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CLIMATE CHANGE TECHNOLOGY AND POLICY OPTIONS

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED SEVENTH CONGRESS

FIRST SESSION

JULY 10, 2001

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED SEVENTH CONGRESS

FIRST SESSION

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CONTENTS

WITNESSES

APPENDIX

CLIMATE CHANGE TECHNOLOGY AND POLICY OPTIONS

TUESDAY, JULY 10, 2001

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met at 9:30 a.m., in room SR–253, Russell Senate Office Building, Hon. John F. Kerry, presiding.

OPENING STATEMENT OF HON. JOHN F. KERRY, U.S. SENATOR FROM MASSACHUSETTS

Senator KERRY. The hearing will come to order, which it appears to already have done brilliantly.

Good morning everybody, and welcome to this full Committee hearing of the Commerce, Science, and Transportation Committee. I would like to thank Chairman Hollings and Ranking Member McCain for calling the hearing and heading us off in the direction that we will move today, and I would like to put that in a context if I can just for a moment.

For many years now, we on this Committee have held hearings on the issue of global warming starting around 1990, 1991. Then Senator Gore joined me to begin the early inquiries into global climate change. A number of us traveled to Rio de Janeiro for the Earth Summit in 1992 where the original framework convention on climate change was passed, which was obviously a voluntary framework, but which established that this is a serious problem and that we need to deal with it.

Here we are now in the next century, the next millennium, 2001, and regrettably some have been still content to just debate the science. This hearing is specifically geared towards building on the hearings that then Chairman McCain held earlier in the year to move us beyond that debate. Today's hearing focuses on the technologies and policies that can help us to mitigate the threat of climate change.

And while obviously we will still focus on some of the science—and clearly the underlying science remains an important concern of the Committee because we have to use that science in making judgments about what technologies make the most sense or what the results may be—this does mark a very significant shift in the focus of this Committee from science to solutions.

Over the past year as I mentioned, Senator McCain held a series of hearings that included some of the top scientists of the world, and not surprisingly, the record of those hearings paralleled the findings of the National Academy of Science's report released in

June on the science of climate change. That report, which follows on the heels of similar findings of the Intergovernmental Panel on Climate Change's report and dozens of other individual studies, concluded that greenhouse gases are accumulating in the Earth's atmosphere as a result of human activities, that air and ocean temperatures are rising and are expected to rise further, and that human activities, mainly burning fossil fuels and deforestation, are a contributing factor.

So this Committee will not ignore the science of climate change, because that obviously drives our agenda. But it is important that we try to move now to constructively considering the options that other countries have already moved to and that seem to become more compelling.

Let me state for the record that the Department of State and the White House were invited to testify before the Committee today, but declined to do so. I wrote both Secretary Powell and Chief of Staff Card late last week, when we heard that they had decided against testifying, in hopes that they would reconsider. Obviously they did not, and I am very pleased to have Dr. Evans, who is a very respected career scientist from NOAA here to represent the Department of Commerce, and I appreciate your doing so, and I appreciate your testimony, which I read just before coming in here.

But I do regret that other officials have not come to share with us their views at this point about what possibilities may exist. This is not a political exercise; this is a policy exercise, one that we are engaged in inquisitively. We are trying to find solutions, as are other people, and it is helpful for the country to have a dialog about this so we can all understand the options better.

I thought this was our chance, two weeks before the next meeting of the parties of the conference, to try to help come to some decision about where we proceed post-Kyoto, that it might have been a good opportunity to be able to have some of that discussion. We have been told that the Administration has committed significant resources at the highest levels of Government to assess this issue. National Security Advisor Condoleezza Rice has described the effort as so intense as to be unprecedented.

The Commerce Committee has demonstrated, through Senator McCain's earlier efforts this year and prior to that, a serious commitment to understanding the science of climate change and also to recognizing our jurisdiction over important laws and programs relevant to this issue, ranging from the basic scientific research to auto efficiency standards, to technological research, development and deployment. So I regret that we can't have as full a discussion, but I hope we will be able to proceed to follow up on that sometime in the near future.

Let me emphasize what this hearing is about. I don't approach this with a preconceived determination as to what the order of priorities is for how we proceed. I am not sure any member of this Committee could or would dare to do so today. What we do want to try to do is lay out on the table some of the technologies and policies that make climate change not an intractable problem, but rather an opportunity and a moment where we could conceivably help our economy and not hurt it, as well as implement good environmental policy at the same time.

Clearly, to address climate change the United States and the world have to move from polluting technologies to sustainable technologies. I don't propose that we immediately stop burning coal, oil and natural gas in order to respond to this problem, nor do I know any other person of common sense who suggests that. It is not an option. I recognize we have to build an additional pipeline and we need to continue to drill. We are stuck, to a certain degree.

But there are many, many things that all of us understand are available as options that could move us much more rapidly, much more affirmatively and proactively, toward the adoption of those sustainable policies in ways that are the least intrusive, most efficient, and least cost—approaches that could wind up being synergistic with our economic interests, rather than counterproductive.

So those are the options that we are interested in looking at. It is interesting to note, in that vein, that our economy today is twice as energy-efficient as it was in 1973, which means that producing a single unit of GDP today requires half the energy that it required in 1973. We have doubled, during that period of time, the efficiency of America's automobiles, thanks to the CAFE program. We save 3 million barrels of oil daily and more than 20 billion annually by building safer, more highly reliable quality cars.

The sale of efficient compact fluorescent lamps increased fivefold from 1990 to 1999. American steel mills are 25 percent more efficient today, and paper and pulp production is nearly 30 percent more efficient than 30 years ago. Many people believe that there are incentives such as tax incentives, grants, various kinds of technological transfer programs, and other mechanisms we could use to excite and rapidly accelerate our capacity to augment those kinds of gains.

In fact, energy efficiency is misunderstood by many people. Conservation means turning off the lights or using less fuel, but energy efficiency means achieving the same output, the same consequence with less, and we have proven over the last 20 years that we have the ability as a country to do that.

We will hear today from people who will talk about many different technologies that are right on the borderline of being able to become economically viable, which could have a profound impact on America's contribution to the entire issue of climate change, and that is the purpose of today's hearing. There are many of us who believe we are moving far too slowly, that we have not really adopted as a national enterprise the effort to prove our bona fides in this area.

Many of the technologies that could help us do that are already in the marketplace, and the challenge is to increase their use, including cogeneration, wind power, solar, methane, biomass, hydrogen fuel cells, more efficient cars and appliances. Others are technologically proven, but have yet to gain a commercial foothold. And still others remain on the drawing board, and while they have tremendous potential, that potential will only be achieved if we pursue them with the same kind of intensity and investment that we have pursued in space exploration, communications, and medicine.

I believe, and others share the belief, that the burden is on us to create the push and pull of incentives and mandates that will move these technologies to the marketplace faster.

[The prepared statement of Senator Kerry follows:]

PREPARED STATEMENT OF HON. JOHN F. KERRY,
U.S. SENATOR FROM MASSACHUSETTS

I want to thank Chairman Hollings and Ranking Member McCain for holding this hearing. To begin, I'd like to put this hearing into context. Today's hearing focuses on the technologies and policies that can help us mitigate the threat of climate change. While we will focus some on the science and while the underlying science remains an important concern of this Committee, today marks a significant shift in our focus from the science to the solutions of climate change.

Over the past year, Senator McCain—as Chairman of this Committee—held a series of hearings that included some of the top scientists in the world. Not surprisingly, the record of those hearings parallels the findings of the National Academy's of Sciences report released in June on the science of climate change. That report—which follows on the heels of similar findings of the Intergovernmental Panel on Climate Change's report and dozens of other individual studies—concluded that greenhouse gases are accumulating in the Earth's atmosphere as a result of human activities; that air and ocean temperatures are rising and are expected to rise further; and that human activities, mainly burning fossil fuels and deforestation, are a contributing factor.

This Committee is by no means ignoring the science of climate change—the science is what is driving this Committee's agenda in regard to climate change—and that is why, after four hearings that together create a compelling argument for action, we are now investigating the technologies and policies that can reduce greenhouse gas emissions. It is an important step, and I'm glad to see the Committee take it.

Second, I want the record to show that the Department of State and the White House were invited to testify before the Committee today but declined to do so. I wrote both Secretary Powell and Chief of Staff Card late last week when I heard that the Administration had decided against testifying in hopes that they would reconsider. Obviously, they did not. While I'm pleased to have Dr. Evans, a respected career scientist from NOAA here to represent the Department of Commerce, I regret that senior officials from the State Department, Commerce Department, and the White House are not here today.

I want to be clear that while I have differences with Administration's approach to this issue, I am not here to assail the Bush Administration. Today was a chance for the Administration to set forth its approach to climate change, which is not an unreasonable request. The Administration has told us that it has committed significant resources at the highest levels of government to assessing climate change—National Security Advisor Condoleezza Rice has described this effort as so intense as to be unprecedented. The Commerce Committee has demonstrated a commitment to understanding the science of climate change over past several years. The Committee has jurisdiction over several laws and programs important to the issue—ranging from basic scientific research to auto efficiency standards to technological research, development and deployment. It seems to me that the Administration might have welcomed the opportunity to come before the Committee and discuss the policies that it believes this nation should enact. It seems to me that today is lost opportunity for the Administration.

Lastly, today's hearing will bring forth some of the technologies and policies that, I believe, make climate change not an intractable problem, but a challenge to be understood and addressed, and, as importantly, an economic opportunity. To address climate change, America and the world must move from polluting technologies to sustainable technologies. I don't propose that we immediately stop burning coal, oil and natural gas to address climate change or other environmental issues. Instead, I advocate a gradual transition from heavily-polluting energy to clean energy at a pace that is technologically viable and economically beneficial. I advocate that we do this in the most efficient, least cost manner and that we address the real world economic realities associated with any technological shift. Today, we are moving far too slowly with almost no recognition of the environmental implications of our pollution and with no purpose to incite the necessary technological innovation. Some of these technologies are already in the marketplace and the challenge is to increase their use—they include cogeneration, wind power, solar, methane, biomass, hydrogen fuel cells and more efficient cars and appliances. Others are technologically proven but have yet to gain a commercial foothold. And still others remain on the drawing board, and while they have tremendous potential, that potential can only be achieved if we pursue them with the same kind of intensity and investment

we have placed in space exploration, communications and medicine. I believe that the burden is on us to create the push and pull of incentives and mandates that will move these technologies into the marketplace for the benefit of our economy and our environment.

Thank you.

Senator KERRY. Senator McCain.

STATEMENT OF HON. JOHN McCAIN,
U.S. SENATOR FROM ARIZONA

Senator MCCAIN. Thank you, Senator Kerry, for continuing this series of hearings on this very, very important topic. I think that each study, each new expert on this issue reveals the urgency and compelling aspect of this problem of climate change in America. Based upon previous hearings, you, I and others have been working on legislation to address many of the options, and hopefully in the near future, we can join together with a joint bipartisan piece of legislation that I think would at least make some progress, towards addressing this issue.

I look forward to hearing about the status of several technologies which can lead to significant emissions reductions. I recognize the solutions to the problems will require increased investments in many different areas, and today's second panel certainly represents a diversity of technologies. Some of these technologies, such as wind and nuclear power, have been around for many years. These technologies possess tremendous abilities to reduce the amount of carbon dioxide in the atmosphere while playing a major role in the future energy production and utilization needs of the country.

Many of these technologies will allow the Nation to become more energy efficient and will conserve precious natural resources. I think the information the second panel will provide us with is critically important as we deliberate on how to increase energy supplies to meet our future energy needs, while taking important measures to protect the environment.

Mr. Chairman, in the recent National Academy report, Climate Change Science and Analysis of Some Key Questions, it was stated that—and I quote—"National policy decisions made now and in the longer term future will influence the extent of any damage suffered by vulnerable human populations and ecosystems later in this century."

The report further states—and I quote—"There is considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols."

These statements by the Academy put the upcoming policy decisions into the proper perspective along with the need for additional research. As we in the Senate continue to debate the policy issues, it is pleasing to see that industry has started to take initiatives of their own to address these problems. I look forward to hearing about their voluntary activities and their impact on the economies.

I feel it is important we fully explore all policy options, including mandatory emission reductions, before proceeding with any final and definitive position. The issue of climate change is an important one, and the Committee should be very informed about the latest

developments. It is also an issue that we need to take some action on.

And I thank you, Senator Kerry, not only for this hearing, but your continued and many years of involvement in this issue. I thank the Chairman.

Senator KERRY. Thank you very much, Senator McCain.

[The prepared statement of Senator McCain follows:]

PREPARED STATEMENT OF HON. JOHN MCCAIN,
U.S. SENATOR FROM ARIZONA

First of all, let me thank Senator Kerry for continuing this series of hearings on this very important topic. I think that today's hearing is an appropriate one considering the fact that several Members are currently considering several options for legislation. Based upon previous hearings, I have been working on legislation to address many of these options and plan to introduce a bill in the near future.

I look forward to hearing about the status of several technologies which can lead to significant emission reductions. I recognize that the solution to this problem will require increased investments in many different areas. Today's second panel certainly represents a diversity of technologies. Some of these technologies, such as wind and nuclear power, have been around for many years. These technologies possess tremendous abilities to reduce the amount of carbon dioxide in the atmosphere while playing a major role in the future energy production and utilization needs of the country. Many of these technologies will allow the Nation to become more energy efficient and will conserve precious natural resources. This is critically important as we deliberate on how to increase energy supplies to meet our future energy needs while taking important measures to protect the environment.

In the recent National Academy Report, "Climate Change Science: An Analysis of Some Key Questions," it was stated that "national policy decisions made now and in the longer-term future will influence the extent of any damage suffered by vulnerable human populations and ecosystems later in this century." The report further states that "there is considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols." These statements by the Academy put the upcoming policy decisions into the proper perspective along with the need for additional research.

As we in the Senate continue to debate the policy issues, it is pleasing to see that industry has started to take initiatives of their own to address these problems. I look forward to hearing about their voluntary activities and their impact on the economy.

I feel that it is important we fully explore all policy options, including mandatory emission reductions, before proceeding with any final and definitive position. This issue of climate change is a very important one and the Committee should be very informed about the latest developments surrounding it. It is also an issue that we need to take action upon.

Again, I thank you Senator Kerry for holding this hearing and welcome all of our witnesses here today.

Senator KERRY. Dr. Evans, thank you very much for joining us today. We look forward to your testimony. If I can state, as is our norm, your full testimony will be placed in the record as if read in full. If you could summarize, that will give us more time to explore possibilities with you. Thank you very much.

STATEMENT OF DR. DAVID L. EVANS, ASSISTANT ADMINISTRATOR, OCEANIC AND ATMOSPHERIC RESEARCH, NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

Dr. EVANS. Thank you very much, Mr. Chairman. As you know, I am David Evans. I am Assistant Administrator of the National Oceanic and Atmospheric Administration's Office of Oceanic and Atmospheric Research, and I am here today to discuss global climate change, how the Department of Commerce is working to im-

prove our understanding, and the Department's programs to advance technologies which may help mitigate climate change.

The information I will present to you is based primarily on the 2001 report of the Intergovernmental Panel on Climate Change (IPCC) and the recent National Academy report that both you and Senator McCain have referred to.

But before addressing those findings, there are two fundamental points that really are quite worthy of note, and they have been known for quite some time. The first one is that the natural greenhouse effect is real. It is an essential component of the planet's climate process. A small percentage, about 2 percent of the atmosphere, is and has long been composed of greenhouse gases, water vapor, carbon dioxide, ozone, methane, and these effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping into space.

The global system responds to this trapped heat with a climate that is warmer on average than it would be otherwise without the presence of these gases and, indeed, supports life as we have come to appreciate it.

In addition, some greenhouse gases are increasing in the atmosphere because of human activities, and are increasingly trapping more heat. Direct atmospheric measurements made over the past 40 years have documented the steady growth in the atmospheric abundance of carbon dioxide. Ice core measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by more than 30 percent over the industrial era compared with the preceding 750 years. The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests.

Particles or aerosols in the atmosphere resulting from human activities can also affect climate. Some aerosol types, such as sulfate aerosols, act in the opposite sense to greenhouse gases and cause a cooling of the climate system, while others, like soot, act in the same sense and warm the climate. In summary, emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate.

Moving on to the more recent findings, there is a growing set of observations that yields a collective picture of a warming world over the past century. The global average surface temperature has increased over the 20th Century by between 0.4 and 0.8 degrees centigrade. The average temperature increase in the Northern Hemisphere over the 20th Century is likely to have been the largest of any century during the past thousand years.

Other observed changes are consistent with this warming. There has been widespread retreat of mountain glaciers in non-polar regions. Snow cover and ice extent have decreased. The global average sea level has risen between 10 and 20 centimeters, and that is consistent with a warmer ocean, occupying more space just due to thermal expansion of sea water.

There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities. Since the IPCC assessment in 1995, there is now a longer and more closely scrutinized temperature record. Climate models have improved significantly since the last assessment, and recent analyses have com-

pared surface temperatures measured over the last 140 years to those simulated by the models.

Both natural climate change agents, such as variations in solar output and episodic explosive volcanic eruptions, and human agents, greenhouse gases and fine particles, have been included in the models. The best agreement between the observations and the model simulations over the last 140 years is found when both the human-related and the natural climate change agents are included. Further model simulations indicate that warming over the past century is very likely not to be due to natural variability alone.

Scenarios of future human activities indicate continued changes in atmospheric composition through the 21st Century. The amount of greenhouse gases and aerosols over the next 100 years cannot be predicted with high confidence, since future emissions will depend on many diverse factors, including world population, the economies, technology development, human choices, and they are not uniquely quantifiable.

Based on scenarios covering a range of those factors, the resulting projection for global temperature increase by the year 2100 ranges from 1.3 to 5.6 degrees C. or about 2½ to 10 degrees Fahrenheit. Such a projected rate of warming would be much larger than the observed 20th Century changes. The corresponding projected change in sea level would be between 10 and 100 centimeters, between about 3½ and 35 inches.

Finally, greenhouse warming could be reversed only very slowly. This is because of the slow rate of removal from the atmosphere of greenhouse gases, a period of centuries, and because of the slow response of the ocean to thermal changes. Global average temperature increases and rising sea level are projected to continue for hundreds of years after stabilization of greenhouse gas concentrations, owing to the long time scales.

The IPCC report stresses a critical role of the oceans in understanding the Earth's climate system due to sea water's capacity to store and transport large amounts of heat. Scientists have recently published a study using newly available data to prepare analysis of ocean warming over the last 50 years. The global volume mean temperature increase in the upper 300 meters was about three-tenths of a degree Centigrade, and just to sort of give you a scale for that, the U.S. consumption of electricity for something like 17,000 years, so it is a very significant amount of energy.

Two recent computer modeling studies have found that model increases in the ocean heat were comparable to that which was observed only when the effects of greenhouse gases and other forcings were included.

The White House requested that the National Academy of Sciences prepare a study to assist in identifying the areas of climate change science where there are greatest certainties and uncertainties and give views on whether there were any substantive differences between the IPCC reports and the IPCC summaries.

The National Academy of Science reported on June 6 with a study entitled, Climate Change Science: An Answer to Some Key Questions, and that summary states that, "Greenhouse gases are accumulating in the Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean

temperatures to rise. Temperatures are, in fact, rising. The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes are also a reflection of the natural variability."

And it goes on to say, "Because there is considerable uncertainty in the current understanding of how the climate system varies naturally and reacts to the emissions of greenhouses gases and aerosols, current estimates of the magnitude of future warming should be regarded as tentative and subject to future adjustments, either upward or downward."

To address this uncertainty, the President has directed a Cabinet-level review of U.S. climate change policy. Based on their findings, the President in his June 11 remarks committed his Administration to increased investments in climate science. He announced the establishment of U.S. climate Change Research Initiative to study areas of uncertainty and identify areas where investments are crucial.

The President directed the Secretary of Commerce, working with other agencies, to set priorities for additional investments in climate change research, review such investments, and provide coordination amongst Federal agencies. He pledged to fully fund high-priority areas for climate change science over the next 5 years and provide resources to build climate-observing systems in developing countries, and to encourage other developed nations to match our commitment. That review process has begun, and we expect the results to be reflected in the President's fiscal 2003 budget submission to Congress.

In addition to better understanding of the science, we will need to advance our technology to deal with climate change. Due to the long lifetime of CO_2 in the atmosphere, stabilizing concentrations means that we must ultimately end up with much lower net emissions.

The long-term objective, the stabilized greenhouse concentrations in the atmosphere, can be addressed in two ways: first by reducing the emissions of greenhouse gases; second by means of capturing and sequestering gases, either at the source or after they have been released into the atmosphere.

There are significant climate change technology programs at many Federal agencies, including notably the Department of Energy, Environmental Protection Agency, and the Department of Agriculture. However, within the Department of Commerce, a NIST advanced technology program has funded research into technologies aimed at reducing emissions—that is the first one of those strategies—and improving energy efficiency, and increasing the use of low-carbon fuels.

Similarly, the Manufacturing Extension Partnership helps manufacturers reduce their dependencies on fossil fuels and the use of ozone-depleting substances. Other agencies are working on capture and sequestration issues, on that side of the problem.

While the development of these and other technologies is crucial, we should recognize that the apparent change in climate that we have seen over the last 100 years has taken, indeed, 100 years to present themselves. Stabilizing the climate will take comparable

time periods. It is not unreasonable to expect that the technology of the world in 100 years will be as different today as today's is from 100 years ago. At NOAA, we will pursue better science to inform the decisions as we proceed along.

Thank you very much for the opportunity to come and talk about the science, Mr. Chairman. I would be happy to answer any of your questions.

[The prepared statement of Dr. Evans follows:]

PREPARED STATEMENT OF DR. DAVID L. EVANS, ASSISTANT ADMINISTRATOR, OCEANIC AND ATMOSPHERIC RESEARCH, NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

Good morning, Mr. Chairman and members of the Committee. I am David Evans, Assistant Administrator of the Office of Oceanic and Atmospheric Research. NOAA Research is one of five line offices within the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce. I have been invited to discuss the Administration's position on climate change, how the Department is working to improve our understanding of climate, and the Department's programs that may advance technologies which may mitigate climate change.

NOAA is the agency within the Department of Commerce tasked with developing much of the ongoing research on climate change and climate variability and has made major contributions to the understanding of the Earth's climate system. We work in partnership with other federal agencies, scientific organizations, and universities to generate the most accurate and reliable science that we can present on this issue. In recent years, we have worked to identify gaps in our knowledge and capabilities and to determine the impacts that climate change may have on society and the environment. While our role in climate change is non-regulatory, our scientific information is relied upon by policy makers in government and industry, including those in the United States and other countries.

The information I will present to you today is based on a number of findings and mainly represents the state of the science, and the Administration's policies as set forth in the initial report of the Climate Change Review. With respect to the science, I will refer primarily to the set of findings of the 2001 report of the Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Sciences (NAS) June 6, 2001 report, "Climate Change Science: Analysis of Some Key Questions."

For more than a decade, NOAA scientists have been involved in various national and international scientific assessments. These include National Academy of Science studies, World Meteorological Organization/United Nations Environment Programme (WMO/UNEP) reports on the scientific understanding of the ozone layer and IPCC climate change science assessments. In the recently concluded IPCC scientific assessment, four of our scientists served as lead authors, and three of our scientists served as coordinating lead authors on the Technical Summary of the Working Group I Report of the IPCC: *Change 2001: The Scientific Basis,* and the Chapter on *Observed Climate Variability and Change;* the Chapter on *Atmospheric Chemistry and Greenhouse Gases;* the Chapter on *Aerosols, Their Direct and Indirect Effects;* the Chapter on *Radiative Forcing of Climate Change;* and the Chapter on the *Projections of Future Climate Change.* The Summary was formally approved in detail and accepted along with the underlying assessment report at the IPCC Working Group I Plenary session in January 2001.

The IPCC assessment took almost three years to prepare and represents the work of more than 100 scientific authors worldwide. It is based on the scientific literature, and was carefully scrutinized by hundreds of scientific peers through an extensive peer review process. The independent NAS report was requested by the administration, and was a consensus report compiled by a 11-member panel of leading U.S. climate scientists, including a mix of scientists who have been skeptical about some findings of the IPCC and other assessments on climate change. The NAS panel attempted to better articulate levels of scientific confidence and caveats than the IPCC Summary for Policy Makers.

Before addressing the findings of both reports, two fundamental points are worthy of note. These have been long-known, are very well understood, and have been deeply underscored in all previous reports and other such scientific summaries.

• *The natural "greenhouse" effect is real, and is an essential component of the planet's climate process.* A small percentage (roughly 2%) of the atmosphere is, and long has been, composed of greenhouse gases (water vapor, carbon dioxide, ozone and

methane). These effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping to space. The global system responds to this trapped heat with a climate that is warmer, on the average, than it would be otherwise without the presence of these gases.

In addition to the natural greenhouse effect above, there is a change underway in the greenhouse radiation balance, namely:

• *Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat.* Direct atmospheric measurements made over the past 40-plus years have documented the steady growth in the atmospheric abundance of carbon dioxide. In addition to these direct real-time measurements, ice cores have revealed the atmospheric carbon dioxide concentrations of the distant past. Measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by more than 30% over the Industrial Era (since 1750), compared to the relatively constant abundance that it had over the preceding 750 years of the past millennium. The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests. Further, methane abundance has doubled over the Industrial Era. Other heat-trapping gases are also increasing as a result of human activities. However, we are unable to state with certainty the rate at which the globe will warm or what effect that will have on society or the environment.

The increase in greenhouse gas concentrations in the atmosphere implies a positive radiative forcing, i.e., a tendency to warm the climate system. Particles (or aerosols) in the atmosphere resulting from human activities can also affect climate. Aerosols vary considerably by region. Some aerosol types act in a sense opposite to the greenhouse gases and cause a negative forcing or cooling of the climate system (e.g., sulfate aerosol), while others act in the same sense and warm the climate (e.g., soot). In contrast to the long-lived nature of carbon dioxide (centuries), aerosols are short-lived and removed from the lower atmosphere relatively quickly (within a few days). Therefore, aerosols exert a long-term forcing on climate only because their emissions continue each year.

In summary, emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate. There are also natural factors which exert a forcing of climate, e.g., changes in the Sun's energy output and short-lived (about 1 to 2 years) aerosols in the stratosphere following episodic and explosive volcanic eruptions. Both reports evaluated the state of the knowledge and assessed the level of scientific understanding of each forcing. The level of understanding and the forcing estimate in the case of the greenhouse gases are greater than for other forcing agents.

What do these changes in the forcing agents mean for changes in the climate system? What climate changes have been observed? How well are the causes of those changes understood? Namely, what are changes due to natural factors, and what are changes due to the greenhouse-gas increases? And, what does this understanding potentially imply about the climate of the future?

These questions bear directly on the scientific points that you have asked me to address today. In doing so, findings emerging from both the recent IPCC and NAS climate change science reports with respect to measurements, analyses of climate change to date, and projections of climate change will be summarized.

• *There is a growing set of observations that yields a collective picture of a warming world over the past century.* The global-average surface temperature has increased over the 20th century by 0.4 to 0.8° C [NAS, p.16]. The average temperature increase in the Northern Hemisphere over the 20th century is likely to have been the largest of any century during the past 1,000 years, based on "proxy" data (and their uncertainties) from tree rings, corals, ice cores, and historical records. Other observed changes are consistent with this warming. There has been a widespread retreat of mountain glaciers in non-polar regions. Snow cover and ice extent have decreased. The global-average sea level has risen between 10 to 20 centimeters, which is consistent with a warmer ocean occupying more space because of the thermal expansion of sea water and loss of land ice. The NAS report also found that at least part of the rapid warming of the Northern Hemisphere during the first part of the 20th century was of natural origin.

• *There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.* The 1995 IPCC climate-science assessment report concluded: "The balance of evidence suggests a discernible human influence on global climate." There is now a longer and more closely scrutinized observed temperature record. Climate models have evolved and improved significantly since the last assessment. Although many of the sources of uncertainty identified

in 1995 still remain to some degree, new evidence and improved understanding support the updated conclusion. Namely, recent analyses have compared the surface temperatures measured over the last 140 years to those simulated by mathematical models of the climate system, thereby evaluating the degree to which human influences can be detected. Both natural climate-change agents (solar variation and episodic, explosive volcanic eruptions) and human-related agents (greenhouse gases and fine particles) were included. The natural climate-change agents alone do not explain the warming in the second half of the 20th century.

• *Scenarios of future human activities indicate continued changes in atmospheric composition throughout the 21st century.* The atmospheric abundances of greenhouse gases and aerosols over the next 100 years cannot be predicted with high confidence, since the future emissions of these species will depend on many diverse factors, e.g., world population, economies, technologies, and human choices, which are not uniquely specifiable. Rather, the IPCC assessment aimed at establishing a set of scenarios of greenhouse gas and aerosol abundances, with each based on a picture of what the world plausibly could be over the 21st century. Based on these scenarios and the estimated uncertainties in climate models, the resulting projection for the global average temperature increase by the year 2100 ranges from 1.3 to 5.6 degrees Celsius. Such a projected rate of warming would be much larger than the observed 20th-century changes and would very likely be without precedent during at least the last 10,000 years. The corresponding projected increase in global sea level by the end of this century ranges from 9 to 88 centimeters. Uncertainties in the understanding of some climate processes make it more difficult to project meaningfully the corresponding changes in regional climate. The NAS report agrees with this projection but notes that future climate change will depend on what technological developments may allow reductions of greenhouse gas emissions.

Finally, I would like to relate a basic scientific aspect that has been underscored with very high confidence in all of the IPCC climate-science assessment reports (1990, 1995, and 2001). It is repeated here because it is a key (perhaps "the" key) aspect of a greenhouse-gas-induced climate change:

• *A greenhouse-gas warming could be reversed only very slowly.* This quasi-irreversibility arises because of the slow rate of removal (centuries) from the atmosphere of many of the greenhouse gases and because of the slow response of the oceans to thermal changes (NAS, p. 10). For example, several centuries after carbon dioxide emissions occur, about a quarter of the increase in the atmospheric concentrations caused by these emissions is projected to still be in the atmosphere. Additionally, global average temperature increases and rising sea level are projected to continue for hundreds of years after a stabilization of greenhouse gas concentrations (including a stabilization at today's abundances), owing to the long timescales (centuries) on which the deep ocean adjusts to climate change.

Both reports stress the critical role of the oceans in understanding the Earth's climate system due to the seawater's capacity to store and transport large amounts of heat. While the first study to conclude that the global radiative balance of the Earth system requires heat transport from the tropics to the poles was published almost a century ago, identifying the mechanisms by which heat is transported remains a central problem of climate research. Because of its large specific heat capacity and mass, the world ocean can store large amounts of heat and remove this heat from direct contact with the atmosphere for long periods of time. Studies of ocean subsurface temperature variability were limited due mostly to the lack of data. About 25 years ago, programs were initiated to provide measurements of upper ocean temperature, and for the past 10 years there has been an increase in the amount of historical upper ocean thermal data available. Levitus *et al.* have used these data to prepare yearly, gridded objective analyses for the period of 1960 to 1990. With the use of the World Atlas Database 1998 temperature anomaly fields were prepared. These analyses lead to the quantification of the interannual-to-decadal variability of the heat content (mean temperature) of the world ocean from the surface through 3000-meter depth for the period 1948 to 1998. The mean temperature of the ocean increased by $\sim 2 \times 10^{23}$ joules, representing a volume mean warming of 0.06° C. This corresponds to a warming rate of 0.3 watt per meter squared (per unit area of Earth's surface). Substantial changes in heat content occurred in the 300- to 1000-meter layers of each ocean and in depths greater than 1000 meters in the North Atlantic. The global volume mean temperature increase for the 0- to 300-meter was 0.31° C. Two studies by U.S. scientists (Levitus *et al.* and Barnett *et al.*) attempted to address the causes of the world ocean warming using computer model simulations.

These studies were published in the April 13, 2001 issue of the journal of Science. Both studies found that the model simulated increase in ocean heat content were

comparable to the observed increase only when the effects of greenhouse gases and other forcings were included. The findings further reported that it is unlikely that the observed increases result from random fluctuations of the climate system. The long-term increase requires a sustained warming, such as would be expected from increasing concentrations of atmospheric greenhouse gases. However, this assessment depends upon how well the models simulate the internal variability of the ocean system on time scales of 40 to 50 years.

The NAS study titled "Climate Change Science—An Analysis of Some Key Questions" was released on June 6 and originated from a White House request to inform the Administration's ongoing review of U.S. climate change policy. In particular, the Administration asked for "assistance in identifying the areas in the science of climate change where there are the greatest certainties and uncertainties," and views on "whether there are any substantive differences between the IPCC reports and the IPCC summaries."

The NAS Committee generally agreed with the assessment of human-caused climate change presented in the IPCC Working Group I (WG I) scientific report, but aimed at articulating more clearly the remaining uncertainties. The NAS report summary states: "Greenhouse gases are accumulating in earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures, are in fact, rising. The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes are also a reflection of natural variability." Importantly, the report observes: "Because there is considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols, current estimates of the magnitude of future warming should be regarded as tentative and subject to future adjustments (either upward or downward)."

To address this uncertainty, the President has directed the Cabinet-level review of U.S. climate change policy. Based on the Cabinet's initial findings, the President in his June 11 remarks committed his Administration to invest in climate science. He announced the establishment of the U.S. Climate Change Research Initiative to study areas of uncertainty and to identify areas where investments are critical. He directed the "Secretary of Commerce, working with other agencies, to set priorities for additional investments in climate change research, review such investments, and to provide coordination amongst federal agencies. We will fully fund high-priority areas for climate change science over the next five years. We'll also provide resources to build climate observation systems in developing countries and encourage other developed nations to match our American commitment."

I would like to underscore that we will use the descriptions of the uncertainties identified in the NAS report as the basis for development of U.S. research in climate. Cited areas of uncertainty include:

- Feedbacks in the climate system that determine the magnitude and rate of temperature increases
- Future usage of fossil fuels
- How much carbon is sequestered on land and in the ocean
- Details of regional climate change
- Natural variability of climate, and the direct and indirect effects of aerosols

We have convened an interagency working groups to develop a science plan to reduce the areas of uncertainties.

There is a great deal of concern as to what are the CO_2 emissions from various countries, and what scientists are finding about what level of CO_2 reductions are needed to stabilize concentrations in the atmosphere. According to the most recent data from the Carbon Dioxide Information Analysis Center at the Department of Energy's Oak Ridge National Laboratory, countries with the highest CO_2 emissions are: the United States, with 1.49 billion tons of carbon emissions a year; China, with 0.91 billion tons; Russia, with 0.39 billion tons; Japan, with 0.32 billion tons; India, with 0.28 billion tons; Germany, with 0.23 billion tons; the United Kingdom, with 0.14 billion tons; and Canada, with 0.13 billion tons.

Ultimately, due to the long lifetime of CO_2 in the atmosphere to stabilize concentrations we must make progress on net emissions. To achieve this goal, technological advances must be made. Technology will continue to play an important role in reducing greenhouse gas emissions and controlling costs of climate change mitigation. The long-term objective—to stabilize greenhouse concentrations in the atmosphere—can be addressed in two ways: first, by reducing emissions of greenhouse

gases; and second, by means of capturing and sequestering gases, either at the source or after they have been released into the atmosphere.

