, the focus on cellulosic biofuels is on cellulosic ethanol. However, cellulosic crops also could be used to produce biomethane if the government were to provide biomethane refineries the same level of incentives as currently being given to ethanol biorefineries.

Climate Change Benefits

The use of conventional natural gas in motor vehicles reduces greenhouse gas emissions by 15–20 percent.[6] More recent emission testing programs indicate that greenhouse gas reductions from using natural gas in heavy-duty applications may be as much as 20–30 percent, based on improvements to natural gas engine technology and changes to petroleum fueled vehicles.[7] These emission benefits are in addition to the very large reductions in volatile organic compounds, nitrogen oxides and air toxics provided by using natural gas as a motor vehicle fuel.

The greenhouse gas benefits provided by natural gas vehicles are significantly greater if the natural gas is biomethane. This is because capturing and using biomethane offsets flaring or venting of methane emissions that would otherwise occur, and also offsets the emissions associated with producing, refining and burning gasoline and diesel fuel. Methane is a significant greenhouse gas—estimated to be 21 times as intense a greenhouse gas as carbon dioxide. Capturing and "flaring" biogas reduces the methane to carbon dioxide. But, in doing so, its energy value is wasted. An energy-wise and greenhouse gas-wise alternative is to capture the biogas from these renewable waste sources, convert that biogas to biomethane, and use the biomethane to displace petroleum or other fossil fuels in transportation or other energy applications. If the potential biomethane resources in the U.S. were realized (i.e., 10 billion gallons per year), the estimated greenhouse gas reductions would be on the order of 500 million metric tons of CO_2 per year—or the equivalent of removing 90 million light-duty gasoline vehicles from the roads.

Paving the Way for Hydrogen

DOE's long-range plans to address energy independence and lessen the environmental impact of motor vehicles call for a transition to hydrogen fuel cell vehicles (FCVs). This goal includes producing hydrogen from renewable energy sources, such as solar, wind, or even landfills. In the near-term, however, hydrogen will most likely be produced by steam-reforming natural gas. Currently, natural gas steam-reforming represents nearly all U.S. hydrogen production (used mostly by refineries) and about half of world hydrogen supply. Natural gas is used because methane (the main constituent of natural gas) has the highest hydrogen-to-carbon ratio of any hydrocarbon fuel. Thus, natural gas provides a near-term, widely available feedstock with a proven technique for separating out hydrogen molecules. During the initial launch of hydrogen-fueled vehicles (both FCVs and internal combustion engine vehicles, or ICEVs), it is likely that demand for hydrogen fuel in the transportation sector will be met through the steam reforming of natural gas.

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[5] The President's Advanced Energy Initiative now includes a target of achieving 35 billion gallons of non-petroleum motor fuels. Few details have been released on this target but it is believed that it is based largely on increased use of ethanol. A gallon of ethanol, however, has far less energy than a gasoline gallon, about 35 percent less energy content. If the 35 billion gallon target is based on the energy content in ethanol, achieving 10 billion gasoline gallon equivalent of biomethane would actually represent about 43–44 percent of the President's target.

[6] See Argonne National Laboratory, GREET Model (2007); http://www.transportation.anl.gov/software/GREET/

[7] See National Renewable Energy Laboratory, WMATA Emission Testing Report, December 2005; http://www.cleanenergyfuels.com/pdf/NREL-WMATA_DieselvNG21606.pdf

There is another equally important link between natural gas and hydrogen, however. That link is the infrastructure, technology, and experience currently being developed to use compressed natural gas and liquefied natural gas as transportations fuels. By advancing the market for CNG and LNG, it just might be possible to accelerate the transition to hydrogen. Attached is a list of some of the ways increased use of natural gas is making the hydrogen future more viable.

Tax Policies and Incentives Needed to Increase Natural Gas Use

In order to achieve the potential benefits of increased natural gas use, NGVAmerica urges the Ways and Means Committee and Congress to consider the following measures.

1. Alternative Fuel Excise Tax Credit

The 2005 Transportation Law (SAFETEA–LU, § 11113, Pub. L. No. 109–59) provides tax incentives for natural gas and other alternative fuels when used as vehicle fuels. That alternative fuel credit expires on 9/30/2009. This short timeframe sends the wrong message to businesses and consumers about the government's support for using natural gas and other alternative fuels, and is inconsistent with the President's 2017 goal of replacing 35 billion gallons of petroleum with alternative fuels. Therefore, the incentive for alternative fuels should be extended until the end of 2016. Moreover, Congress should clarify that the tax credits provided for alternative fuels are not includable in income since such treatment would significantly discount the benefit (and, therefore, the impact) of this incentive. The IRS is currently looking at the treatment of the tax credits when taken by taxable entities, and has indicated that they may be includable income. Also, the tax credits for alternative fuels should be amended so that they are available on an accelerated basis just like the alternative fuel mixture credits; taxpayers filing for alternative fuel credits currently must wait until end of year to file certain claims (over and above excise tax offsets) while persons filing for alternative fuel mixture credits may file multiple claims during the year for payments from the government.

2. Alternative Fuel Vehicle Purchase Income Tax Credit

The 2005 Energy Law (EPAct 2005, § 1341, Pub. L. No. 109–58) provides tax credits for the purchase of dedicated alternative fuel vehicles, including NGVs. The alternative fuel vehicle credit expires on 12/31/2010. As with the fuel credit above, the short timeframe for this incentive sends the wrong message to businesses and consumers about the government's support for NGVs, and is inconsistent with the President's petroleum replacement goal. Therefore, the incentive should be extended until the end of 2016. The existing credit covers 80 percent of the incremental price for dedicated vehicles that meet the most stringent emission standards, and 50 percent for other dedicated vehicles. Since much of the emphasis on promoting alternative fuels has shifted to petroleum replacement and since dedicated NGVs displace 100 percent of the petroleum that would otherwise have been used, the credit for dedicated vehicles should be expanded to 90 percent of the incremental price. Congress also should provide a credit of 50 percent of incremental cost for the acquisition of bi-fuel NGVs since some businesses and consumers will continue to demand the flexibility of a multi-fuel vehicle until alternative fueling infrastructure is more widespread. In order to make these credits attractive to businesses, they should be exempt from tentative minimum tax provisions. Imposition of the minimum tax means that most large fleets are only able to use the tax credits as an incentive to acquire a very small number of new NGVs each year. Fleets represent the best opportunity to maximize the use of alternative fuels but this opportunity will not be realized if fleets receive an incentive that encourages no more than one or two NGV acquisitions each year.

3. Alternative Fueling Station Income Tax Credit

EPAct 2005 (§ 1342, Pub. L. No. 109–58) provides for an income tax credit of 30 percent up to a maximum of $30,000 for the installation of business NGV fueling stations and $1,000 for home refueling equipment. This incentive is inadequate to spur fueling station expansion. Large natural gas fueling facilities, capable of fast-filling frequent customers, cost up to $1 million. The cost of even the least expensive home refueler (with installation) can be upwards of $5,000. Therefore, the fueling station credit should be increased to 50 percent with a maximum of $300,000, and the home refueling credit to a maximum of $2,000. The tax credit for fueling infrastructure also should be exempt from the minimum tax provisions. Most fueling facilities are currently being developed by a small number of companies that build and operate stations for customers. If tax credits are subject to minimum tax, these businesses will only be encouraged to install a minimal number of new stations each year.