There are significant climate change technology programs at many federal agencies, including notably the Department of Energy, the Environmental Protection Agency, and the Department of Agriculture. I will confine myself to discussion of programs at the Department of Commerce. In the past, the Department of Commerce NIST Advanced Technology Program has funded research into technologies aimed at improving energy efficiency, and increasing the use of low carbon fuels. Similarly, the Manufacturing Extension Partnership helps manufacturers to reduce their dependencies on fossil fuels and use of ozone depleting substances. The NIST Measurements and Standards Laboratory Program also provides the measurement science and data to support climate change studies as well as calibration services relating to atmospheric measurements. These activities contribute to the science base for understanding the behavior of industrial chemicals in the environment, evaluation of environmentally benign chemical alternatives, and measurement techniques for key environmental species in the atmosphere.

In closing, we have outlined a significant number of items that challenge our existing understanding, and we will be placing special emphasis on them in the future. We look forward to continuing to work with you on these issues. Thank you again for the invitation to appear today. I hope that this summary has been useful. I would be happy to address any questions.

Sources of cited information:

Levitus, S., J.I. Antonov, J. Wang, T.L. Delworth, K.W. Dixon, and A.J. Broccoli. Anthropogenic Warming of Earth's Climate System. *Science* 292: 267–270 (2001).

Levitus, S., J.I. Antonov, T.B. Boyer, and C. Stephens. Warming of the World Ocean. *Science* 287: 2225–2229 (2000).

Rossby, C. The Atmosphere and the Sea in Motion. Rockefeller Institute. 1959.

Committee on the Science of Climate Change. Climate Change Science: An Analysis of Some Key Questions. National Academy Press: Washington, D.C. 2001. 28 p.

Summary for Policy Makers, Climate Change 2001: The Scientific Basis. Summary for Policymakers and Technical Summary of the Working Group I Report. Cambridge University Press, 98 pp. Also available at http://www.ipcc.ch. The full report will be available this summer.

Parallel IPCC reports:

Climate Change 2001: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report.

Climate Change 2001: Mitigation—Contribution of Working Group III to the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report.

IPCC, 2000: IPCC Special Report on Emissions Scenarios. Cambridge University Press.

Senator KERRY. Let me begin just by, if I can, putting on the record a little bit of your background. How long have you been at this?

Dr. EVANS. How long have I been at this?

Senator KERRY. Yes.

Dr. EVANS. Well, I have been at NOAA for a little over 8 years. Prior to that, I managed the physical oceanography program, large-scale ocean program, for the Office of Naval Research and dealt with the ocean part of climate from the Navy point of view for about 6 years, and prior to that, I was at the University of Rhode Island as an oceanographer, looking at large-scale phenomena for about 15 years. Pretty long time by now.

Senator KERRY. So you have had a lot of experience following the entire evolution of this issue itself.

Dr. EVANS. That is right.

Senator KERRY. And you are deeply immersed in it.

Dr. EVANS. That is right.

Senator KERRY. Now, based on your experience as a scientist, you have made a judgment here which I think is very important,

and I want to just explore for a moment. You said toward the end of your testimony, "Ultimately due to the long lifetime of CO_2 in the atmosphere, to stabilize concentrations, we must make progress on net emissions." Correct?

Dr. EVANS. That is correct.

Senator KERRY. So it is your conclusion that based on all of the science to date, and based on our knowledge of our contribution from a human level, that we are forced to find a way to reduce the net emissions.

Dr. EVANS. I think that is certainly going to be the case. The alternative would be to continue to accumulate CO_2 in the atmosphere at whatever rate and take the consequences of that.

Senator KERRY. And that is unacceptable in your judgment as a scientist.

Dr. EVANS. Well, I didn't say that it was unacceptable. I said that the consequence of not getting to a very low emission rate would be continued accumulation of CO_2, and that would probably lead to continued changes of the sort that we have seen. The acceptability or not, I think, has to do with how we want to live on the planet. It is not strictly a scientific question.

Senator KERRY. Fair enough. But applying your common sense to what we have observed already in terms of consequences, would you deem those consequences acceptable from a policy point of view?

Dr. EVANS. Well, this is going to get us down a slippery slope, I am afraid, Senator. NOAA's position and role in all of these activities really has been to try to present the science as clearly as we can to those folks who are in a position to make the policy determinations. NOAA doesn't really offer any regulation or any management specifically on the policies.

Senator KERRY. Well, let me just ask you. Leaving NOAA aside, talk to me as Dr. Evans, you know, family man, American citizen. What do you think?

Dr. EVANS. I think that if we continue to accumulate CO_2 in the atmosphere, we will continue to see warming of the Earth's climate, change in the Earth's climate. I think that we understand very little about what the consequences of that will be. We are much more confident in looking at the record of what we have done so far and seeing the changes that have occurred so far, which are modest, detectable for sure but modest, and we are far less confident about what the consequences of those changes will be in the future.

You know, we can certainly expect warming to continue, but whether there would be dramatic changes and what those impacts would be, our science for understanding that is far less well developed.

Senator KERRY. Now, accepting, as I do, that some of the models with respect to what happens where, when and how are still in the developmental stages, we are still struggling with those to some degree. But we are not struggling with the notion that there are observable impacts as a result of warming, ranging from ice pack melting, glacier melting, more violent weather, other kinds of things that people have observed. Is that correct?

Dr. EVANS. Well, ice pack melting, glacial melting, those changes are certainly consistent with a warming climate. I am not sure that the evidence is actually in, in changes in violent weather, to be perfectly honest. I think there is really quite a lot of controversy, and there is far less certainty about the impacts on what you call weather as opposed to the overall climate. But we certainly are seeing impacts. I believe that.

Senator KERRY. And do you accept, as some have set forth, that the range of consequences is not simply the increased warming itself, but other things that happen to crops, to forest migration, to spread of disease, to drought, to water supply? There are more complicated consequences that certainly wise people would make some precautionary judgments about, would they not?

Dr. EVANS. I think that there are a range of consequences of the sort that you outlined that are certainly possible in a warmer world. They don't take place in a uniform sense. You know, it is not that any of those phenomena would take place everywhere.

One of the things that we have learned is that as the climate changes, as the world warms, if you will, we will see changes that are more pronounced of one sort or another in different regions. It might be that one part of the country or one continent becomes warmer and another part becomes wetter or drier. Unfortunately, that is the very point where our science begins to provide us with less confidence in our projections.

When we run the climate models, we get increased differences in discrepancies among those models as we look at finer resolution geographically, so that an effort to scientifically assess what the consequences will be, in the northwest or the southeast part of this country, we are less certain there.

Senator KERRY. Well, I completely agree with that, and I think that is part of what makes it difficult, but—the "but" is—it is irreversible.

Dr. EVANS. It will take a very long time to change. We have taken a long time to warm things up now, and I wouldn't say that it is necessarily irreversible. You know, there are natural processes that do remove CO_2 from the atmosphere. It is just that the time scales associated with the change are very long.

Senator KERRY. Can you name a natural process that will reverse the rise of sea level?

Dr. EVANS. If the climate were to cool, then you would see a reverse of that, in the same way that we have warmed it, so if CO_2 were removed from the atmosphere by processes, vegetation processes or continued absorption in the ocean, for example, processes that take a very long time, then you could see a decrease in the concentration of carbon dioxide in the atmosphere, a gradual cooling, and a slow reversal of those processes. The thing that is so striking about it, though, is that these are phenomena that have got time scales in centuries, in fact.

Senator KERRY. And that is what makes it more compelling, because at the moment there is no public policy in any country anywhere in the world that is stimulating or exciting that reversibility, is there?

Dr. EVANS. Not that I am aware of.

Senator KERRY. So, in fact, that is what puts on the table this question of what steps are available to us that might or might not make sense at this point in time. Now, measuring those, do you at this point in time offer this Committee and the policymakers of the administration any set of steps or priorities that you think make the most sense in order of priority that we should be thinking about adopting?

Dr. EVANS. There have been a wide range of possibilities offered, and just taking a look at what you probably will get to hear in the next two panels of your hearing today, I think you will probably see a lot of those explored. My personal expertise is really in how the ocean works and how the ocean and the atmosphere work together, and so one of the things, I think, scientists need to be prepared to do is to explore in their models and with their understanding about the way the world works what the potential consequences are of the options that are offered, whether they are economic options or technical options, technological options.

When some of those options are put forward, then we need to build tools which are very poorly developed right now to explore how those options would actually play out in the physical environment, so that people would have an ability to make a rational choice among the various options that might be in front of them.

Senator KERRY. Are there any that you particularly, just speaking again scientifically, are excited about, that would have the best effect in terms of the net zero emissions or net additional emissions?

Dr. EVANS. Do I have a favorite? I would be hard-pressed to have a favorite, I think. If we can figure out some way to deal with some sort of capture and sequestration programs, I think that those are probably going to be helpful somewhere along the line. We have large amounts of fossil fuel still available, and as you mentioned in your opening comments, we can anticipate using them for some time to come. And so if we can develop some technologies that help us reduce the amount of CO_2 that we put into the atmosphere as we extract energy from those fuels, I think that would probably have some great benefit.

Senator KERRY. One of the greatest natural sequestration efforts comes from the ocean itself. Correct?

Dr. EVANS. That is correct.

Senator KERRY. And there is a huge amount of CO_2 that is contained within the ocean, in effect stored in the ocean.

Dr. EVANS. That is right.

Senator KERRY. But we don't know what the saturation point is with respect to ocean storage, do we?

Dr. EVANS. No, we don't.

Senator KERRY. So it is possible that at some point in time, we could reach that saturation point, and all of a sudden, you have an overload on the rest of the planet. It is possible; I am not saying it will happen. But we don't know the answer, do we?

Dr. EVANS. We certainly don't know the answer. That is right.

Senator KERRY. So you could conceivably have reached the point where the oceans in effect, have swallowed up as much CO_2 as they are capable of, and then it starts being released in the atmosphere

with a much more devastating, rolling impact with further consequences for global warming itself. No?

Dr. EVANS. That is possible. Yes.

Senator KERRY. Given the possibility of that, what does that say to us in your judgment from a policy point of view? I mean, if we are sitting here saying, "Well, gee whiz," we are kind of indolently rolling along here without any knowledge of when we reach this point. Is there a danger in that? Should we be taking more radical steps to avoid whatever might be uncontrollable at the outside of that curve?

Dr. EVANS. That is a very difficult question to answer from a scientific perspective. How much weight you want to put on the possibility of an extreme event of whatever sort and admittedly rare, or an event that you have difficulty assigning the probability to and how much action you would like to take to provide insurance against that, I think.

Unfortunately, one of the areas of climate change science that has been studied a lot recently and where there has been recent new attention placed has been trying to look at the changes in extreme events. What is the probability of making a dramatic change in the ocean's circulation that would significantly affect climate over a short period of time? We know that historically things like that have occurred. We have seen them in the climate record, but we don't understand the physics enough to know what triggers them.

So it would be very difficult for me to tell you, you know, in a probabilistic way whether putting CO_2 in the ocean or some other kind of proposed solution might trigger those events. That is an area of active research where I hope science can make a real contribution in the near term.

Senator KERRY. I have just a couple more questions, and then I will turn it over to Senator McCain and come back. The administration, through National Security Advisor Rice, has said that, "I would dare say, dare challenge you to find a situation in which you have had so many high-ranking people, sitting there week after week after week, understanding the challenge that we face in global climate change, everybody from the Vice President, the Secretary of State, Secretary of Interior, Secretary of Agriculture. It has been quite something to see all of these people grappling with this issue."

Have you been at these meetings, Doctor?

Dr. EVANS. I have been to some of those meetings. Yes.

Senator KERRY. How many Cabinet-level meetings have there been on this?

Dr. EVANS. I would be hard-pressed to count. Over a period of a couple of months, the Cabinet was meeting probably at least weekly on the subject.

Senator KERRY. And can you share with us, so that we get a sense of how this is working, who is actually in charge of this policy?

Dr. EVANS. Who is charge well, the Cabinet is meeting as——

Senator KERRY. No. Who would be in charge of the global warming policy itself? Is it Administrator Whitman? Is it the Vice President? Is it the Secretary of Commerce?

Dr. EVANS. I am not aware that any individual has been designated as the lead for climate change policy. The Cabinet has been meeting, I would say, sort of as a committee of the whole, receiving briefings from experts on a whole—on a wide range of subjects, ranging from science to policy options, to economic considerations, a wide variety of things, and spent a lot of time in deliberation there. But to the best of my knowledge, no individual person has been identified as the principal spokesman as yet.

Senator KERRY. And in a matter of days, the talks resume at COP–6 in Bonn. Has the U.S. at this point, to your knowledge, developed a plan for those talks and what we will do with respect to the next steps of Kyoto?

Dr. EVANS. The simple answer is, I don't know. I haven't been party to those discussions. I know that discussions have been going on over the last couple of weeks to develop a negotiating position, but I haven't been a participant in those discussions.

Senator KERRY. If you were to be presented with a plan that essentially set out the following: No. 1, set greenhouse gas emission targets and timetables to try to achieve significant emission reductions; use flexible compliance mechanisms and more efficient technology to reduce the economic impacts on business; make significant investments in tax incentive and R&D for new technologies; and then give early credit for near-term actions to cut emissions—in other words if somebody cuts them, and they do it more rapidly, they would get additional credit as an added incentive to taking that kind of action; ensure participation of developing countries as part of that solution; institute market-based trading systems, both domestically and internationally; and utilize sequestration, is that a fair outline of a sensible approach, in your judgment, to what we might consider?

Dr. EVANS. I think that all of those items are elements that have been discussed. I think that they have probably all been presented in combinations, one or some together.

Senator KERRY. Is there any one of them that doesn't make sense to you or that has problems?

Dr. EVANS. You know, most of those are not essentially scientific questions. I mean, one of the things that I would like to be able to do, to be honest, is to have the tools available so that if we had a menu of options or menu of approaches such as you just outlined with some details behind it, we would actually be able to evaluate and tell you scientifically what we could expect the world to look like under a scenario like that, given a range of accomplishments.

But we don't have the tools to do that right now, and so it is very difficult to make a scientifically informed judgment as to whether that list of admittedly plausible-sounding things that one might do, in fact, would get us to a particular goal or would achieve a particular purpose.

Senator KERRY. Well, if you want to stick, then, exclusively to science-based, we can pursue the policy part later, but let me come back quickly to the science. As a scientist, are there not also benefits of reducing emissions beyond simply global warming?

Dr. EVANS. Yes. That is particularly true for a number of the species. For example, I mentioned in my testimony that soot, black carbon, if you will, a byproduct of burning, has a positive green-

house effect, that causes warming. It also represents a health hazard. And so if we were to take actions that reduced soot or particulate matter in the atmosphere, we would all realize some health benefits from that.

I should point out that it is a two-sided issue, however. It is not ever quite as simple as it seems. Sulfate aerosol particles, as I mentioned, which are produced largely by burning sulfur-containing fuels, coal in particular, form particles in the atmosphere which actually reflect incoming radiation, and so sulfur, sulfates, tend to have a cooling effect from the climate perspective, and that cooling effect, of course, acts in opposition to the greenhouse warming.

Nevertheless, we have got a vigorous program to try and reduce sulfates in the atmosphere exactly because of the health benefits or the secondary benefits that you mentioned, so that some of these issues play both ways. Tropospheric ozone is another example.

Senator KERRY. Well, it actually plays a third way, because as the author of part of the Clean Air Act that dealt with acid rain, nobody I know is proposing to put additional sulfates in the air in order to induce cooling.

Dr. EVANS. That is right.

Senator KERRY. Because we have an acid rain problem as well as a particulate problem.

Dr. EVANS. Exactly.

Senator KERRY. So that is not exactly a positive counter to the problem of global warming.

Dr. EVANS. No. It is positive only in the sense that those particles provide a negative cooling influence relative to greenhouse warming.

Senator KERRY. Agreed.

Dr. EVANS. Anyone would suggest that we reverse our plan on sulfates.

Senator KERRY. So, in effect, if you are looking for a net positive impact on human beings and on the planet, you want to reduce both.

Dr. EVANS. Absolutely.

Senator KERRY. OK. Thank you.

Senator McCain.

Senator MCCAIN. Dr. Evans, let's talk about, just for a second, observable impacts. Glaciers melting, coral reefs dying—what percent of the coral reefs in the oceans of the world are dying, in your estimation?

Dr. EVANS. Let me see if there is someone here with me that actually knows that number.

[Pause.]

Dr. EVANS. We will have to get back to you with a number on that. [Refer to Appendix.] There have been a number of numbers published. It is significant. A number of folks have published studies showing that apparent warming has led to coral bleaching which may, indeed, be leading to the death of quite a large number of reefs, but I don't know that number right now.

Senator MCCAIN. And, I mean, to state the obvious, when the coral reefs die, the beginning of the food chain is eliminated, and

that has incredible impacts over time on marine life. Throughout Antarctic, holes—large lakes are appearing. Isn't that true?

Dr. EVANS. Yes. There are waters appearing. That is right.

Senator MCCAIN. I guess there is a long list of observable impacts.

Dr. EVANS. That is correct.

Senator MCCAIN. That, to me, is very troubling, and I understand that sometimes these observable impacts are exaggerated by media coverage, et cetera, but it seems to me there is a rather long list of observable impacts which should lend some urgency to at least modest action.

Now, Senator Kerry just quoted some statement that there have been many, many high-level meetings in the White House, and you said you have attended some of these. And by the way, I am very appreciative that you are here.

I also am not appreciative, Mr. Chairman, of other members of the administration. If this issue is, as you just described in the National Security Advisor's statement, as compelling, perhaps they should share some of those views with the Congress and this Committee which has oversight, since any meaningful remedy is going to require legislative action. I hope that you will get a better response in future hearings to your invitations.

But we are very grateful you are here, Dr. Evans. So you have this long list of observable impacts. It seems to me that would impel us to at least some modest action to begin with. Do you have any recommendations as to what immediate action we could take?

Dr. EVANS. I think, to be honest, the people in my business are not of a single mind about what sort of actions to take. The scientists take a look at the way the world changes and there are lots of natural variability in the system as well. Many of the phenomena which are consistent with global warming are also consistent with natural variability in the climate system, and we are just beginning to learn.

So, once you get beyond that level of understanding, I don't think that there really is what you would call a consensus about what to do next. Should we look at automobiles? Should we look at power plants? Should we impose mandatory standards? Should we have voluntary programs? I don't think scientists are necessarily the right group to ask about what one should do in that regard.

Senator KERRY. Would the Senator yield just for one moment?

Senator MCCAIN. Sure.

Senator KERRY. But the critical point you make in your testimony, which you underline, is that we have to make progress on net emissions.

Dr. EVANS. I think that if we don't make progress on net emissions, we are going to continue to accumulate CO_2 in the atmosphere and we are going to see an accumulation and perhaps acceleration of the effects that you are talking about. I believe that is true.

Senator MCCAIN. Well, first of all, in previous testimony, the body of scientific opinion is—and please correct me if I am wrong here—that there is global warming. It just depends—it is the end of that curve that goes on since the beginning of time, and it depends on whether you believe that there is a high end of global

warming or a low end of global warming, but all of it is higher than ever observed before. Is that correct?

Dr. EVANS. Absolutely correct. Yes, sir.

Senator MCCAIN. OK. So now we have a body of scientific opinion that agrees that climate change—let's call it climate change—is a reality. The debate is not whether it is happening. The debate is the extent of it. Is that an accurate statement?

Dr. EVANS. I think the debate is even more sharply focused than that. There are two components: how much of what has happened as part of some natural system of the Earth and how much is anthropogenic, and there is consensus that at least a significant amount of it is caused by human beings.

But the real problem is: Given what we have now, what is a reasonable projection for the future, because you are asking the scientists to project into an area scientifically where, in fact, they don't have any data or they don't have any experience. That curve that you are referring to, if one projects it into the future, one is sort of leaping off into an area where there really aren't any data to substantiate it right now, and you are depending upon the models that we have of the way the physical world works in a way that, quite frankly, stresses them.

And so I think you are right in saying that there isn't doubt about what has happened so far. I don't think that there is doubt that some degree of that will continue to happen in the future.

Senator MCCAIN. Which?

Dr. EVANS.—But the degree to which it happens in the future which is very important is not known very well.

Senator MCCAIN. And just a few years ago, there was not this basic unanimity of opinion, was there?

Dr. EVANS. That is correct. I think the consensus is much stronger right now than five years ago. That is correct.

Senator MCCAIN. With every study, we are gathering in a larger and larger body of scientific opinion.

Dr. EVANS. That is correct.

Senator MCCAIN. All right. Then could I just finally get back to the Chairman's comment. You do agree that net emissions is an issue that must be addressed.

Dr. EVANS. I think that that is true. If we are not going to continue that trend, then I think we are going to have to deal with emissions. Is that correct?

Senator MCCAIN. How do we do that?

Dr. EVANS. At that point, you sort of begin to move personally beyond my area of expertise. There are a lot of things that people have mentioned. Mr. Kerry mentioned the list of topics there which could contribute to reducing emissions, but the trade-offs on those topics, which one or ones of them do you want to use, how strongly do you want to apply it, when do you want to do it, those really become more social and economic decisions than scientific decisions.

Like I said, I would like the science to be able to support a discussion of those options by telling you what the world might look like under a range of scenarios that you would put together by exercising those options. That would be the right role for science to play in this. A choice as to which option to use, though, unfortu-

nately, gentlemen, you are going to have a much harder job than the scientists have had so far in trying to sort through that.

Senator MCCAIN. Is that effort underway, to get some scientific opinion as to what would happen under various options?

Dr. EVANS. Yes. People are working on those scenarios now. That work is underway. I think it is an area that we are going to need to accelerate to some degree.

Senator MCCAIN. In a collective fashion, is your organization involved in that?

Dr. EVANS. We have just begun working on that. We have had a significant activity, as you know, in climate modeling and modeling the physical climate, and we have a growing program, an evolving program, that begins to understand the impacts and provide the tools for doing that kind of interactive modeling that we are going to need to develop.

Senator MCCAIN. Well, I thank you, Dr. Evans.

I know you have other witnesses, but, Mr. Chairman, I guess the question is not only how we act but when do we act. How long do you wait for this body of scientific opinion to be unanimous? You and I can find witnesses who will disagree that there is any global warming of any kind. We have had them before the Committee, but I think that if you look at the historical perspective of scientific studies, there is a larger and larger body of opinion that this is reality. Climate change is a reality.

And then the question, I think, that faces all of us—and the scientific community has to be involved, Dr. Evans—is what actions we will take and when. And I am not sure, Mr. Chairman, if we should wait until every scientist in America agrees that this is a serious and almost unprecedented challenge. I thank you, Mr. Chairman.

I thank you, Dr. Evans.

Senator KERRY. Well, Senator McCain, thank you very much, and I thank you for your leadership when you were chairman in pulling together a very important scientific baseline, on which this Committee can base some judgments.

Let me say personally in answer to the question you posed generically: I am sure that we should not wait, and the reason I am sure that we should not wait is that there are other benefits. We are getting trapped in the wrong debate here, and as we listen to the President and the administration say, "Well, we are studying this," we are, in fact, being misled, because the President is not just studying this. The President has, in fact, taken actions. He has reneged on a campaign promise on CO_2 emissions. That is an action; that is a positive action that runs counter to some of the steps we might have taken.

He has declared the Kyoto Treaty dead, not replacing it with a different alternative, not saying how he could fix it, just declared it dead. That is an action. That is an affirmative action that has a negative consequence on doing something about this.

The President has proposed an energy plan that will increase emissions by 35 percent, directly contrary to what you have said here in your testimony today, that we must have a policy of no net emissions. That is a affirmative step he has taken, not a study, an

affirmative step that runs directly contrary to the efforts to do what we are trying to figure out here today.

We have a tax plan on the table—now signed into law—that has reduced the options of giving incentives to create fuel-efficient vehicles, to create all kinds of other options that we might have with respect to this. Now, that is an affirmative step. It is a declaration of a priority. And so I will just make it very clear that we are not simply studying. We have had a series of proposals made to the Congress and to the country that are directly flying in the face of all of the scientific evidence and of the alarm that Senator McCain just signaled, and that is the concern of many of us here.

The debate should not be over just whether we can predict all of the consequences of what is going to happen scientifically. We know that enough is happening that is negative already, and we know that if you extrapolate that out into the future as you have, we can't continue to add to it. We know that the consequences are negative, so we could at least begin to take some modest steps that might begin to deal with that.

An example: We are back down to 1980 levels in the fuel efficiency standards of our vehicles, while other countries are moving ahead and being more affirmative in trying to reduce their emissions. So there are many things that we could do as a matter of good health policy, for instance.

In 1973 when many of us remember waiting in fuel lines for hours, we were 35 percent dependent on foreign oil. Today we are about 55 percent dependent, and we are about to head into the 60's. Wouldn't it be wonderful if the United States of America were, indeed, independent in terms of our energy base today? And think of what the consequences could be for peace in the Middle East, for not having to perhaps fight another war as we have already fought one in the last 12 years on the subject of oil, if we were to move to that kind of independence.

So there are, in fact, very compelling reasons: health, asthma among children, lung disease, cancer, countless numbers of security reasons—matters of the human condition that should be compelling us to move in this alternative direction. And I wonder, Dr. Evans, if you don't accept the notion that those are compelling options that ought to be on the table?

Dr. EVANS. I think that probably all of those options are on the table. As I indicated earlier, I did attend some of the meetings, and I think quite a few of those options are on the table. I think that lots of them are under discussion right now.

As I tried to indicate before, my particular expertise is on the science side, and basically that is what I have been asked to comment on, and I have tried to indicate, those areas where the science could help choose among those options, to try and deal with some of the issues that you have raised there.

Senator KERRY. Well, actually, both Senator McCain and I tried to ask you what options you might pursue, and you said, Well, that is not really the job of the scientist.

Dr. EVANS. No. I think that the job of the scientist is to try and evaluate those options when they are posed at this point. What would be the consequences of——

Senator KERRY. Well, what would be the consequence of a mandatory target for emissions reduction? That is what I asked you. I gave you the plan. I laid it out. That was my first question to you. What would be the consequence of a greenhouse gas emission target and a timetable to achieve significant emissions reductions at a specific future date?

Dr. EVANS. One would assume, from a scientific point of view, that one would end up with somewhat lower carbon dioxide or at least a decreased rate of increase of carbon dioxide in the atmosphere, but the other consequences of that, economic consequences or what the consequences would be in other aspects of our daily lives, frankly I don't know.

Senator KERRY. But from a scientific point of view, would that goal be a salutary one?

Dr. EVANS. Salutary?

Senator KERRY. Would it be one we would want to achieve?

Dr. EVANS. It would be a goal that would lead to less carbon dioxide in the atmosphere.

Senator KERRY. And is that better?

Dr. EVANS. Better? It would——

Senator KERRY. Is that desirable? Pick any word you want that says whether or not that is something we ought to try to do.

Dr. EVANS. I think at some level the answer is yes, because at the extreme of greatly increased carbon dioxide concentrations, I think that the answer would be that we wouldn't want to go there, but where along the continuum from where we are now to more is desirable, good, safe, to use a word that was in the climate treaty, for example, I think is really an open question right now. It is not one to which we actually have an answer.

Senator KERRY. Would it be a smart policy to adopt a national effort to increase all available beneficial sequestration methods, like increased forest acreage, less deforestation? Would that help reduce CO_2?

Dr. EVANS. Possibly. I mean, I don't know.

Senator KERRY. What do you mean by "possibly"?

Dr. EVANS. I don't know what the trade-offs would be. I don't know what you would stop doing in order to increase forests. I don't know what—you know, whether you would need other kinds of fertilization. There is a whole range of issues associated with pretty much any of those, and I guess what I was suggesting is rather than trying to offer a kind of a general answer off the top of my head about any particular policy, I think that those are exactly the kinds of things that really warrant some pretty careful investigation. What are the consequences of doing one thing versus another? What are the costs of doing one thing versus another? How would they play together, and what would be the overall impact on carbon dioxide in the atmosphere?

Senator KERRY. But isn't——

Dr. EVANS. You know, but to get there——

Senator KERRY. But isn't that specifically one of the options? Didn't we have significantly more forests on this planet in the last centuries?

Dr. EVANS. Yes.

Senator KERRY. And didn't we do pretty well? I mean, was that negative? Did we seek to cut the forests because it was a bad idea?

Dr. EVANS. I don't know how to answer that, sir. I don't think we cut the forests because it was a bad idea. I think we cut the forests to do things with the lumber, to clear the land for agriculture, to make paper. There is a variety of reasons for having cut the forests.

Senator KERRY. Well, I understand that, but aren't we now specifically talking about sequestration through increased planting?

Dr. EVANS. Yes.

Senator KERRY. I mean, we are actually talking about counting forests——

Dr. EVANS. Yes.

Senator KERRY.—as part of the sinks?

Dr. EVANS. Yes.

Senator KERRY. And those sinks are, in fact, what we are seeking as a means of sequestering carbon dioxide.

Dr. EVANS. Yes.

Senator KERRY. So planting them is a benefit. I don't know why we have to struggle to get to that.

Dr. EVANS. Well, the planting is certainly a benefit, over some period of time, and the question honestly in the case of forests is, what is the period of time, because once the trees start growing, if you cut them down, what do you do with the carbon that has been sequestered there. It is not a permanent solution.

Senator KERRY. But we are doing that right now. We are cutting them down without even counting it.

Dr. EVANS. Yes.

Senator KERRY. I think the point is made.

Senator Ensign.

Senator ENSIGN. Thank you, Mr. Chairman.

I just had kind of a couple of general overall questions, because I have spent a lot of time with this issue—we have an institution in Nevada called the Desert Research Institute. They do a lot on atmospheric studies and have a lot of scientists out there that have been studying a lot of climatological changes.

Some of my discussions with them—and I would maybe like you to comment on some of these—are studying climate in general over time, seems to me, to be a difficult prospect at best. Some of the things they talk to me about, are studying some of the densities of glaciers and the various things that they have tried to do over time to be able to tell whether there has been changes in global temperatures, but it also seems that it is difficult in that it is not a closed system.

In other words, it is not like you are taking like in our old chemistry experiments that we have got a little styrofoam cup and we have got a thermometer and we can measure that as almost a closed system. It is not like you have the Earth and a thermometer, and so you are measuring a closed system. Depending on where you are taking the temperatures—are you taking them all in the cities? We know that the more populated that you get in a city and obviously the more emissions that you have in that city, at that particular place, you may have an increased temperature, but it also varies in various parts of the globe.

So I guess I would just like your overall comments about the difficulty in studying that, and what are the implications on setting policy because of those difficulties?

Dr. EVANS. Well, you have raised a number of issues associated with how you measure temperature, for example. There has been a lot of discussion in the scientific literature about that. You referred, in particular, to the so-called heat island effect from cities. These are phenomena which are, I think, becoming rather well understood. The heat island effect in cities and looking at the historical records is something that is known and to a large degree has been corrected in our assessment of temperature change.

There have been the usual scientific discourse back and forth on whether your correction is better than his, and vice versa, but I think that the basic sense of the long-term temperature record right now, collected from a variety of means, instrumental means, thermometers, if you will, for the last 150 years, proxy records and tree rings and ice cores and a wide variety of other methods for much longer periods than that have really achieved a large degree of consensus in the scientific community, so this basic question of whether it is getting warmer or not, or what does the basic pattern of temperature change look like, I personally don't think has a huge degree of controversy associated with.

Yes. There are people with different opinions, and I won't say that this is a consensus view or unanimous view. But it is one that, I think, represents a strong sense of what the scientific community believes, those measurement problems notwithstanding.

Now, you do highlight the need, though, for a real observing system if we want to know what is going on, if we want to better initialize our climate models to understand the future, if we want to have a better understanding of the way the world systems work so we can separate natural variability from warming induced by the things we have put in the atmosphere, having a robust, global climate monitoring system is very important.

There have been a number of plans offered from doing that. We derive some data these days from satellites. There is a long-term instrumental record. There are a variety of organizations worldwide that have proposed systems for doing that, and we are making progress in implementing these worldwide observing systems. We probably need to accelerate that progress for the future.

But to answer your specific question, I think that there is a good sense in the scientific community that a number of those issues that you raised are ones that have been addressed and where we still find a significant record of warming.

Senator ENSIGN. The things that I have read in my literature and my discussions have been that there is not unanimity among scientists. Hopefully, there is never unanimity, because——

Dr. EVANS. Right.

Senator ENSIGN.—then we are not questioning in the way that we should question in science. But given that, there is a fairly strong consensus that there has been an increase in the temperature of the planet in the last 100 years. Can you just comment on how significant that temperature increase, how much has been induced, and what percentage of that has been induced by humans, or have we been able to determine that, and how significant it is

compared to natural increases or decreases in temperature, especially when we are dealing with geologic time?

Dr. EVANS. Well, when you are dealing with geologic time, of course, you can look back through the Ice Ages or the age of the dinosaurs, and you will find climates for the Earth which are very different than the one that sustains our livelihoods right now. So I am not sure that that is really helpful. The Earth certainly has had a variety of different climates in its history. There is no doubt about that.

But the temperature changes that we have seen in the last 150 years, let's say, basically since the Industrial Revolution, really are unprecedented in the record of, say, 1000 years prior to that, and other properties associated with the temperature fluctuation are probably not really detected or are separate from the kinds of variability, natural variability, that we would expect to see in the system going back even 10,000 years. So it is quite significant, the changes that we have seen in the last—certainly over the course of the 20th Century.

And the body of scientific evidence suggests that at least a large fraction of that change is due to the increase of greenhouse gases that we have observed. The best that is measured or the way that we get our arms around that most accurately is by taking the models that we have that capture all of the physics and chemistry that we know, and running those models with a variety of scenarios; that is, include the greenhouse gases, exclude the greenhouse gases, include the sulfates or the particles that come from volcanic eruptions, changes in solar variability, the sulfates that increased and then decreased as a consequence of our actions in the atmosphere.

And what we find is that we get the best agreement with the measured temperature record over the last 150 years, when all of those factors, including the man-caused increases in greenhouse gases are included in those models.

Senator ENSIGN. The question, though, that you didn't answer was: When we are looking at the percent of man-caused versus natural—you mentioned solar. From what I understand, the changes on the sun can be incredibly significant as far as what happens on the Earth, not only temperature-wise, but obviously as far as all kinds of electromagnetic activity and radiation and the various things that can happen here.

And the reason that I am asking the question is I think it is important for policymakers to understand, you know, how big of an impact are we making in the negative to our planet temperature-wise or environmentally, so that if we make changes, how significant of changes can we make percentage-wise as far as will we really make any difference by the policy, because when you are doing any of these, you do have to take costs into account? You have to take into account a lot of other things. So it would be nice if we at least had some kind of a handle on this.

Dr. EVANS. Well, like I said, we have good measurements of a lot of the sorts of natural variability in the system over the last few decades. We have good measurements, for example, of solar input and solar variability over the last 30 years while we have been flying satellites and have good global measurements of those data.

Those kinds of variabilities are included in the models. They have an impact, but solar variability, quite frankly, is rather small. There are other impacts due to variations in the sun. As you know, NOAA does operate the Space Environment Center that monitors solar activity and provides warnings and forecasts of solar events, which can have impacts on all sorts of aspects of daily life, changes in the electric grid and health and safety of astronauts and satellites. There is a wide range of potential impacts of the solar variability on the Earth.