4. AFV and Fueling Infrastructure Tax Credit for Not-For-Profits

As mentioned above, EPAct 2005 (§§ 1341–1342, Pub. L. No. 109–58) provides an income tax credit for part of the incremental price of new alternative fuel vehicles and alternative fuel stations. In an effort to ensure that public agencies also could benefit from this incentive, Congress provided that, when the purchaser is a public entity, the income tax credit can be passed back to the vehicle or equipment seller—with the expectation that the seller would pass some or all of the incentive to the buyer in the form of a lower purchase price. For a number of reasons, however, very few public agencies have benefited from this provision. Frequently, the sellers do not have sufficient tax liability. Transit bus manufacturers are a good example. In other cases, the alternative minimum tax eliminates the seller's ability to capture (and, therefore, pass on to the public agency) the tax credit. To provide public agencies with a clear and certain incentive to buy alternative fuel vehicles and install associated fueling stations, Congress should provide public agencies with the option of receiving the value of the credit as a federal grant or other direct federal payment.

5. Biomethane Production Credit

Biogas (i.e., methane-rich gas produced from animal waste, crop waste, crops, sewage and landfills) that is used to produce electricity is eligible for a Section 45 production tax credit.[8] However, if that same biogas is used directly (e.g., for on-site steam production) or is converted to pipeline quality methane and used for any other purpose, the biogas producer receives no credit. All use of renewable biogas should be encouraged. Therefore, the Section 45 biogas credit should be redefined to include all energy uses of biogas.

6. Tax Credits for Off-Road Vehicles

The vehicle, infrastructure and fuel use credits for alternative fuel vehicles included in the 2005 Energy and Transportation laws are generally limited mostly to on-road vehicles. However, about a quarter of the fuels used in transportation are used in off-road vehicles. Since these vehicles do not have to meet on-road vehicle emission standards, they tend to produce far more emissions than comparable on-road vehicles. To help reduce our dependence on foreign oil as well as air pollution, off-road vehicles should be provided financial incentives to move to non-petroleum fuels and technologies.

Conclusion

NGVAmerica appreciates the opportunity to provide these comments. We look forward to working with the committee as it crafts legislative proposals to address our nation's energy policy in ways that will diversify the mix of fuels used in transportation, provide greater energy security, reduce reliance on petroleum fuels, and increase the use of fuels that address climate change.

Attachment

How NGVs and Helping to Paved the Way for a Hydrogen Transportation Future

Fuel Storage

Until major breakthroughs in hydrogen storage technologies are realized, hydrogen will most likely be stored on-board vehicles as a compressed gas or a cryogenic liquid. Today's prototype hydrogen vehicles are able to use existing tank technology for CNG or liquefied natural gas (LNG) vehicles as base technologies for hydrogen storage. However, to achieve commercialization objectives (e.g., sufficient driving range), FCVs and other types of hydrogen vehicles will require ongoing advancements in on-board hydrogen storage technology. Fuel storage capacity also must be safely increased, while reducing cost and weight. Because of similar material and manufacturing issues, several companies that make NGV tanks are also designing improved fuel-storage systems for hydrogen vehicles, applying their vast experience from years of developing onboard CNG and LNG tanks.

Fuel Management and Safety Systems

As with fuel storage technologies, commonality exists among companies working on fuel management systems for NGVs and FCVs. Generally, advancements made for natural gas systems also have application to hydrogen systems. Onboard safety technology designed for NGVs (e.g., gas detection and fire suppression) are also being applied to hydrogen vehicles.

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[8] See 26 U.S.C. § 45.