We have actually been monitoring solar variability through the last two or three solar cycles, including that kind of measured variability, and the sun doesn't begin to account for the kinds of changes in temperature that we have seen.

Now, in looking at the two bursts of change, if you will, in temperature, the early part of the 20th Century and the latter part of the 20th Century, more of the temperature change can be ascribed to some of these naturally occurring factors, but the changes that we have seen over the last 50 years don't seem to be accounted for that way.

Senator KERRY. Thank you very much, Senator.

Senator Snowe. We are going to move to the next panel right after Senator Snowe.

STATEMENT OF HON. OLYMPIA J. SNOWE,
U.S. SENATOR FROM MAINE

Senator SNOWE. Yes. Thank you, Mr. Chairman, and I will be very brief.

But, Dr. Evans, based on what we know—and obviously we have a significant body of work with respect to climate change and how it is affecting our world in which we live—do you think that we can make some policy changes right now to effect global warming and climate change? I mean, how long do we have—how far do we have to go and how long do we have to take before we can initiate policy changes?

Dr. EVANS. That is a very difficult question. We have taken about 150 years in practical terms over the industrial Revolution to sort of get where we are now. The climate system responds rather slowly. We know that we are going to see increased warming in the oceans. Even if we were to reduce emissions dramatically right now, we are going to continue to see ocean warming, because the processes are very long and slow.

That means that actions that we take will have consequences over a long period of time. It also suggests that dramatically taken actions are not likely to produce dramatically evident results, and so I think that we have time to take a look, to consider what we need to do carefully, but we do need to recognize that the consequences of our actions or inactions have very long time constants associated with them.

Senator SNOWE. But we know that human activity obviously has a significant impact on climate change. For example, why not take steps, like closing the loophole on CAFE standards for SUVs? Knowing that SUVs contribute significantly to carbon dioxide emissions, far more than passenger cars. That is a step that we know

could help in improving the atmosphere. So why not take that kind of step? Would the administration be supportive of that initiative?

Dr. EVANS. Senator Snowe, I have tried to confine most of my answers as best as I have been able to.

Senator SNOWE. Well, let me ask you——

Dr. EVANS. Try and understand the scientific impact of what is happening. If we were to take any steps that reduced the emissions of CO_2, that would probably have a mitigating effect or a slowing effect on the kinds of change that we are attributing to the accumulation of CO_2.

Senator SNOWE. So transportation obviously is a significant contributor.

Dr. EVANS. That is correct.

Senator SNOWE. OK. So then obviously it could have an impact. And, Mr. Chairman, I would even recommend that this Committee have a hearing on closing the CAFE standards loophole on SUVs, because I do believe that it could have a major effect. In fact, if we implemented a standard of 27.5 miles per gallon, we could reduce carbon dioxide emissions by more than 200 million tons every year. I think that has a significant effect and a significant result.

I think the time has come to take policy steps that will have an impact, however incremental they might be. But the fact is we have to begin to take steps. I think the National Academy of Science report on the effectiveness of CAFE standards is a wake-up call for where we are today. So I would hope that the administration, beyond looking to further studies, should also be considering what steps can be taken, what legislative measures could be taken, so that we can begin to address this perilous issue when it comes to our environment.

Senator KERRY. Senator Snowe, thank you very much. Let me just say that Senator McCain and Senator Hollings and I are putting together legislation right now, even as we speak. It will be ready in a few days, and we will be proceeding forward on that as well as several other initiatives.

[The prepared statement of Senator Snowe follows:]

PREPARED STATEMENT OF HON. OLYMPIA J. SNOWE, U.S. SENATOR FROM MAINE

Thank you, Mr. Chairman, and thank you for holding this hearing today, as this is an appropriate follow up to the climate change hearings Ranking Member McCain has held both in the 106th Congress and in the 107th, the latest being this past May. This Committee does have a large responsibility in the oversight of the climate change issue and I'm pleased to see that responsibility being exercised.

In Senator McCain's hearings, we heard from renowned scientists with varying opinions on global warming, and just weeks ago, and at the President's request, a well respected and balanced panel of U.S. scientists came out with a report that there is strong evidence that warming over the past 50 years is attributable to human activities, and significant increases in global temperatures and sea level can be projected. I believe this National Academy of Science Report is the wake up call for many who have not yet gotten engaged in the issue of climate change as we now have a growing collective picture of a warming world over the past century. Climate change is a perilous environmental problem that deserves to be addressed on both the domestic and international level.

It appears clear that regional climate changes, particularly temperature changes, are affecting physical and biological systems. Many human systems, the scientists say, are sensitive to climate change, and the potential for large scale and possibly irreversible impacts pose risks that have yet to be quantified. We must recognize that those around the globe with the least resources have the least capacity to adapt and are the most vulnerable to these changing climate processes.

The United States had a large part in the development of a climate change convention treaty at the "Earth Summit" in Rio de Janeiro in 1992. President George H. W. Bush went on to sign the UNFCCC Treaty and it was unanimously ratified by the U.S. Senate. I believe Congress' prudent response to climate change is to work for the adoption a portfolio of clear and concise U.S. actions aimed at mitigation, adaptation, and research as the issue is one with unique long-term effects involving complex interactions between climatic, environmental, economic, political, institutional, social and technological processes.

As one of the many pieces we can consider, I would like to suggest support for a simple change—the Feinstein-Snowe bill that closes the SUV loophole by raising the fuel efficiency, or CAFE, standards for "light truck" vehicles to meet those expected of passenger vehicles. The overall fuel economy of new cars and trucks sold in America, after improving slightly a year ago, has dropped back to the lowest levels since 1980, mainly because of the lower fuel efficiency standards currently set for the popular SUVs and minivans.

It is estimated that fixing the SUV loophole will save one million barrels of oil a day, reduce oil imports by 10 percent, cut America's trade deficit—oil deficits are the largest of this—save consumers money at the gas pump, and provide healthier and cleaner air benefits, and, very importantly, prevent more than 200 million tons of carbon dioxide—the major greenhouse gas connected to global warming—from going into the atmosphere. This legislation is under the jurisdiction of the Commerce Committee and I urge the Chair to hold a hearing on the Feinstein-Snowe bill.

I have asked the Administration for support of the SUV loophole bill as one way to move toward reducing our carbon dioxide emissions, and I look forward to hearing about what the Administration's strategies are as we work through the domestic and international issues relating to climate change.

Thank you, Mr. Chairman.

Senator Dorgan.

Senator DORGAN. Mr. Chairman, I was delayed, so I will defer questioning. I have read Dr. Evans' statement. Thank you very much for appearing, and I will be here for the next panel.

Senator KERRY. Thank you.

Senator Stevens.

Senator STEVENS. No. Thank you.

Senator KERRY. Dr. Evans, thank you very, very much. The only thing I would conclude by saying is that, as you have pointed out, the slowness of response is a compelling reason to think about some of the things like Senator Snowe and others have suggested. I gather the half-life of existing CO_2, where we are right now is about 70, 80 years.

Dr. EVANS. That is about right. Yes.

Senator KERRY. So what we have already put out there is going to continue to do the current rate of damage for the next 70 years, no matter what we do, unless you and others discover some means of reversing, i.e., of rapid sequestration that takes CO_2 out of the atmosphere. Is that correct?

Dr. EVANS. That is a fair assessment. Yes.

Senator KERRY. So it might even make more compelling the notion that even without knowing fully what those consequences are, we who make policy ought to be more thoughtful about being precautionary and trying to avoid catastrophe.

Dr. EVANS. I think that those of you who make policy at this point have some very difficult challenges in front of you. I think that you have got potentially very significant decisions to make, and I am afraid that in the science community, we are not giving you all the tools that I wish that we were to help make those decisions earlier.

Senator KERRY. Well, this is a great segue into the next panel. I don't find it as economically challenging or policy challenging as some people suggest. There are some wonderful technologies already out there. There are things that we can do that create whole new sectors of our economy, countless numbers of jobs, huge new opportunities, all of which can take us down a different road. So I don't think we have to view this as a difficult challenge.

The Japanese automobile manufacturers and others are moving rapidly to provide hybrid automobiles, to get up to 75, 80 miles per gallon very quickly. I suppose the most significant question is why we are always the last ones to move in these directions, but I think the opportunities are there, and that is what we are going to explore in the next panel.

Thank you, Dr. Evans, very much for being here.

Dr. EVANS. Thank you.

Senator KERRY. If I could invite the next panel to move up as rapidly as possible, we will begin right away with Dr. Kammen, and then Mr. German, Mr. Miller, Mr. Duffy, and Ms. Koetz.

Oh, I apologize. We have a plane problem I wasn't aware of, so Mr. Miller, if you would lead off. I understand you have a flight you have to get, and I apologize for any delay on that.

STATEMENT OF WILLIAM T. MILLER, PRESIDENT, INTERNATIONAL FUEL CELLS

Mr. MILLER. Thank you, Mr. Chairman. I am president of International Fuel Cells, which is a subsidiary of United Technologies Corporation. I appreciate the opportunity today to testify regarding the role of fuel cells in addressing climate change.

Fuel cells are an important climate change technology, because when fueled with hydrogen, they do not produce any carbon dioxide emissions. When fueled by natural gas, fuel cells produce substantially less carbon dioxide emissions than other technologies. IFC has a long history in fuel cells. We have produced the fuel cells for every U.S. manned space mission since 1966, including the space shuttle. These fuel cells produce the electricity for the orbiter when it is in space and all the drinking water for the astronauts.

IFC is also the only company in the world currently producing a commercially available fuel cell. That unit, the PC25™, produces 200 kilowatts of electric power, which is enough to power roughly 150 homes. Currently these units power schools, hospitals, military installations, data processing centers, and other facilities.

Fuel cells are electro-chemical devices that combine hydrogen and oxygen to create electricity. This is a single fuel cell, capable of generating one-third of a kilowatt of electricity. You put hydrogen in the orifices on the end, oxygen from air under these orifices, and you produce electricity, water, and heat. This produces a third of a kilowatt. If you need more, you just stack one on top of another to produce more kilowatts.

Fuel cells do not use combustion to produce electricity, and it is that combustion that creates NO_X, which is responsible for smog, and SO_X, which is responsible for acid rain. When pure hydrogen is the fuel source, fuel cells produce no harmful emissions at all, including no carbon dioxide, which is the primary manmade greenhouse gas involved in global warming.

Because hydrogen is not yet readily available as a fuel, we use fuel processors to reform commonly available hydrocarbon such as natural gas into hydrogen fuel for the fuel cell. When running on these hydrocarbons, fuel cells do produce carbon dioxide, but substantially less carbon dioxide, once again, than other means of electricity generation.

IFC has sold more than 220 fuel cell power plants to customers in 16 countries on five continents. Examples of installations range from the police station in New York City's Central Park to hospitals in several states, and to the main postal facility in Anchorage, Alaska. We have 32 PC25s operating in states represented by Senators on this Committee.

Our total fleet of PC25 power plants has accumulated more than 4.2 million hours of combined operation. They operate day or night, regardless of weather. Our installed base of PC25s has already prevented nearly 800 million pounds of carbon dioxide emissions and more than 14½ million pounds of NO_X and SO_X compared with typical U.S. combustion-based power plants. The U.S. Environmental Protection Agency recognized IFC last year with a climate protection award because of this achievement.

Building on this success, we are now developing fuel cell technology for residential and transportation applications. IFC is currently developing a 5-kilowatt unit for homes and small buildings. We expect to begin marketing these devices in 2003.

For the transportation market, IFC is working with a number of car and bus manufacturers to develop fuel cell vehicles. Our zero emission hydrogen fuel cells now power four Hyundai SUVs. These vehicles are the world's first zero emissions SUVs and get the gasoline equivalent of 50 to 60 miles per gallon.

We have also developed fuel processors capable of taking pump-grade gasoline and reforming it, and using it to power a fuel cell. Such technology will allow fuel cell vehicles to use the existing gasoline infrastructure until a hydrogen infrastructure is in place.

Cars, buses and trucks now represent about one-third of carbon dioxide emissions in the United States. By developing the necessary hydrogen infrastructure and fuel cell vehicles, we can take ground transportation out of the climate change debate.

But there is still one major barrier to the introduction of fuel cells for these various applications, and that is cost. IFC and other fuel cell companies are now developing new fuel cells, like the one I showed you earlier, that are smaller, lighter, and cheaper to produce than the ones presently in manufacturing. This new technology, along with higher production volume, should help us to reduce the cost of fuel cell power plants by two-thirds from today to 2003, so from $4,500 a kilowatt today to $1,500 a kilowatt in 2003, and the cost of fuel cell power plants will trend down even further beyond that. If we achieve the goal of automotive production, costs may decline to as low as $50 a kilowatt.

In conclusion, let me say that fuel cells are already helping to reduce carbon dioxide emissions today. Further commercialization of this technology will produce not only climate change benefits but improved air quality, independence from foreign oil, and technology leadership for the United States.

I look forward to working with you, Mr. Chairman, members of the Committee, and other interested parties, to accelerate the commercialization of fuel cell technology. And I would be happy to answer your questions later. Thank you.

Senator KERRY. Mr. Miller, thank you very much. Thank you also for hitting the timing right on the button. It is helpful to all of us. Do you have time to stay through the other testimonies for questions?

Mr. MILLER. I will stay through.

Senator KERRY. You are able to?

Mr. MILLER. Yes.

Senator KERRY. That would be very helpful. Thank you for doing that.

[The prepared statement of Mr. Miller follows:]

PREPARED STATEMENT OF WILLIAM T. MILLER, PRESIDENT, INTERNATIONAL FUEL CELLS

Good morning. My name is William Miller. I'm the President of International Fuel Cells (IFC), a subsidiary of United Technologies Corporation (UTC). UTC is based in Hartford, Connecticut and provides a broad range of high-technology products and support services to the building systems and aerospace industries. UTC's products include Carrier air conditioners, Otis elevators and escalators, Pratt & Whitney jet engines, Sikorsky helicopters, Hamilton Sundstrand aerospace systems and fuel cells by International Fuel Cells.

IFC has a long history in fuel cells. We've produced the fuel cells for every U.S. manned space mission since 1966, including the Space Shuttle. These fuel cells produce the electricity for the orbiter when it is in space and all the drinking water for the astronauts. IFC is also the only company in the world currently producing a commercially available fuel cell power plant. That unit, the PC25™, produces 200 kilowatts, which is enough to power roughly 150 homes. Currently, these units power schools, hospitals, military installations, data processing centers and other facilities.

Fuel cell technology is a reality today in space and commercial/industrial applications. By the end of this decade it will also power homes, cars, trucks and buses.

Fuel cells offer great potential for addressing climate change. Current fuel cell technology using hydrocarbon feed stocks produces 60% more electricity per pound of carbon dioxide emissions than the average US combustion based power generating system. Using hydrogen as the fuel will enable us to eliminate CO_2 emissions from the fuel cell power plant's operation.

Unlike other environmentally favorable solutions such as solar or wind power, fuel cells can be used as a continuous source of base power—independent of time-of-day or weather—for critical facilities, thereby offloading demand and providing independence from the grid.

Fuel Cell Description

Fuel cells are an electrochemical device that combines hydrogen and oxygen to produce electricity, with only water and heat as the by-products. Fuel cells do not use combustion to create electricity. It is combustion that creates NO_X, which is responsible for smog, and SO_X, which is responsible for acid rain.

IFC History and Current Fuel Cell Applications

International Fuel Cells is the world leader in fuel cell production and development for commercial, transportation, residential and space applications. IFC is the sole supplier of fuel cells for U.S. manned space missions and is the only company in the world producing a commercial fuel cell system, the PC25™ power plant.

IFC's headquarters, research and development, and manufacturing facilities are located in South Windsor, Connecticut, and cover more than 350,000 square feet. IFC employs some 750 engineers, researchers, managers and production workers.

Since 1966, IFC fuel cells have provided electrical power, as well as drinking water, for more than 250 astronauts on all of the United States' manned space flights. Each space shuttle mission carries three IFC 12-kilowatt fuel cell units. These units have accumulated more than 81,000 hours of fuel cell operating experience.

IFC is also the only company in the world currently producing a commercially available fuel cell power plant. That unit, the PC25, produces 200 kilowatts, which is enough to power roughly 150 homes. IFC has delivered more than 220 PC25s to customers in 16 countries and five continents.

This PC25 fleet of fuel cells has accumulated more than 4 million hours of operational experience in a range of operating environments. The PC25 system requires only routine maintenance and has a life of 40,000 hours, or five years, before a major overhaul is required. IFC has 32 PC25s operating in states represented by Senators on the Commerce, Science and Transportation Committee.

IFC is now developing fuel cell technology for residential/light commercial and transportation applications, including buses, fleet vehicles and cars.

Environmental and Climate Change Benefits of Fuel Cells

When pure hydrogen is the fuel source, fuel cells produce no harmful emissions—no carbon dioxide, which is the primary man-made greenhouse gas involved in global warming and no NO_X or SO_X, the pollutants that cause smog and acid rain.

Hydrogen is not yet readily available as a fuel. Because of this, fuel cell power plants incorporate fuel processors to reform commonly available hydrocarbons such as natural gas, propane, or methane from waste water treatment plants into hydrogen fuel.

Even when running on these hydrocarbons, IFC's fuel cells are still very climate friendly and efficient. They produce 60% more electricity per pound of carbon dioxide emission than the average US combustion based power generating system.

IFC'S installed base of PC25 power plants has already prevented nearly 800 million pounds of CO_2 emissions and more than 14.5 million pounds of NO_X and SO_X compared with typical US combustion-based power plants. The U.S. Environmental Protection Agency recognized IFC last year with a Climate Protection Award in recognition of these accomplishments.

Fuel Cells are More Efficient Energy Producers

Fuel cells, because they do not use combustion, are significantly more efficient, meaning they produce more energy from the same amount of fuel

For example, in the "electricity-only" mode of operation, IFC's PC25 unit achieves approximately 40% efficiency. However, fuel cells are generally installed at the point of use, so the waste heat from the fuel cell can be used for such things as space heating. This is known as co-generation. When used in co-generation applications, the PC25 can reach efficiencies as high as 87%.

Fuel Cells for Distributed Generation

Distributed generation is increasingly being recognized as one way to address both the need to reduce the demand on the current electric distribution system and to provide assured power at facilities such as data centers where uninterruptible power is a requirement.

As our society increases its reliance on sophisticated computer systems, very short power interruptions can have profound economic consequences. In 1996 the Electric Power Research Institute reported that US businesses lose $29 billion annually from computer failures due to power outages and lost productivity.

Locating distributed generation assets at the point of use also eliminates transmission line losses that can run as high as 15%.

Fuel cells are an excellent distributed power asset because they are clean, quiet and small enough to provide power at the point of use. For example, two IFC PC25s are located inside the Conde Nast skyscraper at Four Times Square in New York City.

IFC's PC25s are used in a number of installations in this capacity. Some examples:

- The Central Park Police Station in New York City uses a PC25 to provide all the power for the facility on a "24–7" basis completely independent of the grid.
- In Rhode Island, a PC25 system provides power for the South County Hospital. The installation supplies base load electrical and thermal energy to the hospital where it helps ensure clean, reliable power for sensitive medical equipment and systems such as CAT scanners, monitors, analyzers, and laboratory test equipment. If there is a grid outage, the PC25 automatically operates as an independent system, continuing to power critical loads at the hospital. Heat from the installation provides energy for space heating, increasing the fuel cell's overall efficiency.
- The largest commercial fuel cell system in the world is currently operating at a U.S. Postal Service mail-processing center facility in Anchorage, Alaska. The

PC25 units operate in parallel to the grid and are owned and operated by the local utility. The fuel cells can either provide power to the U.S. Postal Service or provide power back to the grid. If the grid fails, a near instantaneous switching system automatically disconnects the grid and allows the fuel cells to provide uninterrupted power.

- One of IFC's installations at the First National Bank of Omaha involves four fuel cells as the major component of an integrated assured power system that is meeting customer requirements for 99.9999% reliability.
- A number of schools and colleges in Massachusetts, New York and New Jersey have purchased fuel cells to ensure clean, efficient, and reliable power for data processing and computer operations, provide basic electricity and heating needs as well as use the units as a teaching tool for students. For example, Cape Cod Community College expects its fuel cell to help save the college about $54,000 of the $185,000 in energy costs each year. This fuel cell power plant installation is part of a comprehensive energy savings performance contract agreement being implemented by NORESCO.

As these examples illustrate, fuel cells are very flexible in meeting customers' power requirements for base load, assured power, emergency back up and co-generation. In addition, fuel cells are being used in grid connected, grid independent and grid parallel applications.

Renewable Energy

Fuel cells are already using renewable energy sources.

IFC and the US Environmental Protection Agency (EPA) collaborated in the early 1990s on a greenhouse gas mitigation program that continues to bear fruit today. Initial efforts targeted landfills and the development of gas cleanup systems that enable fuel cells to use waste methane to generate electricity and resulted in the issuance of several patents jointly held by EPA and IFC. These systems avoid the use of fossil fuels as the fuel source.

Follow-on work has focused on anaerobic digester off-gases (ADGs) from wastewater treatment facilities. This technology has been implemented successfully at PC25 installations in Yonkers, New York; Calabasas, California; Boston, Massachusetts; and Portland, Oregon as well as Cologne, Germany and Tokyo, Japan.

Residential and Light Commercial Fuel Cell Application

IFC, along with several other companies, is currently pursuing residential and light commercial fuel cell applications for homes and businesses using next-generation proton exchange membrane (PEM) fuel cell technology.

IFC is drawing on its experience in commercial programs to develop a five-kilowatt PEM fuel cell system suitable for homes and small commercial buildings. IFC is teaming up with its sister UTC unit Carrier Corp., the world's largest maker of air conditioners, as well as Toshiba Corp. of Japan and Buderus Heiztechnik of Germany on this effort.

IFC is currently testing residential power plants and plans to have residential fuel cell units commercially available in 2003. Initial markets will include off-grid residential (an estimated 150,000 Americans live off the grid today), telecommunications providers who need assured power for cell towers and public buildings such as fire stations that required assured power.

Transportation Fuel Cell Applications

In the transportation arena, IFC is aggressively developing quiet, highly efficient ambient-pressure PEM fuel cells and gasoline reformation technology for automobiles, heavy-duty trucks and bus applications. Fuel reforming technology allows fuel cells to operate on pump gasoline.

IFC is currently working with major automobile manufacturers, including BMW and Hyundai and with the U.S. Department of Energy on development and demonstration programs for automobiles.

Last year, for example, IFC replaced the internal combustion engine in a Hyundai Santa Fe Sport Utility Vehicle with its zero emission Series 300 75-kilowatt hydrogen powered fuel cell. This vehicle was featured at the grand opening ceremony of the California Fuel Cell Partnership on November 1, 2000. This is the world's first zero emission SUV and gets the gasoline equivalent of 50 to 60 miles per gallon. Pure water vapor is the only by-product of this fuel cell power system. Hyundai and IFC have put two fuel cell powered Santa Fe's into driving service in California.

The IFC vehicle power plant is quiet and efficient. It's unique because it uses a near ambient pressure system, which substantially increases its efficiency. Other

transportation fuel cells require a compressor, which is a parasitic drain on the system because it uses part of the electricity produced by the fuel cell.

The IFC system has fewer parts, which translates into lower costs for the consumer and is smaller and hence easier to put in a car. To date, we have demonstrated the following capabilities with the IFC/Hyundai Santa Fe fuel cell vehicle:

- Performs with undetectable noise levels;
- Achieves maximum power output of 75 kW and a top speed in excess of 70 mph;
- Fills the vehicle's fuel tank with hydrogen to a pressure of roughly 3,000 psi in less than 3 minutes; and
- No infringement on passenger or cargo space.

In addition, IFC has also developed fuel cell auxiliary power units (APUs) that can power all the electronic components of a car thus removing this heavy power demand from the engine. In 1999, BMW demonstrated at the Frankfurt Auto Show a Series-7 vehicle featuring a 5-kilowatt hydrogen IFC fuel cell that powered the onboard electrical systems and air conditioning. During the two-week exhibition, we used the APU to run the car's lights and radio continuously without the engine running.

For buses, IFC has teamed with Thor Industries, the largest mid-size bus builder in North America and Irisbus, one of the largest European bus manufacturers, to build fuel cell powered zero emission transit buses. These prototype vehicles will take to the road this year.

Hydrogen Future

Fuel cells are already beginning to bring forth the clean, renewable, hydrogen future.

Some examples:

- IFC's hydrogen fuel cells have been used in space applications since 1966.
- IFC operated a 200-kilowatt fuel cell unit in Germany running on hydrogen.
- BMW has incorporated a hydrogen fuel cell auxiliary power unit into a Series 700 automobile.
- IFC has installed hydrogen-powered fuel cells into four Hyundai Santa Fe sports utility vehicles.
- IFC is developing hydrogen fuel cell buses with US and European partners.

Buses and fleet vehicles, since they return to a central location each day, are a near term opportunity to create the necessary hydrogen infrastructure including production, distribution and storage capability.

Meanwhile, a number of companies are making substantial progress on hydrogen production and storage. Ultimately, the vision is to produce hydrogen for diverse fuel cell applications through the use of renewable energy such as hydroelectric, solar and wind power.

Challenges

The cost of fuel cells has been one of the greatest impediments to their commercial use. However, the costs have been reduced dramatically in the past two decades. The space shuttle fuel cells, developed in the late 1970s, cost roughly $600,000 per kW. The PC25 commercial stationary unit, which was developed in the early 1990, has an installed cost today of $4,500 per kilowatt.

IFC and other fuel cell companies are now developing new fuel cells that are smaller, lighter and cheaper to produce. This new technology, along with higher production volume, should help reduce the cost of fuel cell power plants by two-thirds by 2003, from $4,500 a kilowatt to $1,500. The cost of fuel cells will continue to trend down. If we achieve the goal of automotive production, the cost may decline to as low as $50 per kilowatt.

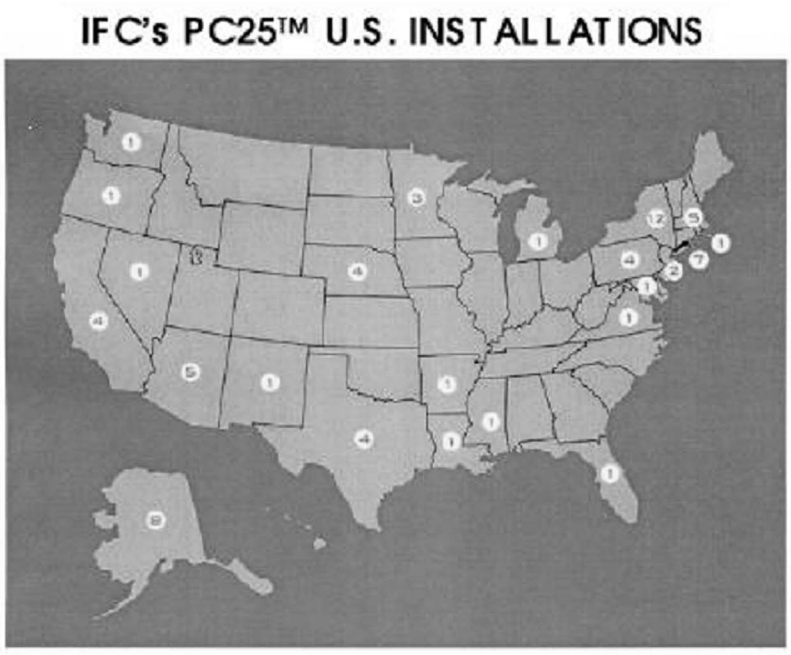
Government Actions

There are a number of things the federal government can do to help accelerate the commercialization of fuel cell technology. These include providing financial incentives, eliminating regulatory barriers, funding government purchases and demonstration programs and continuing the nation's commitment to hydrogen research and development.

Summary

Fuel cell technology represents an important component of the solution to climate change. This technology is already reducing carbon dioxide emissions and using methane as a fuel source. By the end of the decade, fuel cells will power homes, cars, trucks, buses and businesses. Widespread commercialization of fuel cells and establishment of the necessary hydrogen infrastructure will enable a wide spectrum of energy applications to eliminate their emissions of greenhouse gases without sacrificing our standard of living. Fuel cells powered by hydrogen that is produced using renewable energy is the long-term vision, and substantial progress has already been made. We look forward to working with Members of the Senate Commerce Committee and other stakeholders to ensure this vision becomes a reality.

Thank you, Mr. Chairman.



69 sites in 22 states as of June, 2001

More than 220 units delivered to 16 countries on five continents for diverse applications including schools, military installations, data processing centers, hospitals, and public buildings.

IFC'S 200 kW PC25™ FUEL CELLS... DIVERSE APPLICATIONS IN INSTALLATIONS WORLDWIDE

Assured Power
U. S. Postal Service
Anchorage, Alaska

Assured Power
South County Hospital
Wakefield, Rhode Island

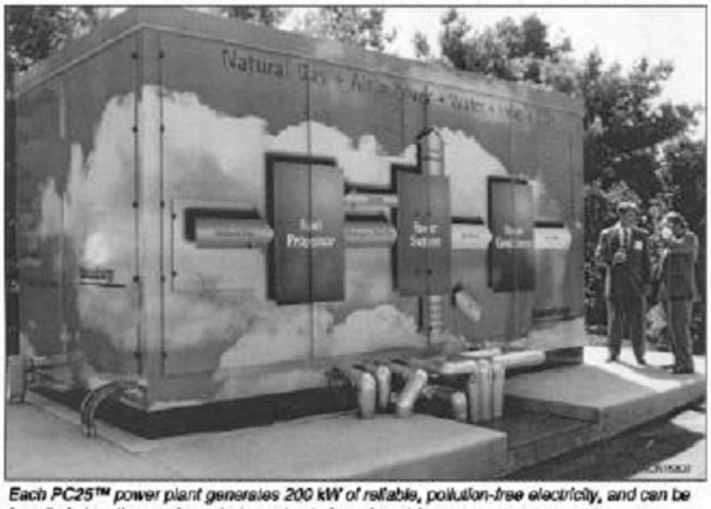
Resource Recovery
Waste Water Treatment Facility
Deer Island, Boston, Massachusetts

Distributed Generation
Central Park Police Station
New York City, New York

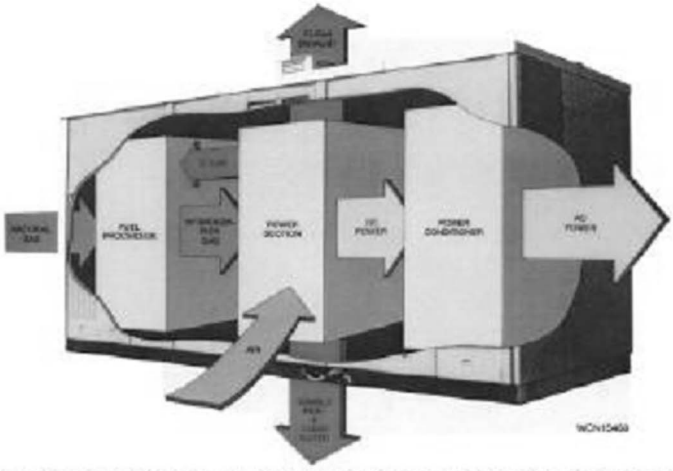
Resource Recovery
Waste Water Treatment Facility
Portland, Oregon

Assured Power
Bank of Omaha
Omaha, Nebraska

PC25™ 200 kW FUEL CELL POWER PLANT



Each PC25™ power plant generates 200 kW of reliable, pollution-free electricity, and can be installed virtually anywhere, independently from the grid.



Fuel cells generate electricity through an electrochemical reaction by combining hydrogen and oxygen. A fuel cell power plant consists of three main components: A ***fuel processor*** *reforms hydrogen from natural gas or other fuel source; the* ***power section*** *(fuel cell stack) produces DC (direct current) power; and a* ***power conditioner*** *converts the electricity from DC to AC (alternating current) power.*

Senator KERRY. Do you have an order you want to proceed in, or, Mr. Koetz, why don't you go next, and then we will run down the table to Mr. Duffy, Mr. Kammen, Mr. German.

STATEMENT OF MAUREEN KOETZ, DIRECTOR OF ENVIRONMENTAL POLICY AND PROGRAMS, NUCLEAR ENERGY INSTITUTE

Ms. KOETZ. Thank you, Mr. Chairman, members of the Committee. On behalf of NEI's over 270 member companies representing a multi-billion-dollar industry operating in almost every state in the nation, I am pleased to be here to discuss the role of nuclear technology in mitigating the potential harmful effects of climate change.

As the old industrial economy transitions into the new digital economy, one thing has remained certain. The backbone of sound economic policy is effective energy policy. As President Bush pointed out in his speech announcing the new national energy policy, our history was built on energy that was abundant and affordable and reliable. So, too, will be this nation's energy future. NEI agrees, and we are delighted to be here among many of the emerging and advanced technologies needed for that energy future.

The challenges of providing abundant, affordable, and reliable energy have historically relied on technological advancements to secure supplies and avoid and minimize environmental degradation. Baseload fission electricity production is a successful example of advanced clean energy technology that is good for the environment, supplants foreign fuel sources, and manages economic risks that can result from price or supply fluctuations.

Nuclear energy was first recognized as an emission control technology for both conventional air pollutants and greenhouse gases in the 1950's and 1960's. Since then, its dual capability to provide secure, reliable baseload supply with minimal environmental impact has made nuclear energy the backbone of an energy system that is not only abundant, reliable, and affordable, but cleaner and more environmentally friendly as well.

As we look to ways to effectively control our greenhouse gas emissions, nuclear electricity will once again play a key role. In his recent address on climate change, President Bush made a critical observation regarding the path forward on climate change, and he stated—and I quote—"There are only two ways to stabilize concentration of greenhouse gases. One is to avoid emitting them in the first place. The other is to try to capture them after they are created."

Avoiding emissions is our specialty. In the year 2000 alone, generating with nuclear plants in lieu of baseload alternatives avoided 174 million metric tons of carbon-equivalent emissions. And just to sort of scale that to what Mr. Miller just told you in terms of the capability of fuel cells, that is actually 1 trillion pounds of CO_2. Give you something to shoot for.

Without this critical contribution, the difference between current U.S. greenhouse gas emission levels and our 1990 baseline established in the framework convention on climate change would double. And just to give you some idea, too, since 1973, the total avoid-

ed emissions from using nuclear power are over 2 billion metric tons of carbon, and again that is approaching 6 billion tons of CO_2.

The value of avoiding emissions is not uniquely known and understood by U.S. leadership. On the contrary, our trading partners and competitors fully intend to take advantage of concentrated, large-scale nuclear energy sources to meet their objectives for climate change abatement. Japan has announced plans to build nuclear plants to meet emission targets. The United Kingdom is reevaluating its nuclear energy program, and Finland is planning a new plant for the European Union grid. Even Germany, long thought to be on a glide path to nuclear phase-out, has effectively postponed any potential plant retirements until well after the timeframe to meet its targets under the Kyoto protocol.

In all, the approximately 150 nuclear plants in Western Europe will be a key technology used by the EU to meet global climate goals without compromising economic growth, and the same is true for the Pacific Rim as well as advanced developing countries like Brazil and South Africa.