Fueling Station Infrastructure & Dispensing Equipment

Fuel cell vehicles will deliver the greatest benefits (zero emissions, highest system efficiency) if they are designed to operate on direct hydrogen, rather than operating on hydrogen reformed onboard the vehicle. FCVs, therefore, require access to hydrogen fueling stations. It is unlikely that, early on, hydrogen for these stations will be produced at large methane-reforming plants, and transported to the stations via trucks or pipelines. A far more likely scenario is that the hydrogen will be reformed in relatively small volumes *at* the local station using pipeline natural gas. Pre-existence of the necessary natural gas pipeline infrastructure makes this feasible. The U.S. has more than 1.3 million miles of natural gas transmission and distribution lines. In addition, the U.S. has more than 1,000 fueling stations that currently supply natural gas for motor vehicle use. It only makes sense that some of these stations also would be modified to serve fleets using hydrogen fuel. In fact, some already are providing hydrogen. The existing natural gas infrastructure makes reforming of natural gas at existing gasoline stations a convenient, relatively cost-effective option for producing hydrogen. Today's natural gas dispensers are a bridge technology to pumps that will fuel tomorrow's vehicles using either compressed or liquefied hydrogen. Much commonality exists between systems that dispense and meter these two fuels, whether in gaseous or liquid form. Consequently, today's natural gas dispensers are paving the way for affordable, user-friendly hydrogen dispensers. NGVs also can be refueled overnight at home—a major advantage compared to gasoline vehicles. Today's home refueling appliances (HRAs) that dispense CNG are also being designed for longer-term capability to refuel FCVs in the residential setting. In this way, home refueling of NGVs provides a clear pathway to the longer-term scenario of fueling FCVs at home.

Natural Gas/Hydrogen Blends

Compressed hydrogen can be blended with CNG to produce an exceptionally clean transportation fuel. With relatively minor vehicle modifications, this blend can be used in today's heavy-duty NGVs. For example, transit buses at SunLine Transit Agency in the Coachella Valley are operating in revenue service on a blend of CNG and hydrogen. This is helping SunLine to gradually transition its bus fleet to 100 percent operation on hydrogen. Similar efforts are underway in other areas, such as Las Vegas. Many members of the NGVAmerica are cooperating in efforts to develop and demonstrate vehicles that operate on this type of hydrogen-natural gas mixture.

Codes & Standards, and Safety Training

A host of other ongoing issues must be addressed for hydrogen to become a common transportation fuel. Many of these issues currently are being addressed by users of natural gas vehicles. As hydrogen transportation technologies gradually move from the demonstration phase into commercial deployment, a new structure of human support services will be needed. This includes specialists such as mechanics, inspectors, and fire marshals who are familiar with FCVs, hydrogen fuel, and fueling stations. The NGV industry is already helping to create such a support structure. To serve today's well-established markets for NGVs and natural gas fueling stations, thousands of people have been trained in related jobs. This support structure continues to grow, serving as a harbinger for training of America's future hydrogen workforce and the people who will be responsible for deploying hydrogen vehicles and fueling stations on a commercial scale.

Statement of Nuclear Energy Institute

Mr. Chairman, Ranking Member McCrery and members of the Committee, the Nuclear Energy Institute[1] appreciates this opportunity to express the nuclear energy industry's views on ensuring America's energy future in a carbon constrained world. We are committed to ensuring that clean, safe, and reliable nuclear energy is part of that future.

[1] NEI is the organization responsible for establishing unified nuclear industry policy on matters affecting the nuclear energy industry. NEI members include all companies licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel suppliers, and other organizations and individuals involved in the nuclear energy industry.

Clearly, the challenge of addressing climate change is a priority with the 110th Congress. The leadership of both houses is committed to meeting this challenge with policies that will both protect our global environment while preserving America's economy.

The climate legislation introduced to date recognizes the need to provide incentives to stimulate the development and deployment of a portfolio of clean-energy technologies, including nuclear energy.

Innovative tax policies are needed to ensure construction of the significant amount of new infrastructure that will be required to reduce greenhouse gas (GHG) emissions, meet increasing demand for electricity, and maintain economic growth in the United States.

Nuclear Energy Is A Non-GHG-Emitting Source of Baseload Electricity Generation

Nuclear energy plays the single-largest role in the U.S. electric industry's contribution to greenhouse gas emissions reductions. At present, approximately 30 percent of America's electricity comes from sources that produce no air emissions or greenhouse gases: nuclear energy, hydroelectric power, wind and solar. Nuclear energy alone produces 73% of this carbon-free electricity, enough for one of every five U.S. homes and businesses.

In 2005, the 103 existing nuclear plants avoided the emission of 682 million metric tons of carbon dioxide (CO_2), which is more than double the emissions avoided by all the other non-emitting sources of electricity combined.

According to the newly released annual report to the U.S. Department of Energy from Power Partners—a voluntary partnership between DOE and the electric power industry—improvements and expansion of the existing nuclear plants accounted for 54 percent of greenhouse gas reductions reported on a project basis by the electric sector in 2004, the equivalent of taking 100 million automobiles off the road.

Although continued improvements by the existing nuclear fleet will achieve further emission reductions, additional large-scale reductions in U.S. GHG emissions will require building new nuclear plants. The Energy Information Administration estimates that U.S. electricity demand will increase 45% by 2030. America must build 50,000 megawatts of new nuclear generation by 2030 just to maintain nuclear energy's current 20% share of electricity supply.

Tax Stimulus Is Needed For Building New Clean-Energy Generation

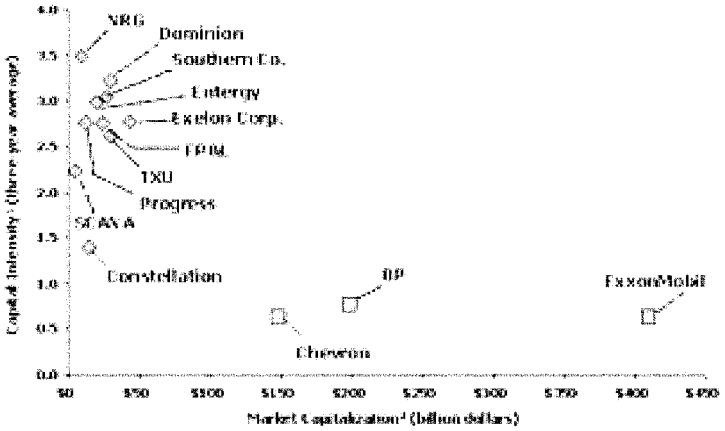
The electric sector must spend over $750 billion by 2020[2] to meet increasing electric demand and more stringent environmental requirements—before considering any climate change policies. Part of that investment will be in new baseload generation, some of which will be new nuclear power plants.

The Energy Policy Act of 2005 provided limited financial incentives to encourage deployment of new, advanced nuclear plants. Since its passage, fifteen companies and consortia have announced plans to license more than 30 new nuclear plants. Turning those licensing plans into the construction of new nuclear power plants will require federal and state government policies that recognize the large capital outlay during construction.

The electric sector is the most capital-intensive among major industrial industries. The electric companies shown in Figure 1 have all announced plans for new nuclear construction. They are significantly more capital-intensive than the major oil companies also shown—and significantly smaller.

[2] Sources: Cambridge Energy Research Associates, Edison Electric Institute.

Figure 1—Capital Intensity Versus Company Size



Constructing a new nuclear power plant is a capital-intensive project—between $3 and $5 billion each. This is a major investment for companies the size of U.S electric companies. To build baseload plants that will provide 40–60 years of stable-priced, non-GHG-emitting generation, many of these companies will require investment stimulus and investment support, to enable them to maintain sound financials and ratings during the four to five year construction period.

Carbon-free Nuclear Energy Must Play a Key Role in Our Nation's Energy Future

The nation's energy portfolio must include clean, reliable and affordable energy sources available today, such as nuclear energy. Nuclear energy offers several unique advantages. It is the only expandable baseload energy source that does not emit carbon or other greenhouse gases into the atmosphere during operation. Nuclear energy safely and reliably provides price stability for electricity customers as the prices for fossil fuels fluctuate.

There are exciting new opportunities in areas such as hydrogen production and plug-in hybrid automobiles, enabling nuclear energy to help reduce carbon emissions from the transportation sector.