In sum, as we tackle the issue of climate change, the United States cannot afford to lose its leadership in advanced nuclear energy. Our designs have been developed to provide even greater safety, improve production efficiencies and additional cost reductions. We employ members of our communities in high-paying jobs, contribute to a tax base that pays for education and municipal services, and we support other economic activities that help grow and improve the standard of living for more and more Americans.

And just to play Ms. Snowe's point about transportation, just to give you an idea, the New York City subway uses 1.8 billion kilowatts of electricity annually. Without large-scale baseload generation, those kinds of transportation programs that are in and of themselves an emission control program, cannot run.

Right now many nuclear plants in the United States make electricity for little more than a penny a kilowatt, and that includes the costs of eliminating greenhouse gases and other conventional pollutants. As we recognize our responsibilities to the world community to support sustainable economic development, our investment in nuclear technologies continues to pay dividends. For example, using uranium for electricity in the developed world slows the depletion of limited global energy resources that are needed in developing countries.

Emission-free baseload electricity will continue to be the backbone of our energy and environmental policies, Mr. Chairman, supporting our sustained economic growth and protecting resources for future generations. The nuclear industry looks forward to working with you and all the parties engaged in climate change, so that we can use the best of our technology wisely and well to mitigate greenhouse gas emissions without undermining the American way of life.

I thank you, and I would be happy to answer your questions.

Senator KERRY. Thank you very much. Am I pronouncing your name correctly?

Ms. KOETZ. Koetz, sir.

Senator KERRY. Koetz. I was correct then. Good. Thank you.

[The prepared statement of Ms. Koetz follows:]

PREPARED STATEMENT OF MAUREEN KOETZ, DIRECTOR OF ENVIRONMENTAL POLICY AND PROGRAMS, NUCLEAR ENERGY INSTITUTE

Mr. Chairman, ranking members, and distinguished members of the Committee, I am Maureen Koetz, director of environmental policy and programs for the Nuclear Energy Institute (NEI). As with other air quality issues we have faced, the potential for climate change is challenging our ingenuity and our markets to devise, enhance and support technologies that avoid or mitigate man-made emissions of greenhouse gases. Foremost among these is a robust, safe nuclear energy industry, able to prevent these emissions while preserving the affordable electricity system that is the foundation for America's commercial success and future economic growth.

On behalf of its more than 270 members, NEI acknowledges and appreciates congressional support for the industry, which has helped bring nuclear energy to the renaissance we see today. In developing public policy for the nuclear industry, NEI represents a broad spectrum of interests from every U.S. utility that operates a nuclear power plant, nuclear fuel cycle companies, suppliers, engineering and consulting firms, national research laboratories, manufacturers of radiopharmaceuticals, universities, labor unions and law firms. The jobs, tax base and economic value the industry represents comprise a vital segment of our energy infrastructure, as well as American communities and families whose welfare and well-being derive from the construction, maintenance and operation of this nation's commercial nuclear power plants.

I am pleased to testify before this Committee regarding the role of our country's 103 nuclear electric generating units in protecting the environment from many potential adverse effects—including climate change—while providing 20 percent of our nation's electricity. The unique ability of nuclear-generated electricity to provide both energy security and protect the environment makes it one of the most important risk management tools available to minimize the adverse economic and environmental impacts from foreign fuel supply limitations and disruptions, energy price fluctuations, or environmental dispatch limits that can threaten U.S. growth and prosperity.

The growing importance of an adequate climate change response is causing energy supply and emission control issues to again converge as they did in the 1960s and 1970s. Effective climate change action will require a comprehensive energy policy that uses all forms of energy, particularly electricity generation, to their full potential and advantage. The national energy policy formulated by President Bush provides a positive framework to accomplish this goal by supporting the expansion of emission-free technologies—including nuclear electricity—to ensure adequate electricity supplies while mitigating the potential for climate change. Additionally, Sens. Bingaman and Murkowski this year have sponsored separate comprehensive energy bills that call for an expanded nuclear energy industry. Sen. Domenici has sponsored stand-alone legislation intended not merely to protect nuclear energy's vital role in our nation's energy portfolio, but to ensure that role continues to grow to help meet the nation's increasing electricity demand—and doing so while avoiding the emission of harmful greenhouse gases.

Emission Avoidance: A Key Policy Tool

In his recent address on climate change, President Bush made a critical observation regarding the path forward on climate change, stating: "There are only two ways to stabilize concentration of greenhouse gases. One is to avoid emitting them in the first place; the other is to try to capture them after they're created." This framework builds on our historical success with combining pollution avoidance and end-of-the-pipe controls in addressing other potentially harmful air emissions from power generation.

As early as 1969, the Department of the Interior listed increased use of nuclear energy as one of 11 methods to control sulfur dioxide emissions. Since then, the advent of nuclear energy has been a major component of achieving domestic air quality goals. For example, from 1975 to 1990, making electricity in nuclear plants instead of fossil-fueled alternatives avoided more tons of nitrogen oxide than were eliminated through controls under the Clean Air Act. In 2000 alone, nuclear plants avoided more than 4 million tons of sulfur dioxide, nearly 2 million tons of nitrogen oxides, and 174 million metric tons of carbon equivalent. In the absence of current nuclear production, the difference between current U.S. greenhouse gas emission levels and our 1990 baseline established in the Framework Convention on Climate Change would double.

As the president correctly points out, future efforts to control greenhouse gases will require our continued investment in emission-free technologies of all kinds, but particularly nuclear plants because of their sizable electric output, minimal environ-

mental impact and siting capability near load demand. To fully understand the vital role of emission avoidance, one need only look at the success of voluntary emission reduction programs to date. With approximately half the units reporting so far, nuclear plants are the single largest contributor to voluntary greenhouse gas emission reductions (40 percent of the program) under the Department of Energy's 1605(b) program (established under the 1992 Energy Policy Act).

Growth Through Efficiency and Safety

In the face of public opposition to alternative fossil options that would have increased air pollution, construction of the first commercial nuclear reactor began at Shippingport, Pa., near Pittsburgh, in 1955. Since that first plant, nuclear energy has evolved into a reliable, affordable and essential baseload electricity technology with an unparalleled safety record.

In 2000, nuclear plants generated a record 754 billion kilowatt-hours of electricity, 25 billion kilowatt-hours more than the previous year and 178 billion kilowatt-hours more than in 1990. Last year's record performance capped the best decade in the industry's history. The average production cost of electricity generated by nuclear power plants during 1999 was 1.83 cents per kilowatt-hour, the lowest of all fuel sources. And improved production was matched with ever-improving safety.

The dramatic increase in electricity generation by America's nuclear plants is also one of the most successful energy efficiency programs of the past decade. Output increases are equivalent to adding 22, 1000-megawatt power plants to our nation's electricity grid, without the environmental disruptions and impacts that would have occurred if new facilities had been brought on line to meet these needs. Although the lack of new nuclear construction since the 1980s often is identified as a sign of industry stagnation, in fact, the more efficient operation of existing nuclear electric generating facilities has been an environmentally beneficial alternative for making additional electricity.

Plant uprates, improved maintenance, reduced outage times and safety improvements will continue to provide higher operating efficiency and additional electricity output from existing power plants. But these increases are finite, limited to the maximum capacity of each reactor. To meet future demands of an electricity-hungry digital economy—especially if carbon mitigation efforts limit some options—some electric companies are beginning to examine the market for new nuclear plants. Advances in renewable generation, distributed sources such as fuel cells, and continued conservation will all improve our competitive energy/environmental position. But these advances will not displace the continued need for baseload sources as part of providing secure energy supplies that meet the 99.9999 percent reliability rating needed in the future.

In addition, bulk users will continue to need bulk electricity supply that mitigates environmental impact, a product these alternative sources may not be able to provide. For example, the New York City subway uses 1.8 billion kilowatt-hours of electricity annually. Mass transit is necessary to mitigate air quality impacts, including increased greenhouse gas emissions, from carbon-based mobile sources. Other environmental protection systems, such as wastewater treatment and water purification, also require bulk electricity to serve the large, urban populations where 80 percent of Americans now live—not to mention to help meet electrical demands of a concentrated population. Continued use and expansion of nuclear electricity works in tandem with other advanced technologies to meet the range of market needs for energy that can also avoid or mitigate impacts such as global warming.

An Unrivaled Waste Management Record

Nuclear energy facilities, like other electricity sources, have waste streams and byproducts that must be managed safely. The environmental policies and practices at nuclear energy plants are unique in having avoided or prevented significant harmful impacts on the environment since the start of the commercial nuclear industry more than 40 years ago. Effective waste avoidance, minimization and management practices have successfully prevented or mitigated adverse impacts on water, land, habitat, species and air from releases or emissions in the production of nuclear electricity, some of which have already been discussed in detail above. Throughout the nuclear electricity production process, the small volumes of waste byproducts actually created are treated and released, or carefully contained, packaged and safely stored.

The safe handling and storage of used nuclear fuel is one of the most successful solid waste management programs in the industrial sector. Used fuel rods are stored in contained, steel-lined pools or in robust stainless steel containers at limited-access reactor sites.

As a result of improved process efficiencies, the average volume of waste generated at nuclear energy plants has decreased significantly in the past two decades. The high-level radioactive material in used fuel rods totals less than 20 metric tons per nuclear plant each year. The trillions of kilowatt-hours of nuclear electricity generated over more than 40 years have produced about 38,000 metric tons of used fuel rods. These rods, if stacked together, would fill a football field to a depth of a little more than four yards. Although this is an astonishingly small residual volume of used fuel from the production of all of the nation's nuclear electricity over the past 40 years, and although it is fully accounted for and very safely separated from the environment, its removal to a central repository has caused considerable angst. It is helpful to keep this very small disposal issue in perspective. For each one ton of this used fuel, 345,000 metric tons of greenhouse gas, dispersed to the atmosphere, were avoided. Surely, seen in this light, the completion of Congress' resolve for the disposal of used fuel enacted in 1982 is clearly in the nation's environmental interest and will encourage expanded use of nuclear energy.

Although U.S. policy originally envisioned recycling reactor fuel to separate out small volumes of waste and reuse the remaining fuel, prior administrations chose instead to dispose of the fuel after only one use in a deep geologic repository, leading to the site characterization project at Yucca Mountain. Research continues to develop improved processes for recycling used fuel—a policy option that will provide strategic fuel reserves that can increase the future contribution of nuclear electricity to sustainable development—but it is imperative that the United States keep its program for a federal repository program on track toward a presidential decision in 2001. The Yucca Mountain program is key to effective climate policy for two reasons. First, cost-effective operation of nuclear plants requires a centralized, permanent site to continue the environmentally preferable practice of isolated storage for used fuel. Second, nations around the world will use emission-free electricity from nuclear plants as part of their climate change mitigation strategies. As the world leader in nuclear technology, the United States must also be the world leader in effective, long-term management of used fuel.

The Future

U.S. electricity demand grew by 2.2 percent a year on average during the 1990s and by 2.6 percent in 2000. Even if demand grows by a modest 1.8 percent annually over the next two decades, the nation will need nearly 400,000 megawatts of new electric generating capacity, according to the U.S. Energy Information Administration. That figure takes into account replacement of retired capacity. This capacity is the equivalent of building about 800 new mid-size (500-megawatt) power plants in the next 20 years, which amounts to roughly 40 plants per year.

Currently, more than one-third of U.S. electricity production is from emission-free sources. In order simply to maintain that percentage—and the contribution to air quality and greenhouse gas abatement it represents—the current nuclear fleet must increase by 50 percent. To meet that challenge, the nuclear industry has established a goal of 50,000 megawatts of new nuclear power plant construction by the year 2020.

Meeting this goal will require effective energy policies that promote adequate supply, a balanced fuel portfolio, and the advancement of clean technologies. We believe those policies should include the following actions:

- Preserve U.S. Global Leadership in Nuclear Science and Technology Through Adequate R&D Funding

The President's Council of Advisors on Science and Technology (PCAST) has said that the government is not doing all it can in nuclear energy research and development. The reason, said the council, is that "the public has been lulled into a sense of complacency by a combination of low energy prices and little sense of the connection between energy and the larger economic, environmental and security issues that people do care very much about."[1] In its 1999 report, PCAST noted that its recommendation for nuclear R&D funding by the year 2003 ($120 million) would merely return the U.S. level of effort to that of 1995.[2]

The Nuclear Energy Research Initiative (NERI) and Nuclear Energy Plant Optimization (NEPO) research programs should be funded at levels double the administration's 2001 budget request. These programs are designed to produce generic improvements that reduce capital and operating costs for both current reactors and ad-

[1] *Federal Energy Research and Development for the Challenges of the 21st Century,* Report of the Energy Research and Development Panel of the President's Council of Advisors on Science and Technology, Page ES–31, November 1997.

[2] November 1997 PCAST Report, Page ES–5.

vanced reactor designs available for new nuclear plant construction. Funding also is important for the Energy Department's University Support Program, which helps maintain research reactors and enhances educational programs in nuclear science and technology at our nation's colleges and universities, thereby encouraging a steady stream of new entrants into the nuclear industry workforce.

In comparison to other electricity-generating sources, nuclear energy unequivocally is the most economical federal research and development investment. In 2000, the federal government spent six cents on nuclear energy R&D for every megawatt-hour ($.06/MWh) of electricity generated at nuclear power plants. By comparison, solar photovoltaics received more than 1,300 times that amount per megawatt-hour ($81.79/MWh). Obtaining a fair share of R&D funding is essential for the expanded use of nuclear energy.

- Level the Electricity Competition Playing Field

In recent years, state and federal initiatives have accelerated the transition to a competitive electricity market. As companies prepare to do business in this new market, the unbundling of their products and services will require a re-examination of costs and allocation of value to activities that previously were not valued. Congress can enact several legislative initiatives that remove unnecessary impediments to nuclear power and pave the way for sensible, market-based business decisions that will preserve and extend the operation of today's nuclear power plants.

First, Congress should eliminate unnecessary requirements that may prevent effective ownership transactions in a competitive market. Consolidated ownership of nuclear plants allows for economies of scale in operations, maintenance, outage planning and administration. These transactions can further improve safety because ownership and operating responsibility will be consolidated in the hands of large companies with the financial and management resources to operate the plant at the highest possible levels of safety and reliability. Resulting cost savings encourage continued plant operation by reducing the operating costs of plants when operated as part of a larger nuclear organization. Policy changes are important to remove potential barriers to permitting otherwise economical plant consolidations, including revision of Section 468A of the Internal Revenue Code, which addresses the tax treatment of nuclear decommissioning trust funds.

In addition, public policy incentives to encourage carbon abatement or avoidance technologies must be equally applied, whether they are production and/or investment tax credits to address climate change, access to market-based pollution control mechanisms, or access to favorable financing and other funding mechanisms. The importance of nuclear energy to clean air and carbon abatement is one of the previously unvalued services that must be recognized to prevent competitive disadvantage and position nuclear power plants to continue their crucial environmental contribution.

Any plausible strategy to mitigate greenhouse gas emissions will require an expanded use of nuclear energy in the United States and around the world. Equal treatment in these market and incentive programs will allow new nuclear plants to effectively compete with alternative forms of generation, extending nuclear energy's unique ability to provide energy security and environmental protection.

- Assure Adequate Funding for the Repository Program at Yucca Mountain

Since 1983, consumers of nuclear-generated electricity have paid one-tenth of a cent per kilowatt-hour into the Nuclear Waste Fund—a fund solely intended to finance the federal government's used fuel management program. The fund, which has collected about $17 billion, has a balance of about $10 billion—and it's growing at about a $1 billion a year. Still, obtaining appropriations from the fund for the Yucca Mountain project between now and 2010—the year it is estimated the facility would be ready for operation—could be significantly challenging because of budgetary rules. The fund initially was intended as an off-budget account, but subsequent congressional laws introduced appropriations caps and other budgetary restrictions. The result has been a perennial failure by Congress to appropriate enough money from the Nuclear Waste Fund to meet the Energy Department's annual budget request, undercutting the Yucca Mountain project.

DOE has requested $445 million for fiscal year 2002 work on the Yucca Mountain project. The House of Representatives endorsed the recommendation of its Appropriations Committee, approving $443 million. We encourage the members of this Committee and the Senate to do the same, facilitating the opening of the Yucca Mountain repository in 2010.

• Extend Self-Insurance Pooling Under the Price-Anderson Act

The public has $9.5 billion of insurance protection in the event of a nuclear reactor accident. The nuclear reactor operators—not the public or the federal government—pay for this insurance. This utility self-insurance pool was first established in 1957, when Congress passed the Price-Anderson Act. The act provides an umbrella of no-fault insurance protection for the public and ensures that money will be immediately available to pay liability claims that could result from a major nuclear accident. Price-Anderson most recently was amended in 1988, and the deadline for reauthorization is 2002.

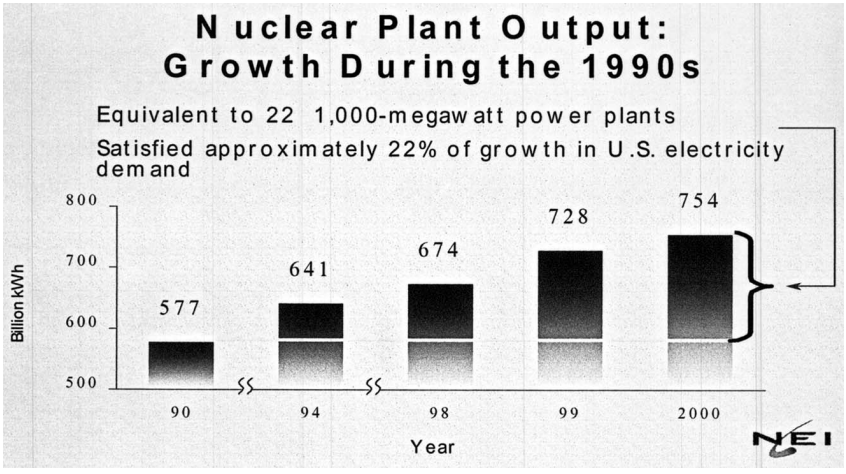
In a 1998 report to Congress, the NRC recommended that the act be extended for an additional 10 years. DOE also has recommended that Congress approve an extension of the Price-Anderson law. Both agencies recommended reauthorization with minimal change. The nuclear industry strongly supports the reauthorization of the Price-Anderson Act for an indefinite period.

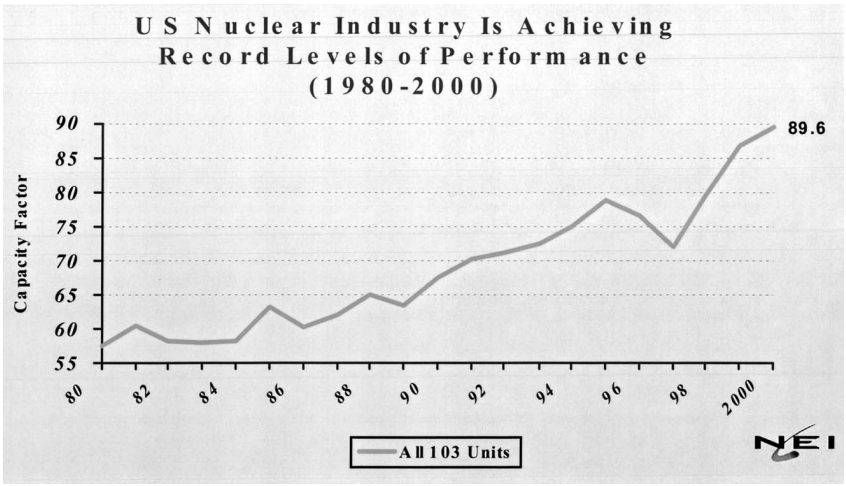
Conclusion

One of the most prominent environmental protection advancements in the industrial sector has been the increased reliance on domestically available nuclear energy to power our fast-growing digital economy while improving air quality. The United States leads the world in the development and application of nuclear technology. The economic value of this export market is substantial, bringing high-paying jobs and revenues to many areas around the country that participate in nuclear power production.

Congress should not lose sight of this important energy security and clean air resource, and policymakers should employ a strategy that maximizes nuclear energy's potential to power our economy and address climate change. Working together for national security and public sector needs, the nuclear energy industry and the federal government can ensure that emission-free electricity will continue to help meet our nation's public policy goals regarding energy production and environmental protection for workers, consumers, businesses, and urban dwellers looking to protect their quality of life and their environment.

Thank you for giving me this opportunity to share the industry's perspective on climate change and technological development issues the Committee is focusing on at this hearing.





Senator KERRY. Mr. Duffy.

STATEMENT OF DENNIS J. DUFFY, VICE PRESIDENT OF REGULATORY AFFAIRS, ENERGY MANAGEMENT, INC.

Mr. DUFFY. Thank you. I appreciate this opportunity to address the Committee regarding the role of wind energy in establishing a balanced environmental and energy policy.

My name is Dennis Duffy, vice president of regulatory affairs for Energy Management, Inc., or EMI. EMI is a privately held company with 25 years of experience in the energy business. As our name implies, our original business was advising industrial energy users as to the conservation and optimal use of their energy resources. We subsequently focused on the development and operation of major electrical generation facilities, and over the past decade, raised a billion dollars in project capital, and developed, owned, and operated some of the most efficient gas-fired combined cycle plants in the United States.

As of the end of last year, however, EMI sold all of its fossil-fueled units and is now focusing exclusively upon the development of wind energy facilities. As indicated by this shift in our energy market segment and the associated commitment of our own capital, we are confident that wind energy technology has now advanced to the point where it is proven reliable and can play a much more meaningful role in our national environmental and energy policy.

As an initial matter, the environmental benefits of wind generation are striking. As the Committee is no doubt aware, the combustion of fossil fuels for the production of electricity is one of the most important factors affecting air quality throughout the nation. While fossil fuels will certainly remain a large portion of our national energy portfolio, the important point is that, as of today, renewable technologies have developed to the point where much more substantial portions of our energy needs can be met without the combustion of fossil fuels.

By way of example, we are currently developing an approximately 400-megawatt wind generation facility located off Massachusetts that would each year offset the combustion of either 85 million gallons of oil or 500,000 tons of coal that would be required to produce an equivalent amount of electricity utilizing traditional combustion technologies. Further, today's wind projects can be designed and sited in a manner that is environmentally sensitive and compatible with existing land and marine uses.

An important point here is that wind generation is often a nonexclusive land use, so, for example, wind units can often be located on operating farms and ranches without disturbing the current operation, so farmers can go ahead, continue their operation, but do so with an incremental revenue stream which really has no adverse effect on their operations.

Wind energy also furthers the important energy policy objective of diversification of supply and reduce dependence on imported fuel. Diversification of supply is important to both maintaining price stability and to get to the continued reliability of electrical service. As experience over the last year has taught us all, electricity prices are directly linked to the often volatile and unregulated pricing of fossil fuels. In this regard, the addition of substantial amounts of wind-generated electricity to supply portfolios would provide a valuable hedge against fuel price spikes and effectively mitigate the volatility of the energy markets.

Further, the current state of regulatory affairs has induced the overwhelming majority of new plants constructed to utilize a single fuel, natural gas, a growing dependence, which has caused some market managers serious reliability concerns.

Additional wind units would also cause consumers in deregulated power market pools to see substantial reductions in their overall power cost, a point which is often not—misapprehended. All sellers in these deregulated pools are paid the same clearing price, which reflects the marginal, primarily fuel, cost of the last generating unit dispatched in any given hour. Each pool prioritizes and dispatches its generating units in economic merit order for the lowest to highest marginal cost bids, until sufficient units are dispatched to meet overall customer demand, and with the last and most expensive unit dispatched, setting the clearing price for the entire pool.

The key point is that because wind units have a marginal cost of close to zero, they will displace higher marginal cost units that might have otherwise set the clearing price and thereby placed downward pressure on pool clearing prices in every hour of every day. Because the resulting reductions in clearing prices are then applied to the entire volume of electricity traded in the spot market of the pool, there is a multiplier savings effect so that the cost of supporting wind industry development results in far greater cost savings to the consuming public.

The bottom line is that in deregulated power pools where the clearing prices are driven by marginal costs, you can spend more to support wind energy and still substantially reduce the overall power costs to the public.

Obviously the degree to which wind energy can be relied upon to further the foregoing policies depends on the performance of the

underlying technology. In this regard, reference to the worldwide growth of wind energy confirms that the technology has advanced to the point where it is not only proven reliable but also a leading source of new generation in the global market. The American Wind Energy Association recently summarized as follows: "Total worldwide wind capacity today is approximately 17,000 megawatts. Wind energy was the world's fastest growing energy source during most of the 1990's, expanding at annual rates ranging from 25 to 35 percent. In the year 2000, about 3,500 megawatts of new wind capacity, close to a $4 billion investment, was installed around the world."

Although the technology has been proven in the field, I think it is important and I will close briefly to note that the technology is still a developing technology in this country and is still needing various market and regulatory supports, most important being the extension of the production tax credit. Now, I know—there seems to be bipartisan support for the extension. It is critical from our perspective that that extension be for a period of not less than 5 years.

What is driving that is that there is such a demand for wind turbines throughout the world, the manufacturers are hard-pressed to assure delivery within the 3-year window, so it is a good technology. It is proven in the field. It is reliable, but we still need the economic incentives, and most importantly the production tax credit.

Thank you. I am available for questions.

Senator KERRY. Mr. Duffy, thank you very, very much.

[The prepared statement of Mr. Duffy follows:]

PREPARED STATEMENT OF DENNIS J. DUFFY, VICE PRESIDENT OF REGULATORY AFFAIRS, ENERGY MANAGEMENT, INC.

1. Introduction

I appreciate this opportunity to address the Senate Commerce Committee regarding the role of wind energy in establishing balanced environmental and energy policy. I am Dennis J. Duffy, Vice President of Regulatory Affairs of Energy Management, Inc. ("EMI"). EMI is a privately-held company with twenty-five years of experience in the energy business. As our name implies, our original business was advising industrial energy users as to the conservation and optimal use of energy resources. We subsequently focused on the development and operation of major electrical generation facilities and, over the past decade, raised $1 billion in project capital and developed some of the most efficient gas-fired plants operating in the United States. As of December of 2000, however, EMI has sold all of its fossil-fueled units and is now focusing exclusively upon wind energy development. As indicated by this shift in energy market segment (and the associated commitment of our capital), we are confident that wind energy technology has now advanced to the point where it is proven and reliable and can play a much more meaningful role in our national environmental and energy policy.

2. Benefits of Wind Energy

A. Environmental Benefits

As an initial matter, the environmental benefits of wind generation are striking. As the Committee is no doubt aware, the combustion of fossil fuels for the production of electricity is one of the most important factors affecting air quality throughout the nation. While fossil fuels will certainly remain an integral part of our national energy portfolio, the important point is that, as of today, renewable technologies have developed to the point where substantial portions of our energy needs can be met *without* the combustion of fossil fuels or the environmental issues associated with nuclear power. By way of example, we are currently developing an approximately 400 megawatt wind facility to be located five miles off the coast of Mas-

sachusetts that would each year offset the combustion of (i) 85,000,000 gallons of oil or (ii) 500,000 tons of coal that would be required to produce an equivalent amount of electricity utilizing traditional technologies. Further, today's wind projects can be designed and sited in a manner that is environmentally sensitive and compatible with existing land and marine uses.

B. Diversification Benefits

Wind energy also furthers the important energy policy objectives of diversification of supply and reduced dependence upon imported fuel. Diversification of supply is important to both maintaining price stability and to the continued reliability of electrical service. As experiences over the last year have taught us, electricity prices are directly linked to the often volatile and unregulated pricing of fossil fuels. In this regard, the addition of substantial amounts of wind-generated electricity to supply portfolios would provide a valuable hedge against fuel price spikes and effectively mitigate the volatility of the energy markets. Further, the current state of regulatory affairs has induced the overwhelming majority of new plant construction to utilize a single fuel—natural gas, a growing dependence which has caused market managers serious concern.[1] The inclusion of significant portions of wind generation in future supply portfolios mitigates these reliability concerns, while at the same time mitigating electric price volatility.

C. Overall Consumer Cost Savings

Additional wind units would also cause consumers in deregulated power pools to see substantial reductions in their overall power costs. All sellers into these pools are paid the same "clearing price" reflecting the *marginal* (i.e., primarily fuel) cost of the last generating unit dispatched in any given hour. Each pool prioritizes and dispatches its generating units in "economic merit" order, from the lowest to highest marginal cost bids, until sufficient units are dispatched to meet customer demand, with the last/most expensive unit dispatched setting the clearing price for the entire pool. The key point is that because wind units have a marginal cost of zero, they will displace higher marginal cost units from the economic dispatch and thereby place downward pressure on pool clearing prices in every hour of every day. Because the resulting reductions in clearing prices are then applied to the entire volume of electricity trading in the pool, there is a multiplier savings effect, so that costs of supporting wind industry development result in far greater cost savings to the consuming public. The bottom line is that, in deregulated power pools, you can spend more for wind energy and still substantially reduce overall power costs to the public.

3. The Proven Performance of Today's Wind Technology

Obviously, the degree to which wind energy may be relied upon to further the foregoing policy objectives depends upon the performance of the underlying technology. In this regard, reference to the world-wide growth of wind energy confirms that the technology has advanced to the point where it is not only proven and reliable, but also a leading source of new generation in the global market. The American Wind Energy Association ("AWEA") recently summarized the global acceptance and implementation of wind power in the following matter:

> Total worldwide wind capacity today is approximately 17,000 mw, enough to generate about 34 billion kilowatt-hours of electricity each year. This is about the same amount of electricity as 5 million average California households (containing 12.5 million people) use. Wind energy was the world's fastest-growing energy source during most of the 1990's, expanding at annual rates ranging from 25% to 35%. In 2000, about 3,500 mw of new wind capacity (close to a $4 billion investment) was installed around the world, but only 53 mw of that total, or little more than 1% was installed in the U.S.

This world-wide growth in wind power is shown in graphic form on Attachments 1 and 2 hereto. Also notable is the marked trend in the European markets towards offshore wind facilities, of which more than 3,000 mw are now under development, as indicated on Attachments 3 and 4, with a representative project shown in Attachment 5.

This international growth in wind generation provides a practical validation of today's wind turbine technology. Indeed, Denmark now obtains approximately 20% of its power from wind resources and northern portions of Germany have achieved even higher concentrations. Importantly, the European experience has also dem-

[1] For example, the Independent System Operator of New England ("ISO–NE") released a report earlier this year noting its serious concern over this potential over-reliance upon a single source of fuel whose deliverability has not been fully assured.

onstrated that utility systems can operate in a safe and reliable manner with concentrations of wind resources far in excess than those now existing in the United States. With respect to the potential for wind energy in the United States, AWEA has stated as follows:

> The leading [US] states in terms of installed wind capacity are California (1,646 mw), Minnesota (272 mw), Iowa (242 mw) and Texas (188 mw). US wind potential is enormous—many times the amount installed. California's potential, for example, is conservatively estimated at 5,000 mw of wind capacity. Other western states have much larger potential—e.g., Wyoming has more than ten times California's. The U.S. is, quite literally, a "Saudi Arabia of wind," with vast resources throughout the Plain States.
>
> * * *
>
> AWEA expects as much as 2,000 mw of new wind capacity to be installed in the U.S. this year.

4. Policy Issues for Wind Energy

Notwithstanding the proven performance of wind technology, further inroads into the U.S. market still require a degree of market and regulatory support. Most important is the extension of the Production Tax Credit ("PTC"), which currently provides an income tax credit for the production of electricity from qualified wind energy facilities. While I am happy to note that there is bipartisan support for an extension of the PTC, some proposals would provide only a three year extension, whereas others propose a five year extension. It is extremely important to the wind industry that the PTC extension be for a period of not less than five years. The global demand for new wind turbines has created substantial doubt as to the ability of manufacturers to produce, deliver and install new units within a three-year window. Thus, a PTC extension of at least five years is necessary in order to accommodate limited production capabilities.

Another policy initiative important to the growth of the wind industry in the U.S. market are Renewables Portfolios Standards ("RPSs"), a "minimum content requirement" specifying that a certain percentage of electric supply portfolios must be obtained from renewable energy resources (wind, solar, and others), either through direct purchase of electricity or the indirect purchase of "green credits" or certificates. Several states have included such RPS requirements as part of their electric utility restructuring legislation. Texas, for example, has set a RPS requirement of 2,000 mw of new renewable energy generation by the year 2009, and one-half of such amount (1,000 mw) will be met by wind generation that will be in service by the end of this year. Massachusetts similarly included an RPS requirement in its electric restructuring legislation, which requires that 10% of all retail supply portfolios be supplied from renewable resources by 2010. We believe that such requirements are a sound policy tool to ensure that the public benefits of renewable power are not frustrated by the established order in the electric industry, and would strongly support initiatives for a RPS requirement as a matter of Federal policy.

Finally, we believe that it is important to encourage utilities to consider *long-term* purchases of renewable energy as part of their overall portfolio planning. While some restructuring plans encouraged utilities to rely primarily or exclusively upon short-term purchases, experience has shown the undue volatility that can result. Further, long-term pricing more fully recognizes the competitive value of wind energy and its ability to provide an economic hedge against market volatility through pricing that can remain fixed irrespective of fuel prices.

5. Conclusion

In closing, I wish to reinforce our conclusion, based upon our experience in the energy business and of the current state of technology, that wind energy is a proven and reliable option that can play a much greater role in the nation's environmental and energy policies. While the environmental benefits of clean and renewable generation are obvious, wind energy would have the additional benefits of (i) reducing overall customer costs, (ii) mitigating fuel-driven price spikes and (iii) improving system reliability through diversification of supply and reduced reliance upon imported fuels. Although wind technology has been validated in the global arena, it remains a developing industry in the U.S. which requires both market and regulatory support in order to make the inroads into the established market that would further the national interests of environmental and energy policy.

Thank you.

Attachment 1

World Growth of Wind Power

Generation Year	Wind Power [1]		Annual Growth % of TWh	All electricity Generation Capacity [2]		Annual Growth % of TWh
	Capacity GW	Energy TWh		Capacity GW	Energy TWh	
1996	6.07	12.23	—	(3,159)	(13,613)	(IEA '00)
1997	7.64	15.39	25.8%	3,221	13,949	2.8%
1998	10.15	21.25	38.1%	3,298	14,340	2.8%
1999	13.93	28.18	32.6%	3,377	14,741	2.8%
2000	18.43	37.30	32.0%	3,458	15,153	2.8%
2010	145.0	355.68		4,386	19,989	
Average Annual growth 1996 through 2000			27.2%			2.8%

Source: BTM Consult ApS—March 2001.
[1] World Market Update, BTM–C (Chapter 2 & 4); 2) IEA World Energy Outlook 2000—General Projection.

Attachment 2

World Share of Wind Power

Generation Technology Year:	Electricity gen. by Wind Power (BTM–C) TWh	Electricity form all gen. Technologies (inc. Wind) IEA TWh	Wind Power's share of the worlds Electricity Generation
1996	12.23	13,613	0.08%
1997	15.39	13,949	0.11%
1998	21.25	14,340	0.15%
1999	28.18	14,741	0.19%
2000	37.30	15,153	0.25%
2010 (est.)	355.68	19,989	1.78%

Source: BTM Consult ApS—March 2001: World Figures: IEA World Energy Outlook 2000.

Attachment 3

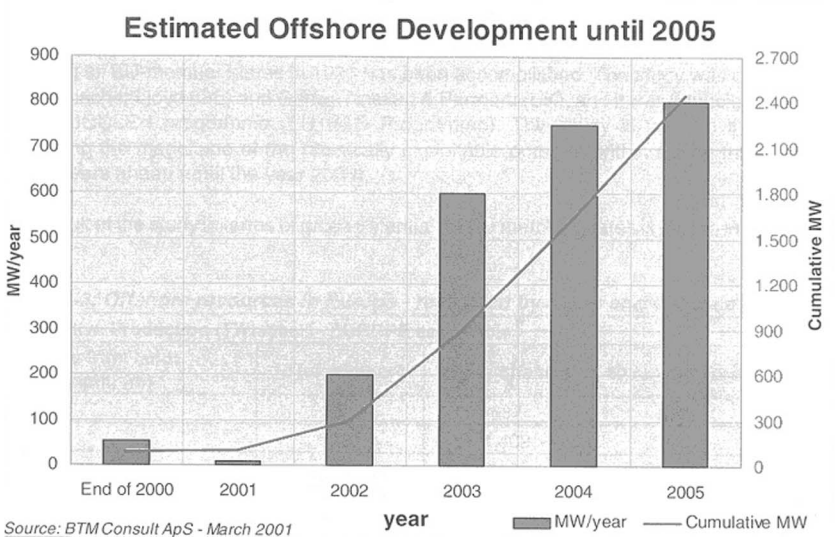
World Share of Wind Power

Country of location: Identification of projects/sites:	Year:	Identified offshore Wind Power Projects in Europe by country MW—capacity planned to be installed						
		Belgium	Denmark	Germany	Ireland	Netherlands	Sweden	UK
Stengrunden (SE)	2001						10	
Horns Rev (DK)	2002		160					
Hakefjorden (SE)	2002						44	
Klasfjorden (SE)	2002						42	
Rostock (GE)	2002			60				
Rodsand (DK)	2003		150					
Laeso (DK)	2003		150					
Lillgrund (SE)	2003						72	
Gros. Vogels. GEO (GE)	2003			80				
Lubeck (SKY) (GE)	2004			100				
NOVEM (NL) N. Shore	2003					100		
Electrabel (BE)	2004	100						
Dublin Bay (IR)	2003–4				240			
Scroby Sands (UK)	2002–3							76
E-Connection (NL)	2003					240		
PNE, Borkum (GE)	2004			60				
Two Projects in UK (UK)	2004–5							260
Eirtricity (Arklow) (IR)	2005				500			
Omo Stalgrund (DK)	2005		150					
Helgoland I (GE)				500				
Total by Country (MW)		**100**	**610**	**800**	**740**	**340**	**168**	**336**

Source: BTM Consult ApS—March 2001.

Attachment 4

Status of Planned Offshore Projects



Attachment 5

Senator KERRY. Mr. Kammen.

STATEMENT OF DR. DANIEL M. KAMMEN, PROFESSOR OF ENERGY AND SOCIETY, ENERGY AND RESOURCES GROUP, AND PROFESSOR OF NUCLEAR ENGINEERING, UNIVERSITY OF CALIFORNIA

Dr. KAMMEN. Thanks very much for having us speak today. I am Daniel Kammen, and I am a professor of energy and society in the University of California at Berkeley. I am also professor of nuclear engineering and director of the Renewable and Appropriate Energy Laboratory.

And what you have heard in the previous testimonies are a number of technologies that are showing market entrance and great potential, and I want to just summarize a couple of key things, and that we are right now in a take-off phase, where a variety of renewables are playing a significant role, but they need a marketplace to be balanced out. And so my testimony details but let me summarize three simple and very clear truths about this.

One is that the U.S. could meet and exceed the Kyoto or other obligations or other targets for climate protection and do that at an economic benefit, not a cost, and I will come back to that at the very end. That is a critical feature that has now been recognized in a variety of recent studies.

The next feature is that research and development for renewable energy alternatives has been on a 25-year roller coaster, and we see funding levels that go up, programs cut and then added to and cut and added to in ways that have been incredibly inefficient. A critical thing is to not pick individual winners, not say, We are going to bank all of our money on a given technology, but to support portfolios that allow a variety of low-carbon and no-carbon energy systems to become part of the mix.

And the third feature is that this technology push needs to be coupled with clear market pull, and so building markets for cleaner technologies is the third and critical piece of what we are looking at, and we are seeing some significant opportunities now, and one of the most disappointing things we have seen in the current roller coaster over funding and over the current national energy policy plan has been that a lot of the lessons about how to use energy efficiency and renewables most effectively are not being utilized in the market.

I am going to say a few words about each of these. Our R&D path has been, as I said, a bizarre roller coaster, with these increases and decreases. The uncertainty in energy markets has also meant that energy companies and industry in general has invested very small amounts of their returns back into R&D. The energy sector in general in the U.S. puts something like of a quarter of a percent of their profits back into R&D. Pharmaceuticals and other areas that I would argue are a little more healthy are investing more like 10 or 15 percent of their revenues back into R&D, so we have got a sector which because of policy, ambiguity, and unclear directions has not performed the way that it might have.

Despite that, we have seen a variety of advances, and if we pick those winners and work for those, both for stationary power plants and for vehicles, as Senator Snowe had mentioned, we have a variety of things that could dramatically improve what we see coming on.

The other last feature of the R&D story is that it has proved to be a dramatically good investment. Investments made in energy efficiency, in wind turbines, in photovoltaics have all been programs that when you cost them out, have had dramatic economic benefits, not in costs, and one of the big claims about the climate debate has been that this is an area where if we do something to reduce greenhouse gas emission, it will come at a cost. And, in fact, a variety of studies are now indicating that we can do all these things and make money at the same time.

The next feature is to look at markets. Currently in the markets, we dramatically subsidize the fossil fuel industry. We subsidize those technologies that are already mature to an overwhelming degree. Oil and gas and coal receive the lion's share of Federal subsidies for energy programs, which doesn't make economic sense, let alone environmental sense, because right now we have emerging opportunities in fuel cells, in wind, in photovoltaics, in a variety of things, in biomass. Those are the areas where we can much more effectively spend Federal dollars and marry Federal programs with state programs.

Another feature of that is that the market entry for new clean air technologies has been particularly difficult. The California energy debacle has been one that has highlighted the degree to which new clean options are prevented from entering the market, because the economic rules have been ones that largely benefit existing technologies and don't pave the way for these new clean options to come on line.

One critical piece of this providing markets for clean energy would be to enact a renewables portfolio standard, which is the way to use markets correctly. It is a way to set targets for how much clean energy we want to see in the market and then to let market forces pick and choose between winners, and that is a way to utilize the competitive feature of industry within markets but not to have a market that is biased against new entrants, and it doesn't make any sense that we haven't pushed harder on that.

In the last 106th Congress, there was a bill on the table, Senate Bill 1369, that looked at renewables portfolio standard. That is a critical piece of what we might do down the line.

The other piece of this is that we have seen from a variety of systems, from energy-efficient lighting to getting some wind capacity on line, to looking at R&D development in the photovoltaic sector, that the industry can respond dramatically to these challenges if given a reasonable timetable to put this into place, and every year and every month that we delay right now in acting on climate change, we make it more difficult and costly for industry to act.

It would make a great deal of sense to set clear standards for renewables portfolio in our energy mix and also for improving the efficiency of lighting and to reduce some of the inefficient technologies we have in the market right now.

The estimates that have come out of a variety of studies in our laboratory from the national labs, from the International Project for Sustainable Energy Paths have all concluded that if we tackled the Kyoto targets, we could do that at a cost of around 30 billion a year, but at reduced energy expenditures of more than 45 billion a year, economic benefits from those reduced energy expenditures

of more than 40 billion, and reduced environmental damage from around 5 billion, so we could be making dramatic amounts of money if we put policies into effect that supported a broad range of renewables and got them much more firmly entrenched in the market, and in fact, doing that at this economic benefit.

The U.S. has also fallen behind in a variety of areas. Our wind production and our photovoltaic production are now slipping behind European and Asian nations. That makes no sense, because this is an area of tremendous economic growth potential.

Let me just say thank you for the chance to appear today, and I would be happy to discuss any of those policies at more length later on.

[The prepared statement of Dr. Kammen follows:]

PREPARED STATEMENT OF DR. DANIEL M. KAMMEN, PROFESSOR OF ENERGY AND SOCIETY, ENERGY AND RESOURCES GROUP, AND PROFESSOR OF NUCLEAR ENGINEERING, UNIVERSITY OF CALIFORNIA

Introduction: the Emerging Critical Role of Renewable Energy and Energy Efficiency

Mr. Chairman and members of the Committee, thank you for this opportunity to appear before you today to provide testimony on how renewable energy and energy efficiency technologies can address climate change. My name is Daniel Kammen, and I am Professor of Energy and Society in the Energy and Resources Group and in the Department of Nuclear Engineering, as well as Director of the Renewable and Appropriate Energy Laboratory (RAEL) at the University of California, Berkeley.[1] I am pleased to be able to present information on how to utilize the many important advances in renewable energy and energy efficiency technology, economics, and management for the formulation of a strong national climate change mitigation policy. This critical initiative is long overdue, and is particularly relevant today. The recent release of the IPCC Third Assessment Report [2] as well as the analysis by the National Academy of Sciences on climate change science [3] both conclude that climate change is real and needs to be addressed now. The clean energy technology options and policies I will discuss are needed to address the challenge of global environmental sustainability. Despite dramatic technical and economic advances, we have seen far too little R&D, and too few incentives and sustained programs to build markets for renewable energy technologies and energy efficiency programs. We stand today at a critical juncture where clean, low-carbon, energy choices make both economic and environmental sense, and where policy action can place us on a path to a clean energy future.

There is a growing understanding that an effective climate mitigation policy is also a responsible energy policy. I am concerned that the current crisis mentality pervading the discussions of energy issues in the country has fostered an ill-founded rush for "quick fix" solutions that, while politically expedient, will ultimately do the country more harm than good from both a climate change and an energy policy perspective. California's energy crisis has focused attention and raised fundamental questions about regional and national energy strategies. Rising demand suggests the need for new energy supplies. However, there is a wide range of options for achieving supply and demand balance, and some of these options have not been given adequate attention. It is clear that an energy policy weighted towards increasing the supply of traditional forms of energy will do little to decrease our greenhouse gas (GHG) emissions and will create a host of other environmental, health and national security problems.

In the last decade the case for renewable energy has become compelling economically, socially, and environmentally. For many years renewables were seen as environmentally and socially attractive options that at best occupied niche markets due to barriers of cost and available infrastructure. That situation has *dramatically* changed. Renewable energy resources and technologies—notably solar, wind, small-scale hydro, and biomass based energy, as well as advanced energy conversion devices such as fuel cells—have undergone a true revolution in technological innovation, cost improvements, and in our understanding and analysis of appropriate applications.[4] There are now a number of energy sources, conversion technologies, and applications, where renewable energy options are either equal, or better, in price and services provided than are prevailing fossil fuel technologies. For example, in

a number of settings in industrialized nations, wind energy is now the *least cost* option across *all* energy technologies with the added benefit of being quick to install and bring on-line, as well as being modular. In fact, some farmers in the Midwest have found that they can generate more income per hectare from the electricity generated by a wind turbine on their land than from their crop or ranching proceeds. Furthermore, photovoltaic panels and solar hot water heaters placed on buildings across America can: dramatically shave peak-power demands; produce a healthier living environment; and increase our energy supply while managing our energy demand.

The potential for renewable energy technologies and energy efficiency to have a significant role in protecting our climate as well as our energy future is an example of the type of energy options that demand far greater examination and commitment to implementation than we have seen to date. And so, I am particularly pleased Mr. Chairman that you are holding this hearing to discuss how we can effectively and efficiently bring these technologies to market.

Energy Policy Recommendations

- **Increase Federal R&D Funding for Renewable Energy and Energy Efficiency Technologies**

Federal investment in renewable energy and energy efficient technologies has been sparse and erratic, with each year producing an appropriations battle that is often lost. A combination of a federal program for steadily increasing funding and active political leadership would transform the clean energy sector from a good idea to a pillar of the new economy.

- **Provide Tax Incentives for Companies that Develop and Use Renewable Energy and Energy Efficiency Technologies**

Support for the production and further development of renewable fuels, all found domestically, would have a greater long-term effect on the energy system than any expansion of fossil-fuel capacity, with major health and environmental benefits as an added bonus. We should extend the existing production tax credits (PTC) for electricity generated from windpower and closed loop biomass for five years. Also, this production credit should be expanded to include electricity produced by open loop biomass (i.e., agricultural and forestry residues but excluding municipal solid waste), solar energy, geothermal energy, and landfill gas. The same credit should be provided to closed loop biomass co-fired with coal, and a smaller credit (one cent per kWh) should be provided for electricity from open-loop biomass co-fired with coal. These provisions (in part or full) are included in the Murkowski-Lott (S. 389) bill, Bingaman-Daschle bill (S. 596), Grassley bill (S. 530), Reid bill (S. 249), Dorgan bill (S. 94), Collins bill (S. 188), Filner bill (HR 269), Foley bill (HR 876), Herger-Matsui bill (HR 1657), and Dunn bill (HR 1677). I also support a minimum of a 15 percent investment tax credit for residential solar electric and water heating systems. This proposal was introduced by Senator Allard (S. 465) and Representative Hayworth (HR 2076). It also is included in the Murkowski-Lott (S. 389) bill. In addition, I support a 30 percent investment tax credit being proposed for small (75 kW and below) windpower systems as in the Bingaman-Daschle (S. 596) bill.

- **Improved Federal Standards for Vehicle Fuel Economy and Increased Incentives for High Fuel Economy Vehicles**

We need to first remove the separate fuel economy standards for cars and light trucks (i.e., close the light truck 'loophole' as proposed in S. 804 by Senators Feinstein and Snowe and H.R. 1815 by Rep. Olver). I then believe that a 40 mpg combined car and light truck fuel economy standard could be accomplished in the 2008 to 2012 timeframe with negligible net cost. I support the tax credits of up to $5,000 for hybrid electric vehicles, up to $6,000 for battery electric vehicles, and $8,000 for fuel cell vehicles, and an incentive scheme for energy-use performance that rewards both fuel savings and lower emissions, as proposed in the CLEAR Act, S. 760, introduced by Senators Hatch, Rockefeller, and Jeffords, and its companion bill (H.R. 1864) introduced by Rep. Camp.

- **A Federal Renewable Portfolio Standard (RPS) to Help Build Renewable Energy Markets**

I support a 20 percent RPS by 2020. A number of studies indicate that this would result in renewable energy development in every region of the country with most coming from wind, biomass, and geothermal sources. A transparent and properly constructed federal standard is needed to set a clear target for industry research, development, and market growth. I recommend a renewable energy component of 2 percent in 2002, growing to 10 percent in 2010 and 20 percent by 2020 that would include wind, biomass, geothermal, solar, and landfill gas. This standard is similar

to the one proposed by Senators Jeffords and Lieberman in the 106th Congress (S. 1369).

- **Federal Standards and Credits to Support Distributed Small-Scale Energy Generation and Cogeneration (CHP)**

Small scale distributed electricity generation has several advantages over traditional central-station utility service, including reducing line losses, deferring the need for new transmission capacity and substation upgrades, providing voltage support, and reducing the demand for spinning reserve capacity. In addition, locating generating equipment close to the end use allows waste heat to be utilized to meet heating and hot water demands, significantly boosting overall system efficiency. I support at least a 10 percent investment tax credit and seven-year depreciation period for renewable energy systems or combined heat and power systems with an overall efficiency of at least 60–70 percent depending on system size. Similar proposals are included in the Murkowski-Lott energy bill (S. 389), the Bingaman-Daschle energy bill (S. 596), as well as bills targeted to CHP promotion introduced by Rep. Wilson (H.R. 1045) and Rep. Quinn (H.R. 1945).

- **Enact New and Strengthen Current Efficiency Standards for Buildings, Equipment, and Appliances**

Significant advances in heating and cooling systems, motor and appliance efficiency have been made in recent years, but more improvements are technologically possible and economically feasible. A clear federal statement of desired improvements in system efficiency is needed to remove uncertainty and reduce the economic costs of implementing these changes. Under such a federal mandate, efficiency standards for equipment and appliances could be steadily increased, helping to expand the market share of existing high efficiency systems.

- **Institute a National Public Benefits Fund**

I recommend a public benefits fund which could be financed through a $0.002/kWh charge on all electricity sales. Such a fund could match state funds to assist in continuing or expanding energy efficiency, low-income services, the deployment of renewables, research and development, as well as public purpose programs the costs of which have traditionally been incorporated into electricity rates by regulated utilities.

Renewable Energy

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time highly damaging to the environment and to human health. These traditional fossil fuel-based energy sources are facing increasing pressure on a host of environmental fronts, with perhaps the most serious being the looming threat of climate change and the need to set GHG emission targets. It is now clear that any effort to maintain atmospheric CO_2 concentrations below even doubled pre-industrial levels[5] cannot be accomplished in an oil and coal-dominated global economy, barring radical and problematic carbon sequestration efforts.

The potential of renewable energy sources is enormous as they can in principle meet many times the world's energy demand. Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services while meeting the challenges of energy security, diversity, and regional needs as well as global environmental quality. A transition to a renewable-intensive energy economy is now possible given the consistent progress in cost and performance of renewable energy technologies, new methods for managing distributed energy generation, and a transformation of the transportation system. Costs of solar and wind power systems have dropped substantially in the past 30 years, and continue to decline, while the price of oil and gas continue to fluctuate. In fact, fossil fuel and renewable energy prices are heading in opposite directions when social and environmental costs are included. Furthermore, the economic and policy mechanisms needed to support the widespread dissemination of renewable energy systems have also rapidly evolved. Financial markets are awakening to the future growth potential of renewable and other new energy technologies, and this is a harbinger of fully competitive renewable energy systems.

In addition, renewable energy systems are ideal components of a decentralized power system that can result in lower capital and environmental costs and improved opportunities for highly efficient cogeneration (combined heat and power) systems. As an alternative to customary centralized power plants, renewable systems based on photovoltaic (PV) arrays, windmills, biomass or small hydropower, can be mass-produced "energy appliances" capable of being manufactured at low cost and tailored to meet specific energy loads and service conditions. These systems can have dramatically reduced as well as widely dispersed environmental impacts, rather than

larger, more centralized impacts that in some cases are serious contributors to ambient air pollution and acid rain. This evolution of our ability to meet energy needs with clean sources is only in its infancy, and policies that reward R&D, power generation from clean sources, and a leveling of the playing-field with existing power providers are all critical components of a sound energy strategy.

Recent Progress in Renewable Energy System Cost and Performance

There has been significant progress in cost reductions made by wind and PV systems, while biomass, geothermal, and solar thermal technologies are also experiencing significant cost reductions. In general, renewable energy systems are characterized by low or no fuel costs, although operation and maintenance (O&M) costs can be considerable. It is important to note, however, that O&M costs for all new technologies are generally high, and can fall rapidly with increasing familiarity and operational experience. Renewable energy systems such as photovoltaics contain far fewer mechanically active parts than comparable fossil fuel combustion systems, and therefore are likely in the long-term to be less costly to maintain. Figure 1 presents U.S. DOE projections for the levelized costs of electricity production from these same renewable energy technologies, from 1997 to 2030.[6]

Given these potential cost reductions, recent analyses have shown that additional generating capacity from wind and solar energy can be added at low incremental costs relative to additions of fossil fuel-based generation. The economic case for renewables looks even better when environmental costs are considered along with capital and operating costs. As shown in Figure 2, geothermal and wind can be competitive with modern combined-cycle power plants, and geothermal, wind, and biomass all have lower total costs than advanced coal-fired plants, once approximate environmental costs are included.

The remarkable difference between the setting for renewable energy today, relative to the past 30 years, is that renewable and other clean energy technologies are now becoming economically competitive, and the push to develop them is no longer being driven solely by environmental concerns. With regard to prospects for investing in companies developing clean energy resources, Merrill Lynch's Robin Batchelor recently stated:

> "This is not an ethical investment opportunity, it's a straightforward business opportunity."

Mr. Batchelor also noted that the traditional energy sector has lacked appeal to investors in recent years because of heavy regulation, low growth, and a tendency to be cyclical. He has identified 300 companies worldwide whose aim is to develop wind, solar, and wave power technologies and to advance capabilities in energy storage, conservation, and on-site power generation. Over the past decade the U.S. has lost its leadership position in the development and production of many clean energy systems—notably wind and solar energy—due to lack of support for innovative new companies and the signals that U.S. energy markets are biased against new entrants. With an expanding global energy market, this is precisely the wrong time not to support the clean energy industry, which could become a world-leading industry akin to that of U.S. semi-conductors and computer systems.

Despite their recent success, renewable energy sources have historically had a difficult time breaking into markets that have been dominated by traditional, large-scale, fossil fuel-based systems. This is partly because renewable and other new energy technologies are only now being mass produced, and have previously had high capital costs relative to more conventional systems, but also because coal, oil, and gas-powered systems have benefited from a range of subsidies over the years. These include military expenditures to protect oil exploration and production interests overseas, the costs of railway construction that have enabled economical delivery of coal to power plants, and a wide range of subsidies such as tax breaks.

One argument used to limit the attention paid to renewable energy systems has been the intermittent nature of some sources, such as wind and solar. A solution to this problem is to develop diversified systems that maximize the contribution of renewable energy sources but that also uses clean natural gas and/or biomass-based power generation to provide base-load power. In fact, this greatest disappointment in the response to the California energy crisis and in the Administration's recent National Energy Policy Plan has been the focus on expanding the gas supply without any attention to the economic and security benefits of building a diverse energy system. The Administration's plan would add one to two new power plants, many gas-fired, a week for the next several years, making us far more dependent on gas than we were on oil even at the height of the OPEC crisis in the 1970s.

In essence, renewable energy technologies face a similar situation confronting any new technology that attempts to dislodge an entrenched technology. For many

years, we have been "locked-in" to a suite of fossil fuel and nuclear-based technologies, and many of our secondary systems and networks have been designed and constructed to accommodate only these sources. Particularly in the absence of targeted policy interventions (discussed below), we will likely remain locked-in to existing technologies, even if the benefits of technology switching *overwhelm* the costs.

Level the Playing Field for Renewables: Public and Private Sector Investments and Market Transformations

As shown in Figure 2, renewable energy technologies are characterized by low environmental costs. In an ideal world, this would aid them in competing with conventional technologies, but of course many of these environmental costs are "externalities" that are not reflected in market prices. Only in certain areas and for certain pollutants do these environmental costs enter the picture, and clearly further internalizing these costs would benefit the spread of renewables. The international effort to limit the growth of greenhouse emissions through the Kyoto Protocol may lead to some form of carbon-based tax, and this could prove to be an enormous boon to renewable energy industries. However, any proposed carbon-based taxation scheme continues to face stiff political opposition in the U.S. Perhaps more likely, concern about particulate matter emission and ozone formation from fossil-fuel power plants will lead to expensive mitigation efforts, and this would help to tip the balance toward cleaner renewable systems.

There are two principal rationales for government support of research and development (R&D) to develop renewables and other clean energy technologies. First, conventional energy prices generally do not reflect the social cost of pollution. This provides the rationale, based on a well-accepted economic argument, to subsidize R&D for alternatives to polluting fossil fuels. Second, private firms are generally unable to appropriate all the benefits of their R&D investments. Consequently, the social rate of return for R&D exceeds available private returns, and firms therefore do not invest enough in R&D to maximize social welfare. Thus, innovation "spillover" among clean energy firms is a form of positive externality that justifies public R&D investment. These provide compelling arguments for public funding of Market Transformation Programs (MTPs) that subsidize demand for some clean energy technologies in order to help commercialize them.

A principal motivation for considering MTPs is inherent in the production process itself. When a new technology is first introduced it is invariably more expensive than established substitutes. There is, however, a clear tendency for the unit cost of manufactured goods to fall as a function of cumulative production experience. Cost reductions are typically very rapid at first, but taper off as the industry matures. This relationship is called an 'experience curve' when it accounts for all production costs, and it can be described by a progress ratio where unit costs fall by a certain percent with every doubling of cumulative production. Gas turbines, photovoltaic cells and wind turbines have both exhibited the expected price-production relationship, with costs falling roughly 20 percent for each doubling of the number of units produced (Figure 3).

If firms retain the benefits of their own production experience they have an incentive to consider experience effects when deciding how much to produce. Consequently, they will "forward-price," producing at a loss initially to bring down their costs and thereby maximize profit over the entire production period.

In practice, however, the benefits of production experience often spill over to competitor firms, causing private firms to under-invest in bringing new products down the experience curve. Among other channels, experience spillovers could result from hiring competitors' employees, reverse engineering rivals' products, informal contacts among employees of rival firms, or even industrial espionage. Strong experience effects therefore imply that output is less than the socially efficient level. MTPs can improve social welfare by correcting the output shortfall associated with these experience effects.[7]

This suggests a role for MTPs in national and international technology policies. MTPs are best limited to emerging technologies with steep industry experience curves, a high probability of major long-term market penetration once subsidies are removed, and price elastic demand. The condition that they be clean technologies mitigates the risk of poor MTP performance by adding the value of displaced environmental externalities. The recent technical and economic advances seen for a range of renewable energy products make them ideal candidates for support through market transformation programs, and I strongly urge federal action to reward the early production and use of clean energy technologies. Finally, as with energy R&D policy, public agencies should invest in a portfolio of new clean energy technologies in order to reduce overall MTP program performance risk through diversification.

Energy Efficiency

To adequately address climate change we must decrease our dependence on fossil fuels and increase our use of clean renewable systems as well as cut energy waste and improve energy efficiency. What the U.S. wastes simply in the production of electricity (~24 quadrillion BTUs annually) is more energy than is used by the entire Japanese economy for all end uses. According to DOE's recent Interlaboratory Working Group study, *Scenarios for a Clean Energy Future,*[8] cost effective end-use technologies could reduce electricity consumption by ~1,000 billion kWh by 2020, which would almost entirely offset business as usual projected growth in electricity use. This level of savings would reduce U.S. carbon emissions by approximately 300 million metric tons of carbon compared to a business-as-usual scenario.

There is often confusion about the definition of energy efficiency and energy conservation that is important to clarify. Energy efficiency means improving equipment and systems to get the same output (e.g., miles traveled or widgets produced) but with less energy input. Energy conservation means reducing energy use, and at times may mean reducing the services received. Examples of energy conservation include changing thermostat settings, reducing lighting levels, and driving less. To the extent energy conservation eliminates waste it is generally desirable. For example, many commercial buildings are excessively lit and over air-conditioned, wasting large amounts of energy without providing any useful service.

Energy efficiency has been the single greatest asset in improving the U.S. energy economy. Based on data from the Energy Information Administration (EIA), U.S. primary energy use per capita in 2000 was almost identical to that in 1973, while over the same period economic output (GDP) per capita increased 74 percent. Between 1996 and 2000, GDP increased 19 percent while primary energy use increased just 5 percent. In addition, national energy intensity (energy use per unit of GDP) fell 42 percent between 1973 and 2000. About 60 percent of this decline is attributable to real energy efficiency improvements and about one-quarter is due to structural changes and fuel switching. These statistics clearly indicate that energy use and GDP do not have to grow or decline in lock step with each other, but rather that GDP can increase while energy use does not.

If the United States had not dramatically reduced its energy intensity over the past 27 years, consumers and businesses would have spent at least $430 billion more on energy purchases in 2000. Energy efficiency improvements have contributed a great deal to our nation's economic growth and increased standard of living over the past 25 years, and there continues to be much potential for energy efficiency increases in the decades to come. It certainly represents the best short-term option for addressing today's environmental and energy concerns. The U.S. Department of Energy (DOE) estimates that increasing energy efficiency throughout the economy could cut national energy use by 10 percent or more in 2010 and about 20 percent in 2020, with net economic benefits for consumers and businesses. The American Council for an Energy-Efficient Economy (ACEEE) estimates that adopting a comprehensive set of policies for advancing energy efficiency could lower national energy use by as much as 18 percent in 2010 and 33 percent in 2020, and do so cost-effectively. Many of these changes can be accomplished at *negative cost,* while others can be realized for only a few cents per kWh, far less than the cost delivered by new power plants.

Increasing the efficiency of our homes, appliances, vehicles, businesses, and industries must be an important part of a sound national energy and climate change policy. Increasing energy efficiency reduces energy waste without forcing consumers to cut back on energy services or amenities, lowers U.S. GHG emissions; saves consumers and businesses money since the energy savings more than pay for any increase in first cost, reduces the risk of energy shortages, reduces energy imports, and reduces air pollution. Furthermore, increasing energy efficiency does not present a trade-off between enhancing national security and energy reliability on the one hand and protecting the environment on the other, as do a number of energy supply options. Increasing energy efficiency is a "win-win" strategy from the perspective of economic growth, national security, reliability, and environmental protection.

Interested consumers—both residential and commercial—lack access to information on energy efficient options. Such market barriers to energy efficiency technologies exist and will continue to persist if we do not invest in tax and market incentives to encourage their implementation in all sectors of our economy.

Climate Change Policy

With proper policy support, investments in renewable energy and energy efficiency can increasingly be justified based on economic arguments alone. At the same time, the U.S. is currently squandering a critical opportunity to provide global envi-

ronmental leadership that is also good business. The need for leadership on the global climate issue has become particularly apparent with President Bush's recent rejection of the Kyoto Protocol. Domestic political opposition to U.S. leadership in this area has been based on outdated views of the science and economics of climate change. First the science is now widely accepted and, second several recent comprehensive analyses have shown that while the *costs* of inaction on global warming can be catastrophic the economic *benefits* of innovative actions to reduce the health and environmental impacts of energy use can be substantial. This represents the classic 'win-win' scenario. Unfortunately, significant action on climate change mitigation is in jeopardy unless the administration returns to the promise made by President Bush to take steps to control our nation's greenhouse gas emissions. I applaud the Chairman and ranking member on this Committee and others in the Senate for their attempts to do just that.

The U.S. can reduce GHG emissions while improving our economic efficiency, creating jobs and saving consumers money, maintaining our technological leadership, and achieving other environmental benefits. Policies to encourage the extensive development and deployment of renewable energy and energy efficiency technologies are a critical part of this equation.

I strongly support the recent bills introduced in Congress to reduce pollutant emissions from electricity generation by Senators Jeffords and Lieberman (S.556) and Representatives Boehlert and Waxman (H.R. 1256). This legislation contained provisions that addressed the environmental impact and competitive distortions created by the patchwork of unequal and inadequate standards that currently apply to electric power plants nationwide. The bill puts a national cap on emissions from power plants of nitrogen oxides, sulfur oxides, mercury, and carbon dioxide, and allows market-oriented mechanisms such as emissions trading to meet the reduction requirements. The reductions in carbon dioxide would bring emissions levels back to 1990 levels by 2007, the same level implied by the non-binding targets of the Rio Treaty of 1992, as ratified by the U.S. Senate. Our analysis indicates that if implemented in an expedient but planned process, consistent with these legislative beginnings, that the costs would likely be dwarfed by the resulting benefits of industrial innovation.[9,10]

Legislation that controls the four major power plant pollutants in an integrated package will help reduce regulatory uncertainties for electric generators and will be less costly than separate programs for each pollutant. Integrated control encourages system-wide efficiency improvements and increased utilization of cleaner fuels. And while voluntary action by American companies is an attractive option to consider, in the last ten years voluntary actions have failed to reduce carbon dioxide emissions in the U.S. Instead, emissions have increased by 15.5 percent since 1990 and continue to increase. The EIA recently released data showing a substantial increase in U.S. carbon dioxide emissions in 2000 of 2.7 percent from the preceding year, with the annual average since 1990 being 1.5 percent. This demonstrates the need for mandatory emissions reductions now and shows that solutions will be more costly and difficult if we continue to stall.

Last December an EIA analysis concluded that such mandatory carbon dioxide caps would cause a large increase in future electricity prices that President Bush then used as a justification for abandoning his campaign promise to regulate carbon emissions from utilities. A more recent analysis by EPA uses the same model but instead allows for the use of advanced technologies to reduce emissions, which are more likely to emerge under tighter emission constraints, as opposed to using the standard reference case of today's technologies as the original analysis did. The re-estimation finds that this simple adjustment substantially decreases the projected price increases.[11] Furthermore, as will now be discussed, if additional policies for encouraging the development and use of renewable and energy efficiency technologies to reduce GHG emissions are included in the analysis, the average consumer electricity price will then be comparable to business as usual projections.

Policy Options for Renewable Energy and Energy Efficiency Technology Development

I firmly believe that the ultimate solutions to cost-effectively reducing our GHG emissions must be based on private sector investment bolstered by well-targeted government R&D and incentives for emerging clean energy technologies. This must be coupled with policies that *open* markets to new clean generating capacity. We now have the opportunity to build a sustainable energy future by engaging and stimulating the tremendous innovative and entrepreneurial capacity of the U.S. private sector. To accomplish this, we must pursue policies that guarantee a stable and predictable economic environment for advancing clean energy technologies. This can

be further bolstered by market incentives to reward actions that further the public good.

With these thoughts in mind, I present several options that will start us down a path of GHG reductions while at the same time creating a sustainable, economic and environmentally sound U.S. energy policy.

1) Increase federal R&D funding for renewable energy and energy efficiency technologies

To date, federal investment in renewable energy and energy efficient technologies has been sparse and erratic, with each year producing an appropriations battle that is often lost. The resulting financial and policy uncertainty discourages effective energy technology development and deployment in the marketplace.[12] With energy now a clear national priority, and I hope climate change quickly becoming one, funding for the U.S. DOE's Energy Efficiency and Renewable Energy Program must be substantially and systematically increased. The realization that R&D funding provides a critical driver to economic growth has resulted in important commitments in Congress, particularly in the life sciences, to double R&D funding in five to ten years. The same return on investment exists in the energy sector, but it has not been translated into increased R&D funding for new renewable and energy efficiency technologies. If the U.S. expects to be a world leader in this industry, as it is in the biomedical and high-tech sectors, such investments in renewable energy and energy efficiency are essential.

DOE recently documented 20 of its most successful energy efficiency projects as having saved the nation 5.5 quadrillion BTUs of energy. This is worth about $30 billion in avoided expenses, mostly over the last decade, with a cost to tax payers of only $712 million, less than 3 percent of the energy bill savings so far. Study after study concludes that spending of taxpayer's money on energy efficiency R&D has been a very sound investment.[13,14] The Bush Administration's initially proposed deep cuts in their FY2002 budget for DOE's renewable energy and energy efficiency programs must be reversed and turned into budget increases. Such cuts would harm existing public-private partnerships as well as the R&D at the national labs and elsewhere. Thankfully, some of these cuts are being restored to current funding levels, in current appropriations bills. This budgetary roller-coaster harms all investments, sends mixed signals to industry, and as a result is the least efficient form of both energy and financial policy. In order to address climate change seriously we must at a minimum double this funding in the next five years (a 15–20 percent increase per year), as was recommended by PCAST.[15]

Federal funding and leadership for renewable energy and energy efficiency projects has resulted in a small number of notable successes, such as the EPA's *Energy Star* and *Green Lights Programs* that has now been emulated in a number of countries. For example, 15 percent of the public sector building space in the country has now signed up for Energy Star Buildings Program and saved more than 21 billion kWh of energy in 1999 or about 4.4 million metric tons of carbon, resulting in $1.6 billion in energy bill savings according to EPA. Despite these achievements, funding in this area has been both scant, and so uneven that private sector involvement has actually been discouraged. By increasing funding for these EPA programs their scope could be considerably expanded resulting in substantially greater savings.