Although our nation must continue to employ a mix of fuel sources for generating electricity, it is important that nuclear energy maintain at least its current 20 percent contribution to U.S. electricity production. Maintaining that level of production will require construction of a significant number of new nuclear plants beginning in the next decade.

To ensure the electric industry builds capital-intensive new nuclear power plants, policies must be in place to stimulate investment and provide limited construction support to companies willing to build the first plants.

Statement of Mark Willers, Minwind Energy, Rock, Minnesota

In our small community of Rock County we have 9,600 people. We have put together 360 farmers and local townspeople to participate in the only local-owned multi stockholder commercial wind farm in the United States.

We are asking for review of the policy in section 45 of the IRS Tax Code which prohibits farmer, military personnel, and local citizens from receiving Production Tax Credit (PTC), and the removal of restrictions on alternative minimum tax (AMT) on their income. This is accomplished currently by restricting PTCs (for wind) to be used only on passive income and not ordinary income. We request that PTCs be available on ordinary income with no AMT applicable.

Local people have no or little passive income. Section 45 tax code is penalizing the middle class, working people and promoting more foreign ownership. Foreign companies are renting up sites for wind turbines for which they can use U.S. tax credits to offset their income. We can not compete in this environment. There is presently no cap on total PTC outlays so this should be scored at zero. I am requesting a chance to explain this to your full committee. I will come to Washington, DC to explain in greater detail.

Please help U.S. citizens first!! There is a GAO report on our company putting 7½ times more income in the local economy. Thank you.

Conyers, Georgia 30012
February 28, 2007

While the use of fossil fuels by mankind may have a slight impact on the Earth's climate, the level is insignificant when compared to the dynamics and subsequent GHG emissions of the Earth itself. The burning of fossil fuels is simply recycling the carbon molecules that have been present on Earth since it began 4 billion years ago.

The single largest anthropogenic forcing on our climate comes in the form of solar radiation from our own Sun. The largest protector the Earth has in preventing dangerous amounts of radiation from penetrating our atmosphere in the first place is the magnetic field generated by the core dynamo of the Earth itself. The magnetic flux lines that are generated in parallel lines of force from the south magnetic pole to the north magnetic pole create a shield the reflects much of the energy before it ever reaches the upper atmosphere.

It is also the weakening of this very same magnetic field for the past 150 years that is responsible for the rapid climate change we perceive is occurring. The weakening of the field can only be theorized at this point that the Earth's magnetic field may be in the infancy stages of a pole reversal, which has not occurred in over 780,000 years (see MSNBC article "Earth's Weakening Magnetic Field," by Andrew Bridges, 12/10/2003). The most significant indicator and possibly the cause of the degrading field coincides with the rapid acceleration of the magnetic poles movement, which is now calculated to reach Siberia by 2040 and is moving at a rate of nearly 40km per year. And since the Earth's poles are shaped like a traditional bar magnet, this also means the South magnetic pole is also moving at the same rate. The normal movement up until the late 1980's dictates the movement has been 5 to 6 km per year.

The effects of this movement are proven to cause a distortion and bending of the normally parallel lines of the protective magnetic shield (flux lines). This distortion automatically weakens the effectiveness to shield out the solar radiation and has been measured to be at least 10% weaker than 100 or 150 years ago (see National Geographic "Earth's Magnetic Field is Fading," by John Roach, Sept. 2004). In layman's terms, this means that 10% more solar radiation is getting through to heat up our atmosphere and oceans, causing hot spots to occur and violent storms to spawn.

In addition to the increased thermal activity, the atmosphere is also being bombarded with 10% more photon/electron penetration as a whole. This increase on the molecular level causes increased electrical activity between the Earth and the atmosphere as the unlike charges naturally try to cancel the imbalance. This is simply one more effect that is noted during thunderstorms, tornadoes, and hurricanes when referencing the amount of electrical activity within the storms and the increase of ozone production due to lightning.

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