A combination of a federal program for steadily increasing funding for clean energy and energy efficiency R&D and active political leadership would transform the clean energy sector from a good idea to a pillar of the new economy. In particular, promising technologies such as fuel cells deserve special attention. Fuel cell development is attracting significant public and private funding and offers the promise of being a keystone technology for the ultimate transition from natural gas, petroleum, and coal energy to a renewable and hydrogen based energy economy.

2) Provide tax incentives for companies and individuals that develop and use renewable energy and energy efficiency technologies

The R&D tax credit has proven remarkably effective and popular with private industry, so much so that there is a strong consensus in both Congress and the Administration to make this credit permanent. In addition to this support of private sector R&D, an increased tax incentive for R&D investment in renewable and energy efficiency technologies is exactly the type of well-targeted federal policy that is needed. To compliment this further, tax incentives directed toward those who use the technologies would provide the 'demand pull' to accelerate the technology transfer process and rate of market development. The U.S. has largely lost its position as the global leader in energy innovation, resulting in the loss of jobs and earning potential for U.S. companies precisely at the time when the international market

for clean energy technologies is booming. Our domestic industries as well as the global energy economy would both benefit directly and significantly from a clear commitment to U.S. clean energy leadership.

Currently, Federal tax expenditures have an unequal distribution across primary energy sources, distorting the market in favor of many conventional energy technologies. The dollar apportionment of expenditures, including income and excise tax credits as well as direct subsidies (such as the Renewable Energy Production Incentive) does not reflect the market distribution of fuels nor does it encourage the establishment of a market niche for disadvantaged emerging technologies. For example, renewable fuels make up four percent of the U.S. primary energy supply, and yet receive only one percent of Federal tax expenditures and direct expenditures combined (see table below). This does not include the Alcohol Fuels Excise Tax, directed towards ethanol production. The largest single tax credit in 1999 was the Alternative Fuel Production Credit,[16] which totaled over one billion dollars. This income tax credit was designed to reduce dependence on foreign energy imports by encouraging the production of gas, coal, and oil from non-conventional sources (such as tight gas formations and coalbed methane) found within the United States. However, support for the production and further development of renewable fuels, all found domestically, would have a greater long-term effect on the energy system than any expansion of fossil-fuel capacity, with major health and environmental benefits as an added bonus.

FUEL SOURCE	PRIMARY ENERGY SUPPLY 1998 CONSUMPTION		DIRECT EXPENDITURES and TAX EXPENDITURES (1999)	
	VALUE (quads, quadrillion BTU)	PERCENT	VALUE (million $)	PERCENT
Oil	36.57	40%	263	16%
Natural Gas *Alternative Fuels Credit*	21.84	24%	1,048 *(1,030)*	64%
Coal	21.62	24%	85	5%
Oil, Gas, Coal Combined			205	12%
Nuclear	7.16	8%	0	—
Renewables	3.48	4%	19	1%
Electricity			40	2%
Total	**90.67**	**100%**	**1,660**	**100%**

Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy,* (Washington, DC: DOE, 1999).

3) Improve federal standards for vehicle fuel economy and increase incentives for high fuel economy vehicles

New vehicles types based on hybrid gasoline-electric and fuel cell-electric power systems are now being produced in commercial (gasoline hybrid) and prototype (fuel cell) quantities. These vehicles are combining high-efficiency AC induction or permanent magnet electric motors with revolutionary power systems to produce a new generation of motor vehicles that are vastly more efficient than today's simple cycle combustion systems. The potential for future hybrid and fuel cell vehicles to achieve up to 100 miles per gallon is believed to be both technically and economically viable in the near-term, and with continued commitments from industry, only clear federal guidelines and support are needed to move from planning to reality. In the longer term, fuel cell vehicles running directly on hydrogen promise to allow motor vehicle use with very low fuel-cycle emissions, and again better government and industry coordination and cooperation over the next ten years could do much to hasten the development of this promising technology.

The improvements in fuel economy that these new vehicle types offer will help to slow growth in petroleum demand, reducing our oil import dependency and trade deficit. While the Partnership for a New Generation of Vehicles helped to generate

some vehicle technology advances, an increase in the Corporate Average Fuel Economy (CAFE) standard, which has been stagnant for 12 years now, is required to provide an incentive for companies to bring these new vehicles types rapidly to market. Tax credits and incentives are an important complement to raising CAFE, but I do not believe that they alone can accomplish the key goal of simultaneously stimulating production of high fuel economy vehicles and provide strong incentives for consumers to purchase them.

Now, after five years of Congressional bans, studies on the potential for increases in CAFE standards to cost-effectively reduce petroleum demand are now underway by the Department of Transportation and the National Academy of Sciences. These studies, with results expected later this summer, will help to suggest optimal levels of increased standards, given the costs and benefits of higher fuel economy, as well as phase-in schedules that will protect the competitive interests of domestic automakers.

In the meantime, other recent analyses of the costs and benefits of providing higher fuel economy motor vehicles have been conducted by the Union of Concerned Scientists,[17,18] MIT,[19] OTA,[20] and Oak Ridge National Lab/ACEEE.[21] These studies have generally concluded that with longer-term technologies, motor vehicle fuel economy can be raised to 45 mpg for cars for $500 to $1,700 per vehicle retail price increase,[22] and to 30 mpg for light trucks for $800 to $1,400 per vehicle retail price increase.[23] These improvements could be the basis for a new combined fuel economy standard of 40 mpg, which could be instituted after first removing the separate fuel economy standards for cars and light trucks (i.e. closing the light truck 'loophole' as proposed in S. 804 by Senators Feinstein and Snowe and H.R. 1815 by Rep. Olver). I believe the 40 mpg combined car and light truck standard could be accomplished in the 2008 to 2012 timeframe with negligible net cost once fuel savings are factored in, given adequate lead time for the auto industry to re-tool for this new generation of vehicles.

I also strongly support tax credits for hybrid electric vehicles, battery electric vehicles, and fuel cell vehicles. These funds could in principle be raised through a revision of the archaic 'gas guzzler' tax, which does not apply to a significant percentage of the light duty car and truck fleet. The tax penalty and tax credit in combination could be a revenue-neutral 'fee-bate' scheme, similar to one recently proposed in California, that would simultaneously send two strong price signals rewarding economical vehicles (particularly those using advanced drive systems) and penalizing uneconomical ones. Furthermore, this would help jump start introduction and purchase of the most innovative, fuel-efficient technologies. However the incentives are designed, they should be based primarily on energy-use performance and ideally provide both fuel savings and lower emissions. I support the CLEAR Act, S. 760, introduced by Senators Hatch, Rockefeller, and Jeffords, and the companion bill (H.R. 1864) introduced by Rep. Camp.

4) Establish a federal Renewable Portfolio Standard (RPS) to help build renewable energy markets

The RPS is a renewable energy content standard, akin to efficiency standards for vehicles and appliances that have proven successful in the past. A gradually increasing RPS provides the most economically efficient way of ensuring that a growing proportion of electricity sales are provided by renewable energy, and is designed to integrate renewables into the marketplace in the most cost-effective fashion. In this manner, the market picks the winning and losing technologies and projects, not administrators. With all the discussion and hype about market forces, a RPS provides the one true means to use market forces most effectively. I recommend a renewable energy component of 2 percent in 2002, growing to 10 percent in 2010 and 20 percent by 2020 that would include wind, biomass, geothermal, solar, and landfill gas. A number of studies indicate that this 20 percent in 2020 level of an RPS is broadly good for business and can readily be achieved.[24,25] This standard is similar to the one proposed by Senators Jeffords and Lieberman in the 106th Congress (S. 1369). This bill has not been reintroduced nor has any other RPS legislation been introduced in this Congress yet. States that decide to pursue more aggressive goals—many of which make economic and environmental sense—could be rewarded through an additional federal incentive program. To achieve compliance a federal RPS should use market dynamics to stimulate innovation through an active trading program of renewable energy credits. Renewable credit trading is analogous to the sulfur allowance trading system established in the Clean Air Act. Like emissions trading, it is designed to be administratively simple and to increase flexibility and decrease the cost of compliance with the standard. Electricity suppliers can generate renewable electricity themselves, purchase renewable electricity and credits from generators, or buy credits in a secondary trading market. The coal, oil, natural gas,

and nuclear power industries are mature; yet continue to receive considerable government subsidies. Moreover, the market price of fossil and nuclear energy does not include the cost of the damage they cause to the environment and human health. Conversely, the market does not give a value to the environmental and social benefits of renewables. Without the RPS or a similar mechanism, many renewables will not be able to compete in an increasingly competitive electricity market focused on producing power at the lowest direct cost. The RPS is designed to deliver renewables that are most ready for the market. Additional policies are still needed to support emerging renewable technologies, like photovoltaics, that have enormous potential to eventually become commercially competitive through targeted investment incentives. Smart investors typically acquire a portfolio of stocks and bonds to reduce risk. Including renewables in America's power supply portfolio would do the same by protecting consumers from fossil fuel price shocks and supply shortages. A properly designed RPS will also establish a viable market for the long-term development of America's renewable energy industries, creating jobs at home and export opportunities abroad.

The RPS is the surest market based approach for securing the public benefits of renewables while supplying the greatest amount of clean power for the lowest price. It creates an ongoing incentive to drive down costs by providing a dependable and predictable market, which has been lacking in this country. The RPS will reduce renewable energy costs by:

- Providing a revenue stream that will enable manufacturers and developers to obtain reasonable cost financing and make investments in expanding capacity to meet an expanding renewable energy market.
- Allowing economies of scale in manufacturing, installation, operation and maintenance of renewable energy facilities.
- Promoting vigorous competition among renewable energy developers and technologies to meet the standard at the lowest cost.
- Inducing development of renewables in the regions of the country where they are the most cost-effective, while avoiding expensive long-distance transmission, by allowing national renewable energy credit trading.
- Reducing transaction costs, by enabling suppliers to buy credits and avoid having to negotiate many small contracts with individual renewable energy projects.

Analysis of the 20 percent RPS target in 2020 that I strongly support would result in renewable energy development in every region of the country with most coming from wind, biomass, and geothermal sources. In particular, the Plains, Western, and Mid-Atlantic States would generate more than 20 percent of their electricity from renewables as shown in Figure 4. Electricity prices are projected to fall 13 percent between 1997 and 2020 under this RPS. While this is not as much as the projected 18 percent decrease under business-as-usual without an RPS, it is nonetheless a substantial decrease and has additional nation-wide environmental and health benefits (see Figure 5).[26] This increase in renewable energy would also reduce some of the projected rise in natural gas prices for all gas consumers by 5 percent in 2020 again saving households money who heat with natural gas.

Texas has been a leader in developing and implementing a successful RPS that then Governor Bush signed into law in 1999. The Texas law requires electricity companies to supply 2,000 MW of new renewable resources by 2009. The state may meet this goal by the end of 2002, seven years early. The RPS has also been signed into law in Arizona, Connecticut, Maine, Massachusetts, Nevada, New Jersey, New Mexico, Pennsylvania, and Wisconsin. Minnesota and Iowa also have minimum renewables requirements similar to an RPS. Bills with the RPS are also pending in several states. Variations in the details of these programs have kept them from being overly successful. A clear and properly constructed federal standard would correct these problems, and set a clear target for industry research, development, and market growth.[27]

5) Institute federal standards needed to support distributed small-scale energy generation and cogeneration (CHP)

Small scale distributed electricity generation has several advantages over traditional central-station utility service. Distributed generation reduces energy losses incurred by sending electricity through an extensive transmission and distribution network (often an 8–10 percent loss of energy), defers the need for new transmission capacity and substation upgrades, provides voltage support, and reduces the demand for spinning reserve capacity. In addition, the location of generating equip-

ment close to the end use allows waste heat to be utilized to meet heating and hot water demands, significantly boosting overall system efficiency.

Distributed generation has faced several barriers in the marketplace, most notably from complicated and expensive utility interconnection requirements. These barriers have led to a push for national safety and power quality standards, currently being finalized by the Institute of Electrical and Electronics Engineers (IEEE). Although adoption of these standards would significantly decrease the economic burden on manufacturers, installers, and customers, the utilities are allowed discretion in adopting or rejecting these standards. Therefore, a Federal mandate to require utilities to accept these standards, along with tax incentives for utilities and customers who use distributed generation systems would ease their acceptance into the marketplace.

While all distributed generation systems have the advantage of lower line losses, there is large variability in the overall efficiencies of the systems based on system type and installation. It is important to design credits based on overall efficiency and offset emissions compared to central station generation. This is accomplished by giving highest priority to renewable systems or fossil fuel systems that utilize waste heat through combined heat and power designs. While a distributed generation system may achieve 35–45 percent electrical efficiency, the addition of heat utilization can raise overall efficiency to 80 percent. U.S. CHP capacity in 1999 totaled 52,800 MW of power, but the estimated potential is several times this. Industrial CHP potential is estimated to be 88,000 MW, the largest sectors being in the chemicals and paper industries. Commercial CHP potential is estimated to be 75,000 MW, with education, health care, and office building applications making up the most significant percentages [28] (see Figure 6). This tremendous resource has the advantage of offsetting separate electric and fossil fuel heating systems, but CHP applications are only feasible through the use of onsite distributed electricity generation.

I support at least a 10 percent investment tax credit and seven-year depreciation period for *renewable energy systems* or combined heat and power systems with an overall efficiency of at least 60–70 percent depending on system size. This proposal is similar to one included in the Murkowski-Lott energy bill (S. 389), the Bingaman-Daschle energy bill (S. 596), as well as bills targeted to CHP promotion introduced by Rep. Wilson (H.R. 1045) and Rep. Quinn (H.R. 1945). It is important to note again that these measures would be most effective coupled with mandated utility interconnection requirements.

The U.S. should pursue a policy of not only net-metered energy use, but also real-time pricing where homeowners, businesses, and industry can all participate fully in supplying their excess power generation into the market. Homes with solar photovoltaic, wind, or fuel-cell systems should be able to sell their excess energy. Opening the energy supply markets to local generation will provide strong, economically sound, signals to the utilities, the Qualifying Facilities, and homeowners that the energy market is fair, accessible, and one where clean energy generation will be rewarded. The investment in the grid, largely in the form of upgrades to local substations, will lead to further energy efficiency benefits as an added bonus. Federal leadership and standards are needed to guide this transformation.

6) Enact new and strengthen existing efficiency standards on buildings, equipment, and appliances

Buildings, appliance, and equipment standards are an important strategy for promoting energy efficiency. Tax credits, while important, do not necessarily remove the market barriers that prevent clean energy technologies from spreading throughout the marketplace. Minimum efficiency standards were adopted by President Reagan in 1987, and then expanded under President Bush in 1992, because market barriers inhibited the purchase of efficient appliances and equipment. These barriers include lack of awareness, rush purchases when an existing appliance breaks down, and purchases by builders and landlords. Figure 7 shows how federal standards dramatically increased the market share of highly efficient magnet ballasts used for lighting.

Significant advances in heating and cooling system, motor, and appliance efficiency, have been made in recent years, but more improvements are technologically possible and economically feasible. A clear federal statement of desired improvements in system efficiency is needed to remove uncertainty and reduce the economic costs of implementing these changes. Under such a federal mandate, efficiency standards for equipment and appliances could be gradually increased, helping to expand the market share of existing high efficiency systems.[29]

Historically, building, appliance, and equipment standards have proven to be one of the federal government's most effective energy-saving programs. Analyses by DOE and others indicate that in 2000, appliance and equipment efficiency standards

saved 1.2 quadrillion BTUs of energy (1.3 percent of U.S. electric use) and reduced consumer energy bills by approximately $9 billion with energy bill savings far exceeding any increase in product cost. By 2020, standards already enacted will save 4.3 quadrillion BTU/year (3.5 percent of projected U.S. energy use), and reduce peak electric demand by 120,000 MW (more than a 10 percent reduction). ACEEE estimates that energy would be reduced in 2020 by 1.0 quadrillion BTU by quickly adopting higher standards for equipment currently covered under federal laws, such as central air-conditioners and heat pumps, and by adopting new standards for equipment not covered, such as torchiere (halogen) light fixtures, commercial refrigerators and reduction of appliance's standby power consumption (see Figure 8 for standby power used by today's televisions). This is nearly a 1 percent reduction in projected U.S. energy use, resulting in a savings of nearly 20 million metric tons of carbon. Consumers and businesses would see their energy bills decline by approximately $7 billion per year by 2020. Additional savings can be achieved by future updates and expansions to the appliance standards program; the savings estimated here just apply to actions that can be taken in the next few years.

7) Institute a National Public Benefits Fund based on revenue collected from a national, competitively neutral wires charge

Electric utilities have historically funded programs to encourage the development of a host of clean energy technologies. Unfortunately, increasing competition and deregulation have led utilities to cut these discretionary expenditures in the last several years. Total utility spending on demand side management programs fell more than 50 percent from 1993 to 1999. Lack of investment in the future has been a hallmark of utility 'planning' in face of deregulation, and needs to be reversed through rewards (such as tax incentives) for companies that re-invest profits and invigorate the power sector.[30] I recommend a national public benefits fund which could be funded through a $0.002/kWh charge. This concept and amount were put forth in bills sponsored by Senator Jeffords (S. 1369) and Rep. Pallone (H.R. 2569) in the last Congress and in the Bingaman-Daschle energy bill (S. 597). Furthermore, there should be federal matching of state funds. The funds could be used for programs promoting:

- R&D
- Low-cost financing or financing guarantees
- Grants, production incentives, or buy-downs for project costs
- Infrastructure development
- Development of uniform standards for siting, permitting, and connection with the electrical grid
- Education of the public on the benefits and costs of clean energy technologies and efficiency
- Incentives, such as rebates, to help establish markets for new products
- Installation, operation, and maintenance of renewable energy and energy efficient technologies

Cost and Benefit Analysis of Clean Energy Policies on Electricity Generation

I agree wholeheartedly with the findings of the Union of Concerned Scientists' report, *Clean Energy Blueprint: A Smarter National Energy Policy for Today and the Future*,[31] which examines the costs, environmental impacts, and effects on fossil fuel prices and consumer energy bills of a package of clean energy polices. These policies include: incentives for consumers to purchase more efficient appliances; stricter energy codes for buildings; residential and commercial building retrofits; voluntary programs with industry to reduce energy use meaningfully; a RPS requiring electricity providers to obtain 20 percent of their supplies from renewables power sources by 2020 using tradable renewable energy credits; an expanded production tax credit to include all renewables; and a public benefits fund funded through a $0.002/kWh charge to customers.

This analysis is based on the Energy Information Administrations National Energy Modeling Systems (NEMS) with modifications used in the Interlaboratory Working Group's study to accurately account for the growth and costs of the renewable and energy efficiency technologies modeled. Under the business-as-usual scenario the nation is expected to increase its reliance on coal and natural gas to meet strong growth in electricity use of 42 percent by 2020 as shown in Figure 9. To meet this demand it is estimated that 1,300 300–MW power plants would need to be built with electricity generation from non-hydro renewables increasing from 2 percent

today to only 2.4 percent of total generation in 2020. This amounts to a policy of energy and economic stagnation. If, on the other hand, the set of clean energy polices listed above are implemented energy efficiency and renewables will meet a much larger share of our future energy needs with energy efficiency measures almost completely offsetting the projected business-as-usual growth in electricity (Figure 10). Unlike the Bush-Cheney energy plan, this clean energy strategy plan builds energy security for the U.S. by supporting energy diversity and domestic supplies. The result is a large decrease in emissions from the utilities sector compared to business-as-usual projections with declines continuing beyond 2020. Figure 11 compares the projected power plant carbon dioxide reductions with the level proposed by the Senator Jeffords' and Representative Waxman's 4-pollutant power plant emission reduction bills (S. 556 and H.R. 1256). Through a steady shift to clean energy production, the requirements of these bills would not be difficult or expensive to meet, and if anything are expected to increase U.S. economic activity.

Finally the more efficient use of energy and the switch from fossil fuels to renewable energy sources saves consumers money by decreasing energy use in homes, businesses, and industry. This results in price drops for natural gas, as shown in Figure 12, and reduced household electricity bills from business-as-usual predictions (Figure 13), while average consumer prices are about the same. One of the greatest advantages that energy efficiency and renewable energy sources offer over new power plants, transmission lines, and pipelines is the ability to deploy these technologies very quickly. We can begin to deploy these technologies now and so reap the benefits all that much sooner.[32] CO_2 emission reductions will also have a 'clean cascade' effect on the economy since many other pollutants are emitted in concert with carbon from fossil fuel use.

A range of studies are all coming to the conclusion that simple but sustained standards and investments in a clean energy economy are not only possible but would be highly beneficial to our nation's future prosperity.[33] A recent analysis of the whole economy shows that we can easily meet Kyoto type targets with a net increase of 1 percent in the Nation's GDP 2020.[34] The types of energy efficiency and renewable technologies and policies described here have already proven successful and cost-effective at the national and state level. I argue that this is even more reason to increase their support. Figure 14 shows how a combination of readily available options can be used to meet the Kyoto Protocol targets. This type of strategy would cost-effectively enable us to meet goals of GHG emission reductions[35] while providing a sustainable clean energy future.

Conclusions

We stand at a critical point in the energy, economic, and environmental evolution of the United States. Renewable energy and energy efficiency are now not only affordable, but their use will also open new areas of innovation and technological and economic leadership for the U.S., if we choose to embrace these options. Creating opportunities and—critically—a fair market place for a clean energy economy requires leadership and vision. The tools to implement this evolution are now well known, and are listed in the previous section. I look forward to the opportunity to work with you to put these cost-effective measures into effect.

Biographical Sketch: Daniel M. Kammen

Daniel M. Kammen received his undergraduate degree physics from Cornell University 1984, and his Masters (1986) and Doctorate (1988) degrees in physics, from Harvard University. He was a Bantrell & Weizmann Postdoctoral Fellow at the California Institute of Technology, and then a lecturer in the Department of Physics at Harvard University. From 1992–1998 Kammen was on the faculty of the Woodrow Wilson School of Public and International Affairs at Princeton University, where he was Chair of the Science, Technology and Environmental Policy Program. Kammen is now Professor of Energy and Society in the Energy and Resources Group (ERG), and in the Department of Nuclear Engineering at the University of California, Berkeley. At Berkeley Kammen is the founding director of the Renewable and Appropriate Energy Laboratory (http://socrates.berkeley.edu/~rael), and is campus representative to the University of California Energy Institute. He has been a Lecturer in Physics and Natural Science at the University of Nairobi.

Kammen's research centers on the science, engineering, economics and policy aspects of energy management, and dissemination of renewable energy systems. He also works on the health and environmental impacts of energy generation and use; rural resource management, including issues of gender and ethnicity; international R&D policy, climate change; and energy forecasting and risk analysis. He is the author of over 110 journal publications, a book on environmental, technological, and health risks (*Should We Risk It?,* Princeton University Press, 1999) and numerous

reports on renewable energy and development. Kammen received the *1993 21st Century Earth Award* and is a Fellow of the American Physical Society. He is a Permanent Fellow of the African Academy of Sciences. For information of any of these activities and for copies of Professor Kammen's writings, see http://socrates.berkeley.edu/~dkammen.

Figure 1. Levelized cost of electricity forecast for renewable energy technologies (U.S. DOE, 1997)

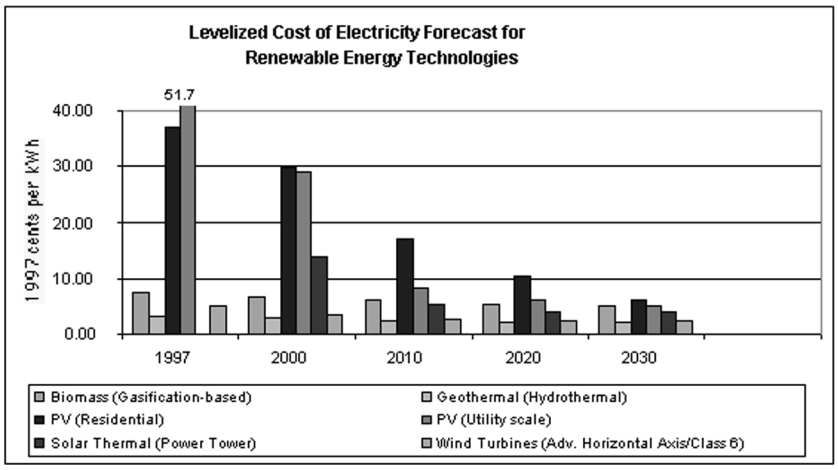
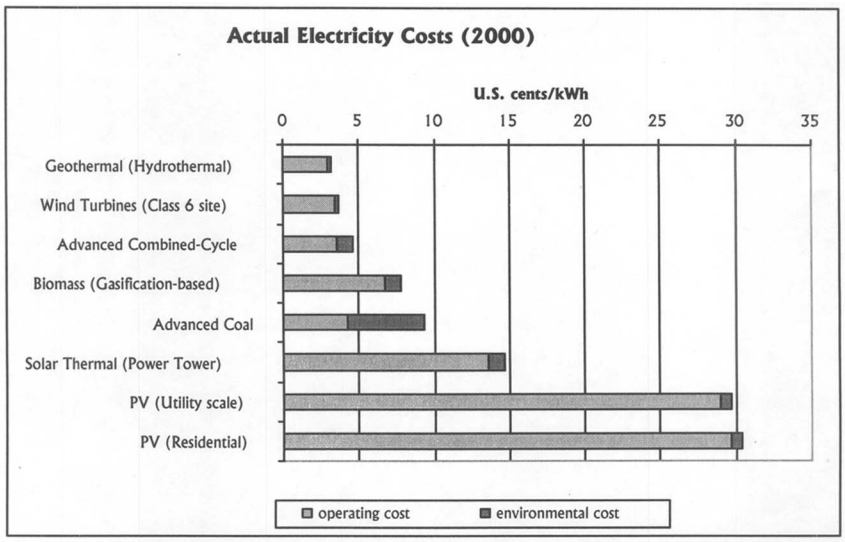
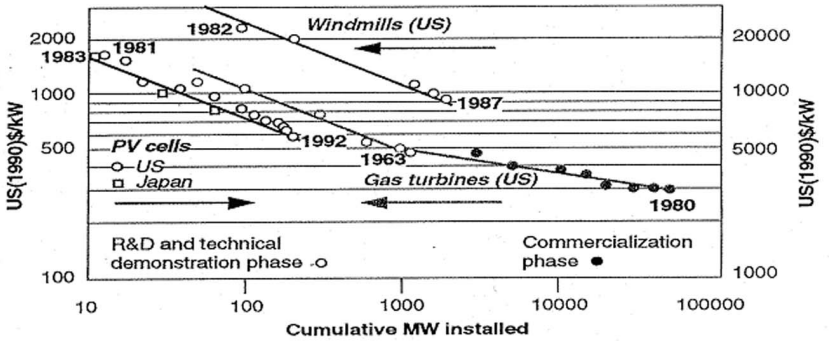


Figure 2. Actual electricity costs in year 2000



Source: Ottinger, R. L. *et al.* (1991) *Environmental Costs of Electricity* (Oceana Publications, Inc: New York); U.S. Department of Energy (2000), *Annual Energy Outlook 2000,* DOE/EIA–0383(00), Energy Information Administration, Washington, D. C., December; U.S. DOE, 1997.

Figure 3. Progress ratios (experience curves) for photovoltaics, windmills, and gas turbines



Source: IIASA/WEC (1995) *Global Energy Perspectives to 2050 and Beyond* (Laxenburg, Austria and London, UK).

Figure 4. Renewable energy generation in the U.S. by region for a RPS with a 20 percent target in 2020 (Clemmer, 1999)

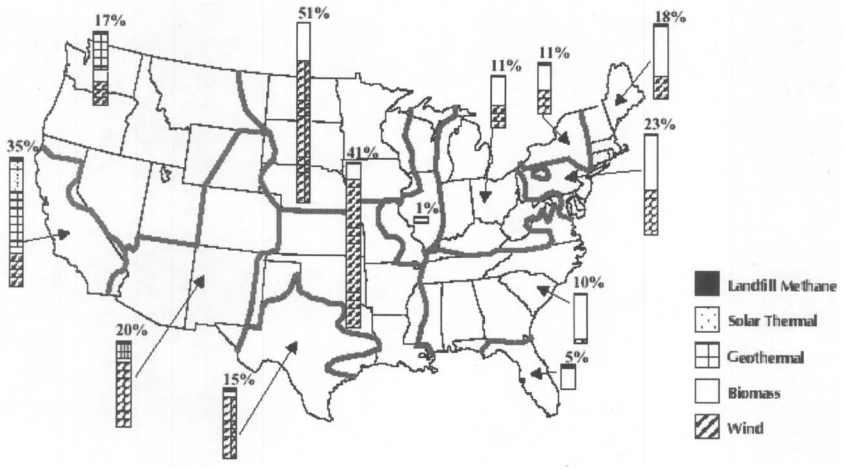
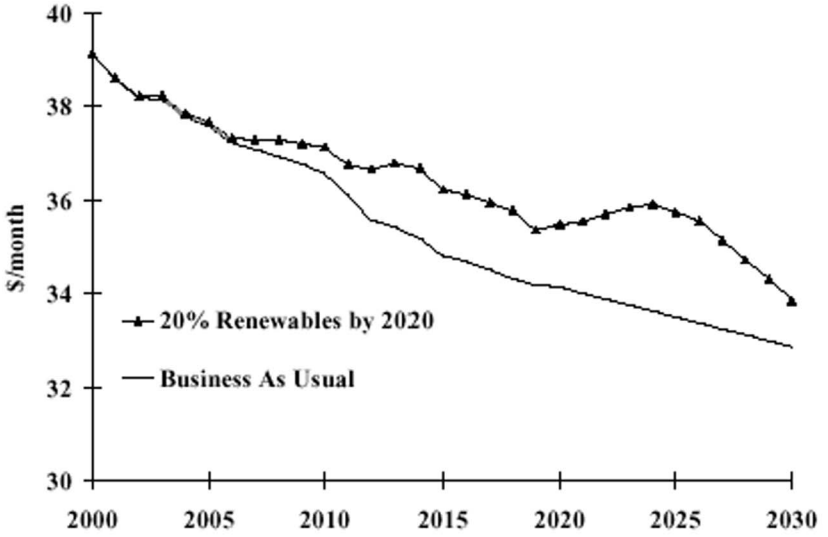


Figure 5. Average monthly electricity bill for typical non-electric heating household



Source: Nogee, A., Clemmer, S., Paulos, B., and Haddad, B. (1999) "Powerful Solutions: 7 Ways to Switch America to Renewable Energy," Union of Concerned Scientists, January.

Figure 6. CHP growth potential within several sectors of the economy (ACEEE, 2001)

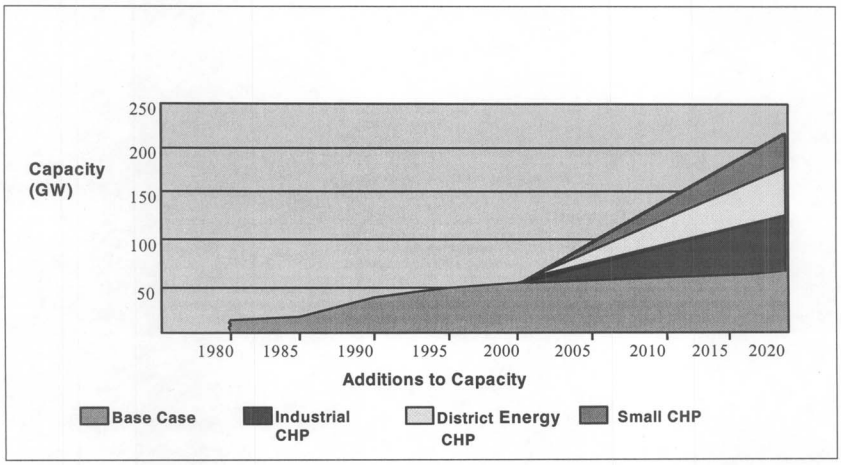


Figure 7. Market Share of efficient magnetic ballasts for lighting (Interlaboratory Working Group, 2000)

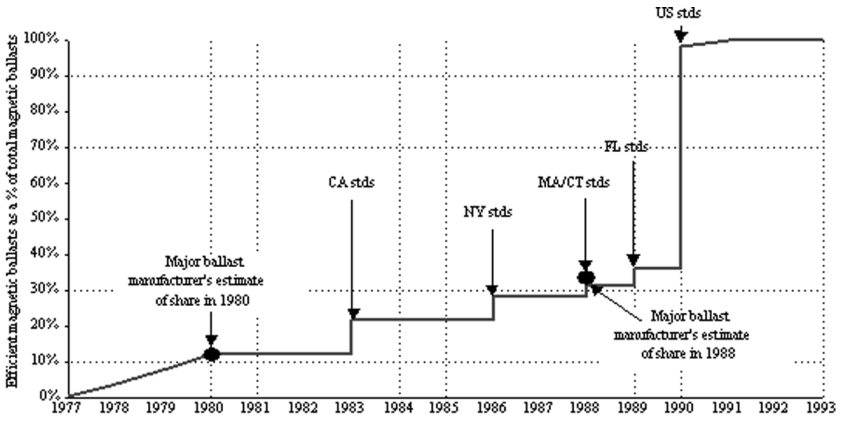
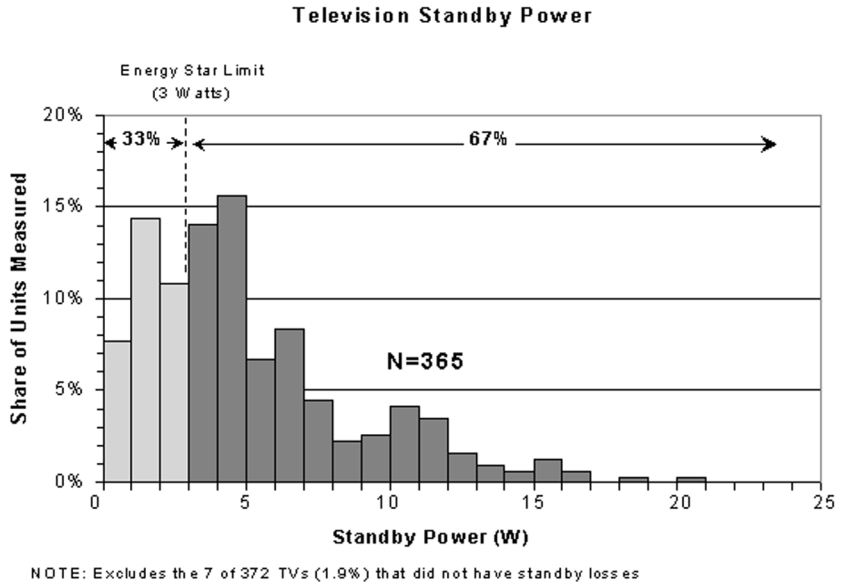


Figure 8. Standby power consumption for a selection of 365 televisions



Source: K. Rosen, LBNL, US DOE, 1999.

Figure 9. Electricity Deregulation under business as usual* (Clemmer, 2001)

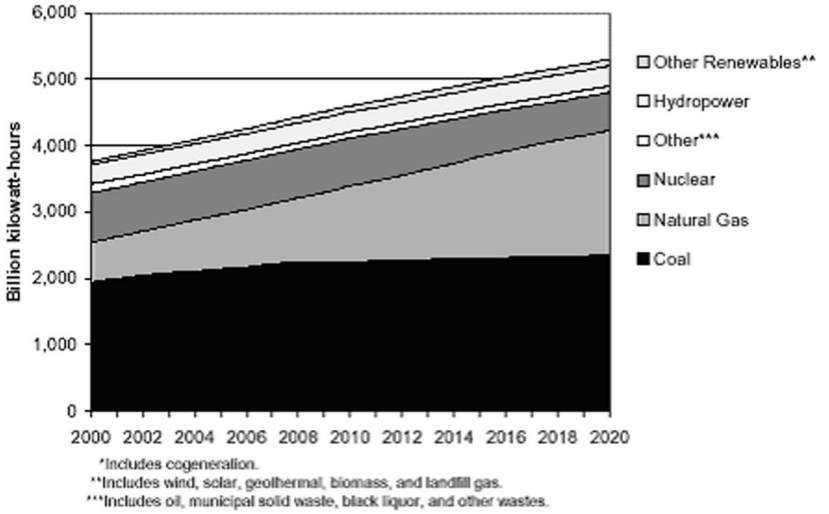


Figure 10. Energy generation with the implementation of various renewable energy and energy efficient policy options* (Clemmer, 2001)

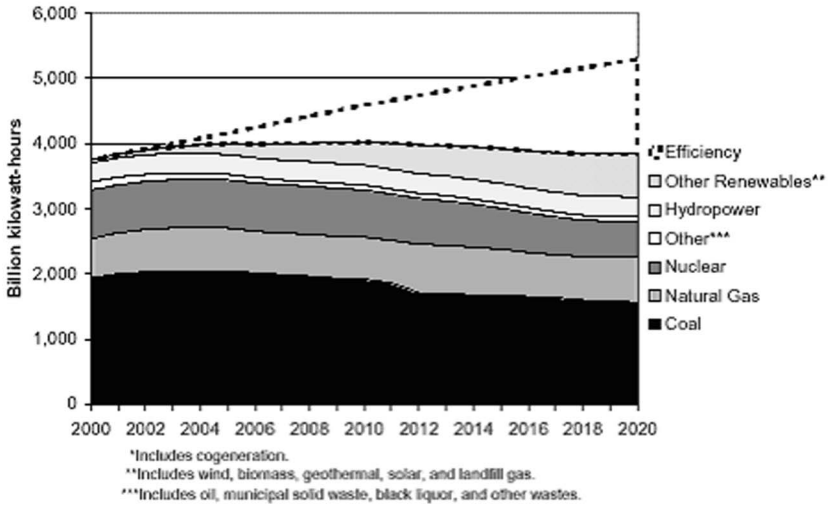


Figure 11. Power plant carbon dioxide emissions (Clemmer, 2001)

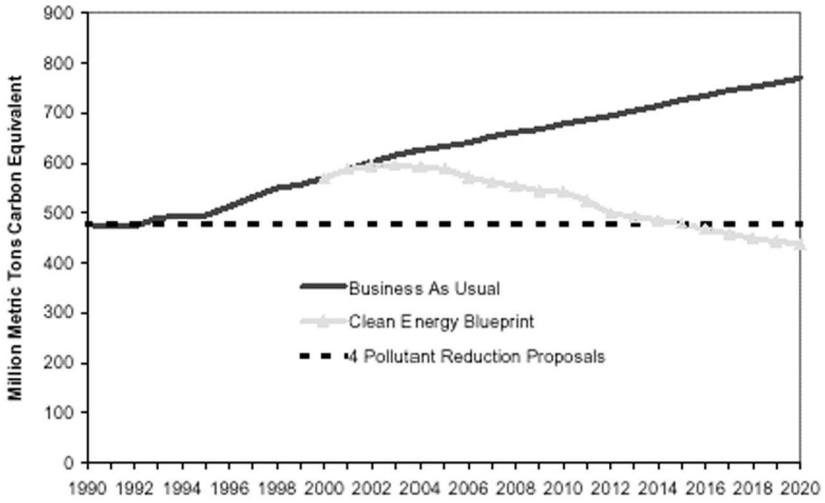
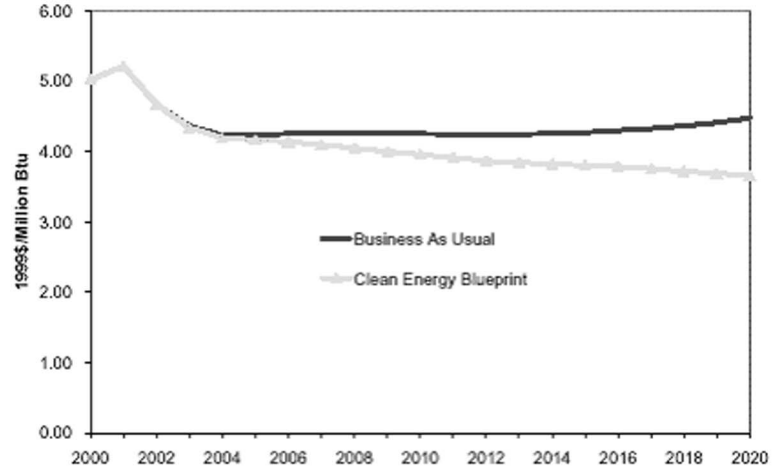


Figure 12. Natural gas prices (national average)* (Clemmer, 2001)



**In the AEO 2001 version of the National Energy Modeling System (NEMS), which was used for this analysis, the year 2000 is the first year of the forecast. Actual natural gas prices in 2000 were significantly higher than shown in the figure.*

Figure 13. Typical household electricity bill (Clemmer, 2001)

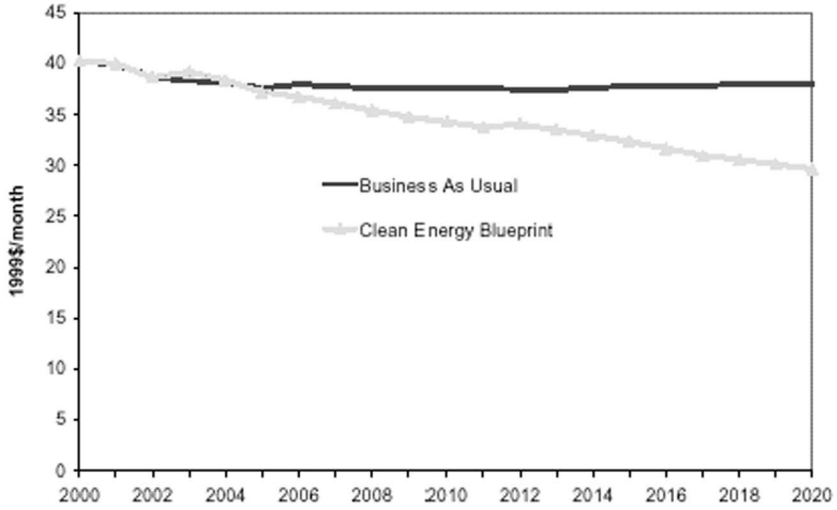
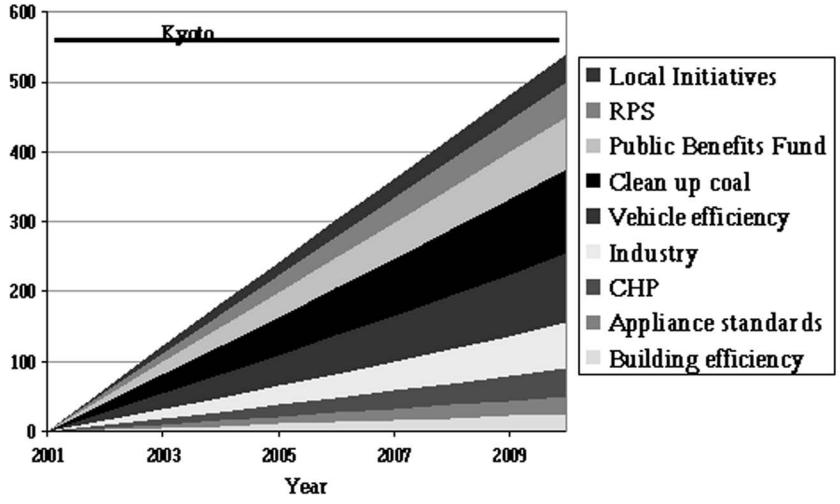


Figure 14. Potential carbon reductions from energy efficiency and renewable energy measures



Source: Energy Foundation, 2001.

ENDNOTES

1. The Renewable and Appropriate Energy Laboratory: URL http://socrates.berkeley.edu/~rael

2. IPCC (Intergovernmental Panel on Climate Change) (2001) *Climate Change 2001: The Scientific Basis*, January.

3. National Research Council (NRC) (2001) "Climate Change Science: An Analysis of Some Key Questions," Committee on the Science of Climate Change, National Research Council, National Academy Press, Washington, DC.

4. Herzog, A.V., Lipman, T.E., and Kammen, D.M. (2001) "Energy Resource Science and Technology Issues in Sustainable Development: Renewable Energy Sources," in, *OUR FRAGILE WORLD: Challenges and Opportunities for Sustainable Developmen*t, forerunner to the Encyclopedia of Life Support Systems (EOLSS), (UNESCO–EOLSS Secretariat, EOLSS Publishers Co. Ltd.).

5. IPCCi, *op. cit*.

6. U.S. Department of Energy (1997) *Renewable Energy Technology Characterizations*, Topical Report Prepared by U.S. DOE Office of Utility Technologies and EPRI, TR–109496, December.

7. Duke, R. D., and Kammen, D. M. (1999), "The economics of energy market transformation initiatives," *The Energy Journal*, **20**: 15–64.

8. Interlaboratory Working Group (2000) *Scenarios for a Clean Energy Future* (Oak Ridge, TN; Oak Ridge National Laboratory and Berkeley, CA; Lawrence Berkeley National Laboratory), ORNL/CON–476 and LBNL–44029.

9. Kinzig, A. P. and Kammen, D. M. (1998) "National trajectories of carbon emissions: Analysis of proposals to foster the transition to low-carbon economies," *Global Environmental Change*, **8 (3)**, pages 183–208.

10. Krause, F., DeCanio, S, and Baer, P. (2001) "Cutting Carbon Emissions at a Profit: Opportunities for the U.S.," (International Project for Sustainable Energy Paths: El Cerrito, CA), May.

11. Personal communication, S. Laitner, EPA Office of Atmospheric Programs, Washington, DC, 2001.

12. Margolis and Kammen, *op. cit.*

13. President's Committee of Advisors on Science and Technology (PCAST) (1997) *Federal Energy Research and Development for the Challenges of the Twenty-First Century* (Washington, D.C. OSTP).

14. Krause, F. et al., 2001, op cit.

15. PCAST, *op cit.*

16. Established by the Windfall Profit Tax Act of 1980. Tax credit is $3 per barrel of oil equivalent produced, and phases out when the price of oil rises to $29.50 per barrel (1979 dollars).

17. Mark, J. (1999) "Greener SUVs: A Blueprint for Cleaner, More Efficient Light Trucks," Union of Concerned Scientists.

18. David J. Friedman, Jason Mark, Patricia Monahan, Carl Nash, and Clarence Ditlow (2001) *Drilling in Detroit: Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles*, U. of Concerned Scientists, Cambridge, MA.

19. Malcolm A. Weiss, John B. Heywood, Elisabeth M. Drake, Andreas Schafer, and Felix F. AuYeung (2000) "On the Road in 2020: A lifecycle analysis of new automobile technologies," Energy Laboratory, Massachusetts Institute of Technology, MIT EL 00–003, Cambridge, October.

20. Office of Technology Assessment (1995) *Advanced Vehicle Technology: Visions of a Super-Efficient Family Car*, OTA–ETI–638, Office of Technology Assessment, U.S. Congress, Washington, D.C., September.

21. David L. Greene and John Decicco (2000) "Engineering-Economic Analyses of Automotive Fuel Economy Potential In The United States," Annual Rev. Energy Environ. **25**: 477–536.

22. Greene, D.L. and DeCicco J., *op cit*.

23. Interlaboratory Working Group, *op cit*.

24. Clemmer, S.L., Nogee, A., and Brower, M. (1999) "A Powerful Opportunity: Making Renewable Electricity the Standard," Union of Concerned Scientists, January.

25. PCAST, *op cit.*

26. Clemmer, S., Nogee, A, and Brower M. (1999) "A Powerful Opportunity; Making Renewable Electricity the Standard," Union of Concerned Scientists, January.

27. Rader, N. (2000) "Getting it Right and Wrong in the States," Windpower Monthly, pp. 42–47, April.

28. Dixon, R. K. (2001) Office of Power Technologies, U.S. Department of Energy, Second International CHP Symposium, Amsterdam, Netherlands, May.

29. Clemmer, S.L., Donovan, D., Nogee, A. (2001), "Clean Energy Blueprint: A Smarter National Energy Policy for Today and the Future, Phase I" Union of Concerned Scientists and Tellus Institute, June.
30. Margolis and Kammen, *op cit;*
31. Clemmer, S.L., Donovan, D., Nogee, A., *op c it.*
32. Kinzig and Kammen, *op cit.*
33. Interlaboratory Working Group, *op cit*.
34. Krause, F., et al, *op cit*.
35. Baer, P., Harte, J., Haya, B., Herzog, A.V., Holdren, J., Hultman, N.E., Kammen, D.M., Norgaard, R.B., and Raymond, L. (2000) "Equity and Greenhouse Gas Responsibility," *Science*, **289**, page 2287.

Senator KERRY. Thank you very much. We will, Mr. Kammen.
Mr. German.

STATEMENT OF JOHN GERMAN, MANAGER, ENVIRONMENT AND ENERGY ANALYSES, PRODUCT REGULATORY OFFICE, AMERICAN HONDA MOTOR COMPANY, INC.

Mr. GERMAN. My name is John German. I am the manager of environmental energy analyses in the product regulatory office for American Honda Motor Company.

I appreciate the opportunity to testify this morning on near, mid-, and long-term technological opportunities for increased motor vehicle fuel efficiency. I will summarize my prepared statement and ask that the full statement be printed in the hearing record.

Senator KERRY. It will be printed in the record.

Mr. GERMAN. There is a popular misconception that vehicle manufacturers have not introduced fuel-efficient technology since the mid–1980's. The basis of this belief is that car and light-truck CAFE have remained constant for the last 15 years. The fact is, however, that there has been a substantial amount of efficiency technology introduced during this period, including lock-up torque converters, port fuel injection, and four-valve-per-cylinder technologies.

However, this new technology has been employed to respond to vehicle attributes demanded by the marketplace rather than to increase fuel economy. Over the past two decades, consumers have insisted on such features as enhanced performance, luxury and safety, and greater utility. As reflected in my prepared statement, even though vehicle weight increased 12 percent from 1987 to 2000, the zero to 60 acceleration time decreased by 22 percent from 1981 to 2000. This is because average horsepower increased by more than 70 percent.

The bottom line is that it is these other attributes, not fuel economy, that influence customer decisions in the marketplace. We calculate that if these technologies had been used solely for fuel economy instead of performance and other attributes, if the current car fleet were still at 1981 performance weight and transmission levels, then passenger CAFE would be almost 36 miles per gallon, rather than the current level of 28.1. Since 1987, technology has gone into the fleet that could have improved fuel economy by almost 1.5 percent per year if it had not gone to other attributes demanded by the market. Thus, while fuel economy did not increase, the fuel efficiency of the vehicles did.

We see four pathways to improve fuel efficiency in the future. First, in the near term, we believe that the 1.5 percent efficiency

improvement from conventional technology could continue into the future. There are a number of technologies that are just beginning to penetrate the market, including direct injection gasoline engines, five-speed automatic and six-speed manual transmissions, continuously variable transmissions, cylinder cut-off during light-load operation, and idle-off features.

Honda, for example, has been aggressive in incorporating fuel-efficient variable valve timing in almost 60 percent of our 2000 model year vehicles. Other manufacturers are beginning to utilize this technology as well. However, for this level of fuel economy improvement to continue, it would require that all benefits of these new technologies be applied to fuel economy and not the other vehicle attributes such as comfort, convenience, and performance.

Second, use of materials for weight and strength optimization, measures to reduce friction and accessory losses, and aerodynamic designs can be effective in both the near and the long-term. Many of these approaches to fuel efficiency were incorporated in our new Acura seven-passenger sport utility, the MPX, which has the highest fuel economy in its class. They are also used extensively in the Honda Insight, which attained 68 miles per gallon highway and 61 miles per gallon city.

While I will discuss the hybrid system in this vehicle in a moment, I simply want to point out that 30 percent of the enhanced fuel economy of the Insight is attributable to body technologies, such as an all-aluminum body and low rolling resistance tires.

Third, over the next five to fifteen years, we believe the most promising opportunities will come through hybrid technology, vehicles which employ two power sources. There are currently two such vehicles sold in the U.S. today, the Honda Insight and the Toyota Prius. There are some basic operating characteristics that help shape the design of any hybrid system. The primary demands on horsepower and torque occur while accelerating and climbing grades. Minimal power is needed to maintain a vehicle's speed while cruising on a level road. By using an electric motor to provide a power boost to the engine when needed, a smaller, more fuel-efficient gasoline engine can be used.

In addition, the electric motor can be used to capture energy that would normally be lost during deceleration and braking. This energy can then be used to recharge the battery. One of the attributes of hybrids is that they run on gasoline and do not require a new refueling infrastructure. Moreover, hybrids do not need to be plugged in for recharging; they recharge themselves.

A number of manufacturers have announced their intentions to introduce hybrid vehicles over the next few years. We believe that a good hybrid system will give a 20 to 40 percent improvement in fuel economy. While a number of challenges remain before we will see high levels of hybrid penetration in the marketplace, there is no greater challenge than cost.

Hybrid systems are not cheap. While manufacturers are understandably reluctant to discuss cost, hybrids could cost several thousand dollars more than the equivalent conventional gasoline vehicle. With fuel costs so inexpensive in the U.S. relative to Japan and Europe, it is likely that hybrid sales will increase more quickly there than in the U.S.

In the long-term, the most promising technology appears to be fuel cell vehicles. Fuel cell vehicles run on hydrogen gas. The only emission is water. Honda's work currently focuses on direct hydrogen fuel cell vehicles in which hydrogen is carried on board the vehicle in highly compressed form and is used to make electric energy to power the vehicle. Other manufacturers are working with reformers which convert a fuel like gasoline or methanol into hydrogen on board the vehicle.

While we have been making good progress in our work, major hurdles remain. Reformers are expensive, take up a lot of room in the vehicle, and are slow to warm up and respond to transient driving conditions. They reduce the efficiency of the vehicle, both because of the energy needed for the reforming process and because the resulting fuel stream is not pure hydrogen. For compressed hydrogen fuel cell vehicles, in addition to significant technological challenges, there would also be the need for a new refueling infrastructure.

While fuel cell technology is promising, we must be realistic in our expectations. We do not anticipate seeing a consumer fuel cell vehicle market for at least one or two decades, and we must be forever mindful of our experience with battery electric vehicles. A decade or so ago, we all thought battery electric vehicles were the future, but the battery technology simply never evolved to the point we expected. The best battery electric vehicles out there today have a range of up to only 100 miles, take three to 8 hours to recharge, and cost tens of thousands of dollars for the batteries alone, and there are no technological breakthroughs on the horizon.

Mr. Chairman, I think there is much that technology can do to achieve enhanced fuel efficiency, but we must be realistic about the pace of technology and the hurdles that we will encounter along the way. Also manufacturers can sell only what consumers are willing to buy. Absent programs or marketplace conditions that stimulate demand or provide incentives, the manufacturers' challenge will be to increase fuel efficiency without sacrificing the performance, safety, convenience, and comfort that customers demand.

Thank you. I would be happy to answer any questions.

[The prepared statement of Mr. German follows:]

PREPARED STATEMENT OF JOHN GERMAN, MANAGER, ENVIRONMENT AND ENERGY ANALYSES, PRODUCT REGULATORY OFFICE, AMERICAN HONDA MOTOR COMPANY, INC.

Good morning, my name is John German, Manager, Environment and Energy Analyses, Product Regulatory Office, American Honda Motor Co., Inc. Honda appreciates the opportunity to appear before the Senate Commerce, Science and Transportation Committee to discuss automotive fuel efficiency with a focus on technology.

The environmental challenge is one that Honda has long embraced. Honda products have always focused on the most efficient use of resources. It has been a part of Honda's culture from the beginning. To quote our founder, Mr. Honda, in 1974, "I cannot overstress the importance of continuing to cope with the pollution problem." We believe that we must think about more than just the products we make. We think about the people who use them and the world in which we live. We believe that it is our responsibility, as a manufacturer of these products, to do all we can to reduce the pollutants that are created from the use of products that we produce.

Conventional Technology

There is a popular misconception that vehicle manufacturers have not introduced fuel efficient technology since the mid-80s. This is understandable, as the car and light truck CAFE have remained constant for the last 15 years (and the combined

fleet has gone down due to increasing light truck market penetration), as shown in Figure 1. However, there has been a substantial amount of efficiency technology introduced in this time period. Some examples for the entire car and light truck fleet from EPA's 2000 Fuel Economy Trends are shown in Figure 2.

Figure 1

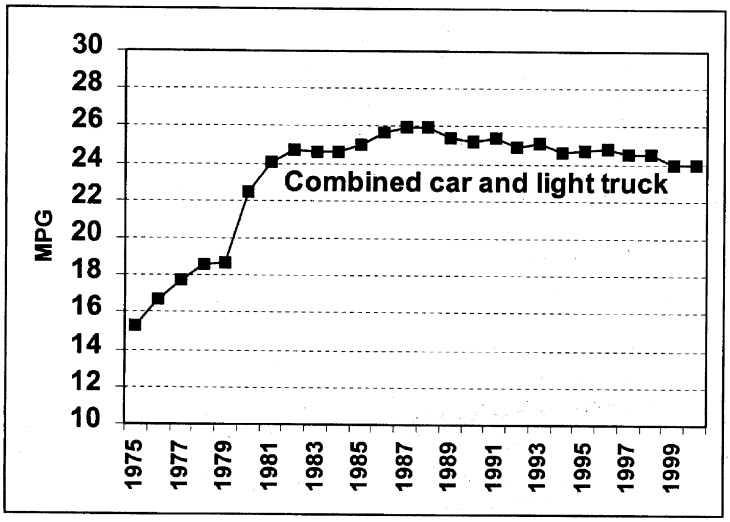
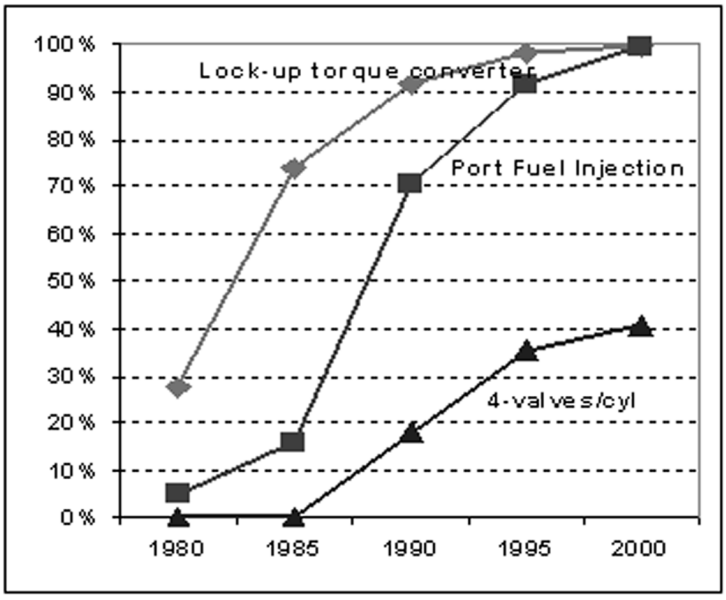
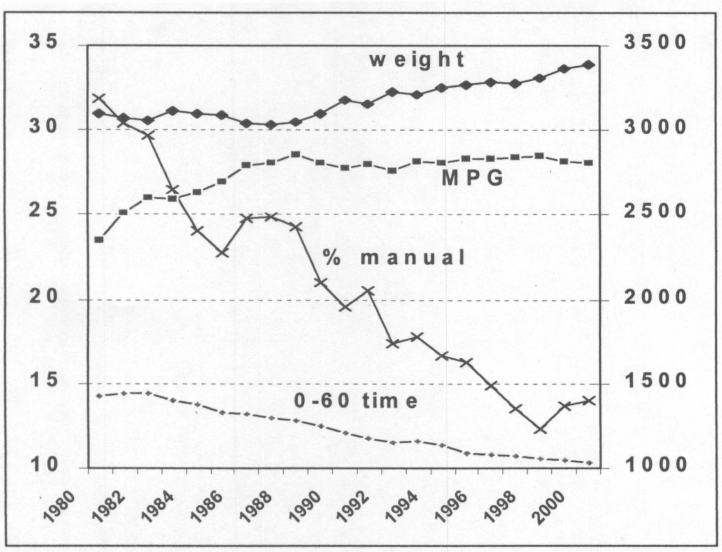


Figure 2



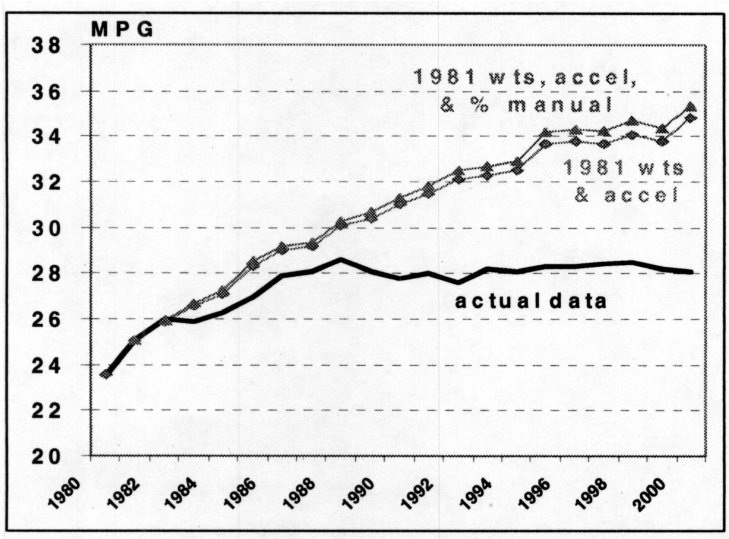
However, this new technology has been employed more to respond to vehicle attributes demanded by the marketplace than to increase fuel economy. Over the past two decades consumers have insisted on such features as enhanced performance, luxury, utility, and safety, without decreasing fuel economy. Figure 3 shows the changes in vehicle weight, performance, and proportion of automatic transmissions since 1980 in the passenger car fleet. Even though weight increased by 12% from 1987 to 2000, the 0–60 time decreased by 22% from 1981 to 2000. This is because average horsepower increased by over 70% from 1982 (99 hp) to 2000 (170 hp). In addition, the proportion of manual transmissions, which are much more fuel efficient than automatic transmissions, decreased from 32% in 1980 to 14% in 2000.

Figure 3



It is clear that technology has been used for vehicle attributes which consumers have demanded or value more highly than fuel economy. Figure 4 compares the actual fuel economy for cars to what the fuel economy would have been if the technology were used solely for fuel economy instead of performance and other attributes. If the current car fleet were still at 1981 performance, weight, and transmission levels, the passenger car CAFE would be almost 36 mpg instead of the current level of 28.1 mpg. The trend is particularly pronounced since 1987. From 1987 to 2000, technology has gone into the fleet at a rate that could have improved fuel economy by about 1.5% per year, if it had not gone to other attributes demanded by the marketplace.

Figure 4



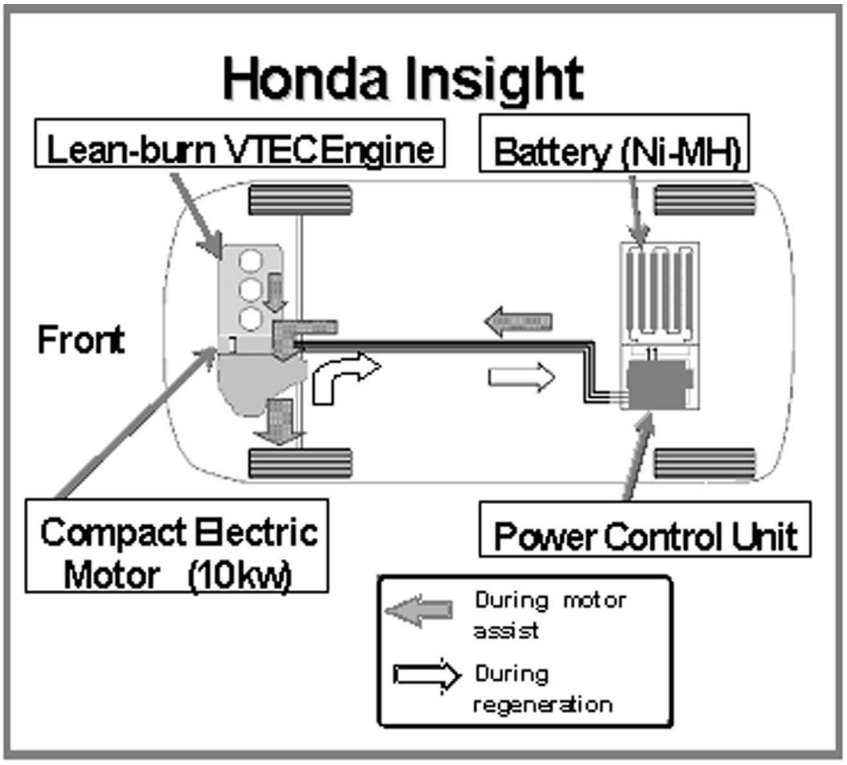
There is no reason why this technology trend of improved efficiency (as opposed to fuel economy) should not continue. Many of the technologies in the 2000 fleet, such as 4-valve per cylinder, have not yet spread throughout the entire fleet (although Honda vehicles have been virtually 100% 4-valve per cylinder since 1988). In addition, several new technologies that will have significant efficiency benefits are just beginning to penetrate the fleet. One technology pioneered by Honda is variable valve timing. While Honda used variable valve timing in almost 60% of our 2000 vehicles, penetration in the other manufacturers' fleets is only a percent or two. Other technologies that have recently been introduced or for which at least one manufacturer has announced plans to introduce include:

- Direct injection gasoline engines (only announced for Europe and Japan to date)
- 5-speed automatic and 6-speed manual transmissions
- Continuously variable transmissions (works like an automatic, but more efficient)
- Lightweight materials
- Low rolling resistance tires
- Improved aerodynamics
- Cylinder cut-off during light-load operation (for example, an 8-cylinder engine shuts off 4 cylinders during cruise conditions)
- Idle-off (the engine stops at idle)

Technologies are continuously being incorporated into vehicles. However, consumer's sense of value usually puts fuel efficiency near the bottom of their list. The dilemma facing manufacturers is that customers may not value putting in these technologies just to improve fuel economy.

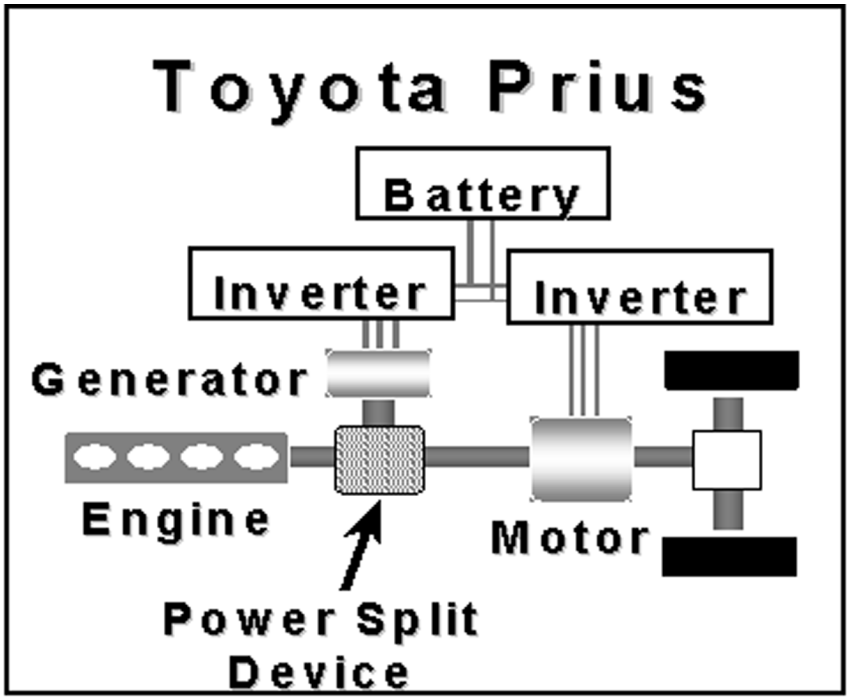
Gasoline-Electric Hybrids

The competitive technologies that I have just described will be integrated in vehicle fleets in the relative near term. The most promising technology on the mid-term horizon (5–15 years) are hybrid vehicles—vehicles which employ two power sources. The two hybrid vehicles recently introduced in the US, the Honda Insight and the Toyota Prius, both use innovative hybrid techniques. There are some basic operating characteristics that help shape the design of any hybrid system. The greatest demands on horsepower and torque occur while accelerating and climbing grades. Minimal power is needed to maintain a vehicle's speed while cruising on a level road. By using an electric motor to provide a power boost to the engine when appropriate, a smaller, more fuel-efficient gasoline engine can be used. In addition, the motor can be used to capture energy that would normally be lost during deceleration and braking and use this energy to recharge the battery. This process is referred to as "regenerative braking." These vehicles do not need to be plugged in. Finally, the powerful electric motor can restart the engine far quicker than a conventional starter motor and with minimal emission impact, allowing the engine to be shut off at idle.



Honda's Integrated Motor Assist (IMA) relies primarily on a small gasoline motor and is supplemented by a high torque, high efficiency DC brushless motor located between the engine and the transmission.[1] This 10 kW motor is only 60 mm (2.4″) thick and is connected directly to the engine's crankshaft. It supplies up to 36 ft-lb. of torque during acceleration and acts as a generator during deceleration to recharge the battery pack. This is a simple, elegant method to package a parallel hybrid system and minimizes the weight increase.

[1] "Development of Integrated Motor Assist Hybrid System," K. Aoki et al, Honda, June, 2000, SAE paper # 2000–01–2059.



Toyota's hybrid system combines both series and parallel systems.[2] The Prius powertrain is based on the parallel type. However, to optimize the engine's operation point, it allows series-like operation with a separate generator.

Both models use relatively small battery packs. The Insight's NiMH battery pack is rated at about 1 kW-hr of storage and only weighs about 22 kg (48 pounds). The battery pack on the Prius is larger, but is still no more than twice the size of the Insight's. These lightweight battery packs help to maintain in-use performance and efficiency while maintaining most of the hybrid system benefits. The larger motor and battery on the Prius also allow limited acceleration and cruise at light loads on electricity only.

Both the Insight and the Prius incorporate substantial engine efficiency improvements, in addition to the downsizing allowed by the hybrid system. The Prius uses a low friction, Atkinson cycle 1.5L engine. The Atkinson cycle uses a longer expansion stroke to extract more energy from the combustion process to boost efficiency.

The Insight engine incorporates a number of different strategies to improve efficiency. The engine has Honda's variable valve technology, which boosts peak horsepower and allows even more engine downsizing. The 1.0L, 3-cylinder engine also incorporates lean-burn operation, low friction, and lightweight technologies to maximize fuel efficiency. Despite the small engine size, the Insight can sustain good performance with a depleted battery, due to the high power/weight from the VTEC engine.

What is especially interesting about the Insight and Prius comparison is that very different powertrain technologies were used to achieve similar efficiency goals. One important lesson is that the different types of hybrid systems have reasonably similar environmental performance. The new continuously variable transmission (CVT) Insight is rated as a SULEV. There are an infinite number of ways to combine hybrid components to create a practical hybrid electric vehicle.

Both the Insight and the Prius have achieved impressive fuel economy improvements. The manual transmission Insight has the highest fuel economy label values

[2] Prius information is based upon October, 1999 Presentation by Dave Hermance of Toyota, "Toyota Hybrid System Concept and Technologies."

ever for a gasoline vehicle, 61 mpg city and 68 highway. The CVT Insight is rated at a slightly lower level. While much of the high fuel efficiency is attributable to the hybrid engine, other fuel efficient technologies, such as aerodynamic design and strategic use of lightweight materials were incorporated into the Insight as well. The Prius values are 52 mpg city and 45 highway.

Projections have also been made for prototype or future hybrid designs. Table 1 compares the manufacturer claims for the prototype vehicles to the production values for the Insight and Prius. It should be noted that Table 1 presents CAFE values, instead of fuel economy label values.[3]

Table 1: Hybrid Vehicle Comparison

		CAFE mpg	% improvement**
Commercial	Honda Insight	76	91%
Commercial	Toyota Prius	58	50%
Prototype	Ford Escape SUV	40	40–70%
Prototype	Dodge Durango SUV	19	20%
Prototype	GM SUV	35	20%
Prototype	GM full-size pickup	20	15%
Prototype	Ford Prodigy—PNGV diesel	70*	155%
Prototype	DC ESX3—PNGV diesel	72*	162%
Prototype	GM Precept—PNGV diesel	80*	191%

*Gasoline-equivalent mpg.
**Baseline for Escape is 24 mpg (V6) to 29 mpg (4-cyl).
Baseline for PNGV is 28 mpg (based on typical midsize car).

While it is easy to overlook because of the large efficiency benefits, hybrids also offer some potential emission reductions. The lower fuel consumption directly reduces upstream emissions from gasoline production and distribution. If the higher efficiency is used to increase range, evaporative emissions from refueling are reduced.

Future potential for hybrid powerplant applications and volume sales

Hybrids have a number of positive features that are desired by customers. They use gasoline (or diesel fuel); thus there are no concerns about creating a new infrastructure to support fueling. The customer benefits from lower fuel costs, extended range, and fewer trips to the gas station. Hybrids have good synergy with other fuel economy technologies and even help reduce emissions. Equally important, there is little impact on how the vehicle operates. The vehicles drive and operate similar to conventional vehicles.

Recent announcements from a number of manufacturers indicate that hybrid systems are being considered across a very broad vehicle spectrum. Toyota has announced production of a hybrid electric minivan for the Japanese market.[4] Honda recently announced a hybrid version of the Civic 4-door sedan that will be sold in the US beginning in spring 2002. Ford has announced plans to put a hybrid system into a 2003 model year Escape, a small SUV.[5] DaimlerChrysler will offer a hybrid in its Durango SUV sometime in 2003.[6] General Motors is already selling hybrid bus systems and plans to sell hybrid versions of its full-size pickup truck and the forthcoming Saturn VUE SUV in 2004.[7] There appears to be no inherent limitation

[3] EPA discounts the city test by 10% and the highway by 22% when calculating fuel economy values, so the combined FE based upon the label values discussed in the last paragraph is about 15% lower than the CAFE values in Table 1.
[4] "Toyota sees a hybrid future," Autoweek, October 30, 2000
[5] Ford Motor Co. press releases, January 10, 2000 and April 7, 2000
[6] Associated Press article by Justin Hyde, October 25, 2000
[7] General Motors Co. press release, January 9, 2001

on the use of hybrid systems, as long as packaging, weight, and cost issues can be managed.

While there have been tremendous strides in hybrid technology, there remain some packaging issues such as finding space for the motor, battery pack, and power electronics, as well as some additional weight. However, these issues are secondary compared to the cost issue.

Unfortunately, hybrid systems are not cheap. Manufacturers are understandably reluctant to discuss the cost of their hybrid systems, so it is difficult to determine a realistic cost. Initially, hybrids also have high development costs spread over relatively low sales. DaimlerChrysler has said the hybrid Durango will cost about $3000 more than the standard model.[8] Peugeot-Citroen recently stated that they ". . . have set a target of making the cost of stepping up to hybrid power no greater than the amount motorists are now prepared to pay for the switch from petrol to diesel."[9] Ford stated that the hybrid is expected to add about $3000 to the price of the Escape,[10] although it should be noted that a Ford engineer recently stated that the $3000 price increment will not cover all of their costs.[11]

To put the cost issue into context, let's take a look at what customers might be willing to pay in exchange for the fuel savings, both in the US and overseas. To do this, we need to make a few assumptions. The most critical is customer discounting of fuel savings. It is generally understood that most customers in the US only consider the first four years of fuel savings, plus they heavily discount even these four years. This is roughly equivalent to assuming that customers only value the fuel savings from the first 50,000 miles. For lack of information, the same 50,000 mile assumption is used for overseas customers (who drive less per year but may value the fuel savings more).

Estimates were made for three different size vehicles, small cars, midsize cars, and large trucks. Three estimates were also made for the hybrid benefits, as the improvements listed in Table 2 range from 15% to 196%. Of course, most of the vehicles in Table 1 include factors that go well beyond the impact of the hybrid system itself, such as weight and load reduction, engine efficiency improvements, and dieselization. A reasonable factor for just the hybrid system and corresponding engine size reduction is probably about 30–40% over combined cycles. Sensitivity cases of 20% (for very mild hybrids) and 80% (for hybrids combined with moderate engine and load improvements) are also shown in Table 2.

The final factor is fuel cost. Table 2 lists two cases: $1.50/gallon (US) and $4.00/gallon (Europe and Japan). The formula used to calculate the fuel savings in Table 2 is:

$$\left[\frac{50{,}000 \text{ miles}}{\text{baseline mpg}} - \frac{50{,}000 \text{ miles}}{\text{base mpg}*(1+\text{FE inc.})} \right] * \text{Fuel cost}$$

Table 2: Customer Value of Hybrid Fuel Savings (savings for the first 50,000 miles)

FE increase	Fuel cost	Small car	Midsize car	Large truck
		40 mpg	27 mpg	16 mpg
20%	$1.50/gal	$313	$463	$781
	$4.00/gal	$833	$1,235	$2,083
40%	$1.50/gal	$536	$794	$1,339
	$4.00/gal	$1,429	$2,116	$3,571
80%	$1.50/gal	$833	$1,235	$2,083
	$4.00/gal	$2,222	$3,292	$5,556

[8] Associated Press article by Justin Hyde, October 25, 2000

[9] Parallel hybrid project director Emmanuel Combes of PSA in August, 2000 issue of Global Automotive Network.

[10] Ford Motor Co. press release, January 10, 2000

[11] Ford Escape Chief Engineer, comments during May 18, 2001 edition of PBS Science Friday

The results are sobering. From a **societal** view, the fuel savings over the full life of the vehicle (which are about three times the values in Table 2), would likely justify the approximately $3000 cost of hybrid systems. However, the typical **customer** would not make up the incremental cost of $3000 by the fuel savings, especially in the US. In Japan and Europe, there may be a substantial market for hybrids even at a cost of $3000, due to the higher fuel prices. If the hybrid cost could be reduced to $1500 or $2000, the majority of customers in Japan and Europe might be willing to purchase a hybrid vehicle.

Even in the US, there are customers who, because they drive a lot or value the benefits more highly, will be willing to pay a $3000 premium for a hybrid vehicle. However, it is clear that hybrids will not break into the mainstream market in the US unless the cost of hybrid systems comes down and/or some sort of market assistance or incentive program is adopted.

Over the next five to ten years, we are likely to see a gradual increase in hybrid sales in the US. While the approximately $3000 cost increment in 2003 is too high for the mass market in the US, enough customers will desire the features to keep the market growing. In addition, hybrid sales are likely to increase much faster in Europe and Japan, due to their much higher fuel costs. This will lead to higher volume production and further development, both of which will reduce cost worldwide. Sales in the US will continue to increase as the costs come down.

But there is a broader message here for US policymakers. All of the technology improvements that can be made are incremental and have a financial cost. Absent marketplace signals as well, progress on achieving higher fuel efficiency in the marketplace may be slower than we may desire.

Fuel Cells

Fuel cells are the most promising mid- to long-term option. Hydrogen fuel cells have virtually no emissions and are extremely efficient. Large-scale production of hydrogen would probably use natural gas, which would reduce our dependence on fossil fuels. Even longer term, we may be able to produce hydrogen using solar energy or biomass fuels.

However, there remain a lot of issues to resolve before fuel cell vehicles become commercially viable. Cost and size must be drastically reduced and on-board hydrogen storage density must be significantly improved. Durability must also be proved. Even after all these problems are solved, there are still infrastructure issues for fueling systems to resolve. Thus, fuel cells will be a long time in development.

There also are some serious concerns about on-board reformers for creating hydrogen. Reformers are the hardware that converts fuel like natural gas or methane, to hydrogen. These reformers are expensive, take up valuable space in the vehicle, and are slow to warm up and respond to transient driving conditions. In addition, they reduce the efficiency of the vehicle, both because of the energy needed for the reforming process and because the resulting fuel stream is not pure hydrogen. The dilution of the fuel stream requires a larger fuel cell stack to maintain the same performance, increasing weight, size, and cost of the system. In fact, recent research has concluded that fuel cells with on-board reformers may not be more efficient than a good gasoline hybrid.[12]

Honda's current research efforts are focused on direct hydrogen fuel cell vehicles. These are not yet ready for the public, not ready for "numbers," not ready to help fill requirements for zero emission vehicles. There is much work to be done—our focus is to see if we can stimulate progress on R&D for hydrogen production ideas and toward infrastructure concepts and development. But even if all of the technological and infrastructure obstacles can be overcome, we are still one to two decades away from serious commercial introduction. However Honda is serious about this technology because it holds promise for environmentally sound transportation.

Electric Vehicles

While we are optimistic about the prospects of fuel cell vehicles, our experience with battery electric cars must serve as a warning. A decade ago, we all thought battery electric vehicles were the wave of the future. They promised emission-free, potentially renewable mobility with the performance of conventional internal combustion engines. So confident was California in the technology that the state required all major manufacturers to sell battery electric vehicles for 10% of their California sales.

Unfortunately, the battery technology did not evolve as we all had hoped or expected. Today's batteries—even the most sophisticated—are heavy, expensive (tens

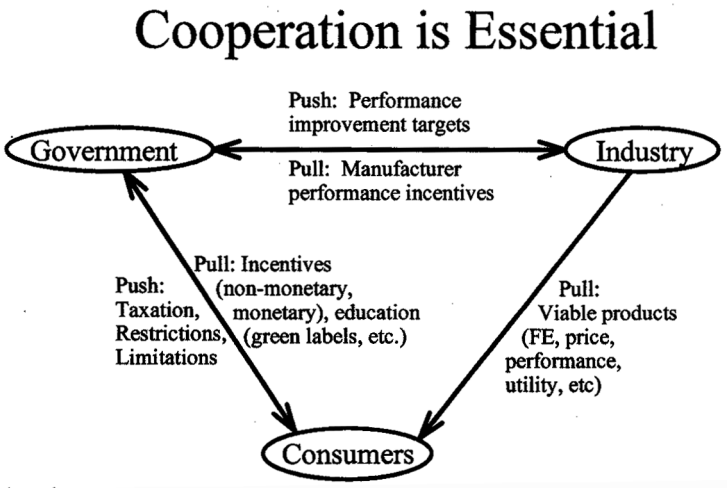
[12] "On the Road in 2020," M. Weiss, J. Heywood, E. Drake, A. Schafer, and F. AuYeung, Massachusetts Institute of Technology, October 2000.

of thousands of dollars per vehicle at production levels), have poor capacity (100 miles at best) and take 3 to 8 hours to charge. Moreover, there is nothing on the horizon that will make these vehicles acceptable in the marketplace. While California stubbornly clings to the hope that battery EVs will evolve (although it will now require these vehicles to constitute 2% of sales) they simply will not meet our expectations as an alternative to the internal combustion engine. I offer this experience as a caution that policymakers cannot get too far ahead of the technology. Sometimes what we expect simply does not occur.

But there is also another lesson to be learned from our experience with electric vehicles. Market-forcing regulation should remain technologically neutral. California's zero emission vehicle mandate essentially requires manufacturers to sell electric vehicles—vehicles which very few consumers will want. In response to the California mandate, there will be a flood of golf cart type electric vehicles hitting the California market—which technically comply with the mandate but whose real contribution to air quality will be very mild at best. If there is to be regulation, it should be in the form of realistic performance standards which leave to the ingenuity of industry the opportunity to explore, develop or market technologies that are practical, perform as required and are economical.

Customer Preference

Honda believes it has a duty to be a responsible member of society and to help preserve the global environment. Honda is committed to contributing to mitigation of greenhouse gas emissions through technological progress. We believe it is our responsibility to develop and offer efficient products in the market. We have been an industry leader in introducing such products and will continue to do so.



However, unless the customer becomes an integral participant in the process of reducing greenhouse gases, market acceptance of these products will be limited. Programs will be far more effective if they include government and customers, not just industry. The industry can provide a "pull" by providing products desired by the consumer. But, we cannot push customers into buying vehicles they do not want. Government programs to stimulate demand, provide incentives, and educate the customer could dramatically affect acceptance of new technologies and market penetration.

Thank you for this opportunity to testify. I would be pleased answer any questions you may have.

Senator KERRY. Thank you very much, Mr. German. It is very interesting, and we do want to come back to a number of those things.

Mr. Miller, picking up on what Dr. Kammen said about the market, that you have to create the market balance, et cetera, here you are. The fuel cells work in a limited fashion. We know that you have small power generation capacity. Is there an expectation that this could become a source of larger power capacity?

Mr. MILLER. Mr. Chairman, we definitely think that is true. The one thing that is preventing that from becoming more ubiquitous, let's say, in the economy is the cost. Our cost today is $4,500 a kilowatt. Our new technology, which will be out in less than 2 years, is one-tenth the size and one-tenth the weight of the current technology, and we think we can dramatically reduce the cost and make it economical for more people to buy these for home use, for building use, ultimately for automobile use. It would certainly help—we have been helped historically by government incentives, and certainly future government incentives would help from the standpoint of increasing volume and therefore driving down costs even faster.

Senator KERRY. Which is the bigger problem as a restraint on your penetration of the marketplace? Is it the cost, or is it the technological problem?

Mr. MILLER. I would say it is cost, because today we have fuel cells that will operate 5 years continuously. They get extremely good efficiency. In other words, they convert most of the energy and the natural gas into electricity or usable heat. And so our fuel cells today are very reliable.

Senator KERRY. So you are saying your cost is $4,500 a kilowatt.

Mr. MILLER. Right.

Senator KERRY. The kilowatt, competitive cost is what? About $1,000?

Mr. MILLER. $1,000 to $1,500, we start getting into being economical, and that is why this new type of fuel cell, which is one-tenth the size and weight, gives us the promise that within 24 months, we will be down to that $1,500 kilowatt level.

Senator KERRY. And begin to become competitive.

Mr. MILLER. Begin to become competitive.

Senator KERRY. Now, how does that compare to what Mr. German was talking about in terms of the fuel for the automobile itself? Is that the same?

Mr. MILLER. OK. A car—to become economical in a car, we are going to have to get down to $50 a kilowatt. Now, that seems like a long way, but I would tell you that there are probably six or seven auto makers, spending in excess of $100 million a year on fuel cell vehicles, because they think that that can be accomplished over time. Now, we see that occurring toward the end of this decade, but as was indicated earlier, it may be a little longer, it might be a little sooner.

Senator KERRY. Now, what do you think we either could or should do—and if the two mix, terrific—to facilitate the kind of market pull that Dr. Kammen was talking about?

Mr. MILLER. Well, there are bills in Congress today, co-sponsored by a number of members of your Committee, to give fuel cell tax credits for residential and stationary fuel cells starting next year. That would be an initial one.

The second issue which I think is important is that buses are one of the main pollutants in inner cities, and they also obviously emit tremendous amounts of carbon dioxide. Buses may be the first transportation market which comes about, because whereas with cars, you have the whole infrastructure to change, buses come home every night, and if you put a hydrogen fueling station at those few bus terminals, you could have hydrogen fuel cell buses in the 2005 timeframe.

And what we have been recommending from a government standpoint is a program to test fuel cell buses and to prove to transit agencies that they are reliable. And there have been a number of——

Senator KERRY. What is the resistance to that?

Mr. MILLER. Transit bus companies, their No. 1 criteria is reliability, and they are very reluctant to try a new technology until it has been proven out. And so that is why we need a couple of programs in a couple of cities to show them that fuel cell vehicles are just as reliable as diesel and gasoline buses, and they have the added advantage they are much more fuel-efficient. They will get many times——

Senator KERRY. So you could provide a fleet of those how quickly?

Mr. MILLER. Well, we have buses right now. We have one that will enter commercial service in Turin, Italy, this year. We are partnered with Iris bus, which is basically Fiat over there, to demonstrate a vehicle in commercial service over——

Senator KERRY. One vehicle.

Mr. MILLER. Pardon?

Senator KERRY. One vehicle.

Mr. MILLER. A large transit bus. We are also working with Thor Industries, which is a U.S. company, and we will have one fuel cell bus on the road also beginning next year.

Senator KERRY. If we were to create a pilot program that tried to designate a specific community, either for school buses or for transit buses, how fast could the supply of buses be made available?

Mr. MILLER. We could have those—I think we could have buses available for a demonstration program like that by the end of next year.

Senator KERRY. And what we are talking about is a vehicle which has literally zero emissions, zero, no NO_X——

Mr. MILLER. Fueled by hydrogen——

Senator KERRY.—no SO_X, fueled by hydrogen. Hydrogen, incidentally, is it not about 80 percent of the matter here on Earth?

Mr. MILLER. I am not sure of the exact percentage, but obviously water, you know, has—hydrogen as the main——

Senator KERRY. So it is ample in terms of supply and potential; plus, you can create it.

Mr. MILLER. Yes. We can also reform hydrocarbons which separate the hydrogen atoms from the carbon atoms and actually produce hydrogen that way. That is what we do with our natural gas PC25s today.

Senator KERRY. Now, Dr. Kammen, pick up on that. What do you think we should and could do that would have a positive impact in helping to expand the market?

Dr. KAMMEN. Well, certainly. I mean, the key lesson that the more product turnover cycles you get, the better. The more generations of vehicles you build, the more efficient they get, the lower the cost comes down.

A couple of things one could do right off——

Senator KERRY. But how do we get to the point where——

Dr. KAMMEN. Right.

Senator KERRY. Mr. German referred to the consumer here. The consumer wants that acceleration, zero to 60, wants the comfort—I mean, there are certain things that the marketplace is automatically responding to. Now, in Europe, the prices of fuel are higher, so you have had a marketplace response as a consequence. Nobody here in the Congress is going to advocate a higher fuel price, so how do we deal with this in those circumstances?

Dr. KAMMEN. Well, it is interesting. I mean, Mr. German mentioned the degree that we have seen vehicles improve quite a bit, but a lot has gone into performance, not into efficiency. If we (a) close the SUV loophole standard on the CAFE standard and if we raise the overall CAFE standards, those would send a strong signal to companies that some of that R&D effort should go back into these more efficient vehicles that would get the costs down.

We could also institute tax credits for hybrid vehicles, for fuel cell vehicles, and those would have an important effect, because those would tell companies——

Senator KERRY. We actually have a bill. Senator Rockefeller and I and others are hoping we could actually pass that here.

Dr. KAMMEN. That is what I am hoping as well, and that really does set the clear standard for industry, that it is an area worth investing in, because the market is going to be there for a while. That is what I mentioned before, that building markets for these clean technologies is a critical thing. In the past, markets have come and gone, and there has been individual programs, but setting standards like the CAFE is one way to really focus that effort on those technologies.

Senator KERRY. Mr. Miller, what would have the greatest impact, the fastest impact on you, beyond the pilot project here? If we wanted to accelerate the creation of a vehicle that has no emissions, how could we do that as rapidly as possible?

Mr. MILLER. Well, I think the tax credit bill which you referred to is an important part of that, but I would also say once again the fuel cell cost target is very low for transportation, and what would help the industry drive down the cost is to start also working the stationary fuel cell supports and incentives, because that is the first initial application. We think for stationary you will see fuel cells in buildings and homes in 2003. So if we can increase the demand for those products, that will drive the cost curve down and help us get toward that $50 a kilowatt number that we need to achieve to be competitive with the internal combustion engine.

Senator KERRY. Now, each of you heard the discussion with the first panel where we were talking about the requirements to try to reduce our net emissions. It is obvious, is it not, that if this country

rapidly began to adopt the technologies you have talked about, you could have a fairly painless movement very rapidly to a more responsible position, would you not?

Mr. MILLER. I would agree.

Dr. KAMMEN. I certainly agree. And, in fact, the issue, I think, is really delay, because the longer we wait, the harder it is for companies to make those changes, and the earlier that we put in standards like more efficient vehicles, like carbon targets, those are the ways to really get companies to make those investments in this area, and those have paid off. We have seen companies consistently making money by investing in clean technologies, despite a lot of earlier rhetoric that these energy-efficient technologies are, in fact, costly. They are, in fact, not.

The more we invest in them, like with compact fluorescent lighting, the Federal program, the green lights program, paid dramatic dividends back and transformed the lighting of the country, and those kinds of programs have a big effect.

Mr. DUFFY. Senator, I would also concur, and I would like to reference an example as to how quickly markets will respond to the right incentives, and that is the renewable portfolio standard, or RPS as it was referred to earlier, that was established by Texas several years ago, and in many respects, it is the national model for people who want to see the competitive development of renewable fuel.

Texas had an RPS requirement for 2,000 new megawatts of renewable energy generation to be in service by the year 2009. Onehalf of that amount, 1,000 megawatts, will be met by wind generation that will be placed in service by the end of this year, so the technology is ready, and with the right market incentives, the industry will respond.

Ms. KOETZ. Senator, if I may, there is another aspect to all of this market penetration that I think might be useful. Most of the technologies you see here sitting at the table are almost zero-emitting. The problem is that none of our systems for accounting for emissions take into account a zero emitter. If you never make the emissions to begin with, you never get on the books; you are never part of a static baseline for—that is measured, that somebody wants to measure reductions off of, so you essentially wind up in a category that has now become known as "anyway tons." You were sort of going to do that anyway, and in many respects, being zero-emitting is thought of as just almost an accident of design rather than as a positive public output.

So if there is one other thing—and that also translates into some of the numbers you are hearing here. 1,000 to $1,500 a kilowatt is the price for combustion fuels, and those combustion fuels do not have to make the additional investment it takes to go all the way to zero-emitting. So we are aiming for targets that don't include the cost of getting this additional public value that we say we want to get.

Senator KERRY. And obviously that needs to be reflected in the equation. I understand. I agree with you.

It is also part of what we need to do as we cost out these issues. Whenever we are thrown the costs of doing something in the economic analysis, we are always given a cost that is very one-sided.

We never have the costs factored in for the cleanup, for the damage, for the disease, for all the other negative sides. We often don't weigh that balance. Dr. Kammen, that is why you are saying there is a $45 billion upside. Am I correct?

Dr. KAMMEN. It is even more than that. I mean, that is the direct upside. If you instituted these energy efficiency and lower cost fuels, you get that, but you also get an economic stimulus, because that fossil fuel cost is essentially like the national debt. That is money we are paying and not getting something out of. If we invest in these clean technologies, we generate new markets. We then see an additional effect on the market.

And what is interesting is that is now a very robust result. As I said in the testimony, there is national lab studies. Our research group at Berkeley has seen some of that. There are independent groups who have all, coming along, seen different programs that they would support, that overall the more investment in energy efficiency and renewables that we see, the better economic stimulus we see. So it is having the exact opposite effect as the detractors have been claiming for many years.

Senator KERRY. Let me document that by saying that in 1980, the end of the Carter administration, after the initial investments of the 1970's in response to the 1973 crisis, we were the world's leader in photovoltaics and renewables. We started the Energy Institute in Colorado. Tenured professors left positions to go out there and help feed this engine, and then the Reagan administration came in, didn't believe in that kind of market support or intervention, and completely gutted the program. We lost the lead in both technologies to Germany and Japan, if I am correct, and not to mention, discarded our leadership overall in that field.

So the consequences are enormous in these fields when you make these choices. In Massachusetts during that same timeframe, the fastest growing sector of the Massachusetts economy, notwithstanding our extraordinary presence in education, in health care, in financial services, in defense technology, in bio technology, and other technologies, the fastest growing sector of the Massachusetts economy was environment companies that were growing as a consequence of those incentives that were created, and we had a job base going from 50,000 up to about 75,000 people.

The brakes were put on, as several of you mentioned earlier, and progress kind of ground to a halt because we weren't consistent and sustained in our commitment. I believe too much is being made of the difficulties of this transition personally. We are the world's greatest technological leader and creator on the planet. If we would unleash our technological capacity to pursue some of these things, the market responds: "Build it and they will come." If we will do this, we can quickly lower the current dependencies that we are all so concerned about.

Now, I am not going to say it is going to happen overnight. Obviously, I understand the difficulties. There are regulatory issues we have to work through; there are liability issues that we have to work through. I think many of us on our side of the aisle who have been very supportive of some of those efforts need to be very thoughtful about the changes and approaches we need to think about in the context of the regulatory schemes. There are many of

these things that could get out there today that can't because of the heavy-handedness of the regulatory process itself and other kinds of issues, and I think we have to be really thoughtful about how we come at that.

On the topic of wind energy—and then I want to defer to Senator Ensign who has been very patient. Mr. Duffy, how many countries are using wind today as a major source of energy?

Mr. DUFFY. I am going to have to get back to you with a number on that, Senator, but I think it is safe to say that throughout Europe, it is being relied upon as one of the primary new sources, as new construction is being placed into service. And as I mentioned before, the number from the AWEA study, $4 billion investment last year. I mean, it is—we also see it as—we try to develop plants in the United States. We see the impact of how well accepted and proven it is in Europe by the backlog that is quickly building up to get wind turbines in service within a reasonable period of time.

So globally there is no question it is one of the leading sources and particularly one of the leading new sources. What we need to do is just take the additional steps so we can expand that into this country.

Senator KERRY. And just very quickly, Ms. Koetz, obviously nuclear is zero emission, and its record is stronger in many regards than many people have acknowledged. On the other hand, there are two very significant issues that still stand out there, and maybe you would share with us what progress has been made and what one might look forward to there. One is the waste issue, and the other is the safety concerns that people have had. Do you just want to comment quickly on both of those?

Ms. KOETZ. I will do that. Thank you, sir. First of all, I will go to safety. We have had an ever-increasing safety record such that we are one of the safest ways to produce power in the world right now. In addition, we see a direct correlation between safety improvements and economic enhancement. We have many plants, as I mentioned, making electricity for just over a penny a kilowatt. Those are the same plants with the best safety records, so we do not see any need to sacrifice safety or otherwise fail to live up to our own imposed safety standards in order to get improved economic performance, and we intend to see more plants going forward on that correlation as well.

As to the—and if you don't mind, I am going to call it the so-called waste issue, sir, because one of the most important things we deal with here in global climate change is dealing with our greenhouse gas emissions as we approach sustainability.

And, frankly, we have always understood that our processed uranium fuel stocks were reusable at some point in time. We also understood that this was valuable material that we needed to take care of, so in many respects, although it has been labeled waste because of some of the policies we have pursued, in fact, this is a secondary raw material.

And before I get to the details of what we have been doing, I think it is important to put it in context. We make about 40 million tons of hazardous waste every year in the United States. We have 40,000 tons of used nuclear fuel from 50 years of making carbon-

free, sulfur-free, nitrogen-free electricity. That material would cover roughly the size of football field to about 15 or 16 feet.

There is no denying that this is potentially dangerous material that must be very effectively managed. However, the good news is it has been very effectively managed. There are no Superfund sites at commercial nuclear power plants. There are no RCRA corrective actions going on commercial nuclear power plants. We have always done the right thing with this material from the get-go. And because of that, we have not had any adverse environmental impacts from this material. it has been what I would call the poster child for effective waste management for the last 45 years.

We have had a program in place for the last decade or so to create a centralized repository for this material. Unfortunately from Mr. Ensign's standpoint, that is now in Nevada. This does replicate what has been the systemic solid waste management programs followed by the United States over the last several decades. You identify your hazardous waste at the end of a process. You secure it. You package it, and you transport it to a centrally located facility where it can be better managed than it would be in dispersed facilities.

We are tracking every other waste management program we have. Unfortunately, this does create significant political issues, and we understand that. At the same time——

Senator KERRY. Fortunately for Mr. Ensign and for Nevada, Harry Reid is in the majority, and it is not going to happen, so——

Ms. KOETZ. Yes. Well, we understand that. But fortunately for this country, the onsite facilities are doing such a good job managing that material that if we either do not eventually use Yucca Mountain or we come up with a different recycling technology, such as separation and recycling technologies, which are under research and development now. The best thing to do frankly for sustainable development in many ways is to reuse this material more effectively. We think that we must be very careful not to presume two things. First, we can't assume that the current handling situation is inadequate; it is really quite adequate for what we will need to do to make decisions in policy space over the next several decades. And, second, we can't assume static technological development in this area. I mean, we are going to get better at using this material.

Senator KERRY. Well, thank you. That was an articulate answer, and I appreciate it.

Senator Ensign.

Senator ENSIGN. Thank you, Mr. Chairman.

I want to followup on that line of questioning. And, Ms. Koetz, I was actually excited about especially your last couple of comments that you made, and I would like you to comment in general. We now have Yucca Mountain out there that is—I think originally was supposed to cost somewhere around $15 billion, and now the GAO, I think their latest cost estimate was $58 billion. And some of the scientists think that it could go as high as $75 billion, which by the way, would be the most expensive construction project in the history of the world.

Senator KERRY. Puts the Big Dig to shame.

Ms. KOETZ. Maybe we could call it Big Dig II.

Senator KERRY. Please don't.

Senator ENSIGN. The bottom line, the reason I wanted to mention the cost, because when you are mentioning kilowatt hours, Mr. Kammen, when you were talking about taking total costs in, if you figured a $60 billion cost to that, what does that take your kilowatt hours to, when you put—do you have that figure?

Ms. KOETZ. I don't know if we have done that. Now, right now, as most of you know, we are adding a mill to the price of nuclear electricities, and that is being put in a fund. That fund is already far in excess of what we anticipate being able to spend over the next several decades. My estimation would be, to be honest with you, Senator, that if we continue to pay the mill in, we would have enough money to pay for the repository, even if it got to $60 billion. I couldn't tell you that definitively.

Senator ENSIGN. I was going to say, that is not my understanding of what the GAO—GAO, that was the purpose of their report.

Ms. KOETZ. I apologize. I haven't seen the report.

Senator ENSIGN. Their report basically was saying that the taxpayer is going to end up holding the bag. The reason I bring that up also is not just to—you know, I don't want to get into a tit for tat on any of that. But if, as you said, the sites are handling it adequately at this point—obviously we don't have some national crisis with nuclear waste right now.

Dry cask storage, which a few of the sites are doing currently—and that is happening around the world as well. Dry cask storage, I understand, you know, maybe is a $2 billion, maybe $3 billion type of—we don't have the transportation problems. We don't have a lot of those types of things. If we went to something like dry cask storage onsite—and I know the biggest problem that you have with dry cask storage is not from your industry's point of view; it is the states' point of view, is getting the sites licensed for dry cask storage.

But if the states would do that—and we are looking at a countrywide policy, because I think that nuclear power is part of the answer for the global warming and some of the things that we are talking about in this hearing today. I just don't think it is part of the solution if we don't deal with the economic problem.

But the—if we go to onsite dry cask storage, which is far cheaper, doesn't that, in fact, make nuclear power more viable from an economic standpoint and therefore help us in the future as far as the environment is concerned?

Ms. KOETZ. Well, Senator Ensign, the first thing we would have to do is examine whether it truly is cheaper, if you will, to have dry cask storage at the facilities. Yes. You are correct in the actual cost of putting the facilities up. But then we are put in the position of having to maintain those separately funded facilities with proper security and proper other costly items to maintain them very effectively as a repository for this kind of material.

So in the long term, although the initial perhaps capital costs of the facility would be a little bit less, from a long-term perspective, it is not cost-effective to have separate facilities for this material, no more than it would be cost-effective not to have a centralized hazardous waste landfill under RCRA in a state or a locality where you centrally moved your other hazardous byproducts that we

make all the time, just like you are not going to keep computers which contain lead in various dispersed municipal landfills. We are going to eventually have to consolidate them in well-run, centrally located, secure facilities.

So I think you can't just look at an initial capital cost situation. You have to have the much longer term costs in mind.

Senator ENSIGN. Well, and speaking of some of those longer term costs, when we are looking at recycling technology, separation, recycling, whether it is accelerated or transmutation accelerator technology or the reprocessing that several countries are doing—I understand that Japan is building a new reprocessing plant, one of the most modern in the world.

We are looking at those types of technology. I mean, we understand—we cannot separate politics from any of this, and transportation is one of the most difficult parts of any of this. And so if you are looking at the total cost, we also have to look at political costs. I just want the industry to keep in mind that because of transportation, if we can look at onsite dry cask storage as the alternative right now, looking at the long-term future, because I believe that recycling this waste is very, very important thing to do and looking at new technologies. It seems to me that the overall benefits, if we can do onsite dry cask storage, as we develop the technology, we won't have to transport it, and then transport it again.

Ms. KOETZ. There is a very interesting climate change connection to what you are saying. One of the things we want to do the most for climate change, not just in this country but around the world, is to engage in successful technology transfer. And interestingly enough, nuclear, again, represents a 30- or 40-year history of very successful technology transfer to the rest of the world, mostly in the form of research reactors. And that research reactor fuel has been coming back into this country and been transported to centrally located places on government facilities in this particular instance for years as well.

So I agree with you that while transportation is a difficult political issue, it is also a successful transportation, scientific and climate change issue, because we have been transporting spent nuclear fuel around this country for decades now very, very safely. So I agree with you. We try to take all of those costs, political and technical, into account. But we also hopefully can take some of the realities into account as well.

Senator ENSIGN. Mr. Chairman, could I ask a couple other questions to the other witnesses? Obviously this is kind of a big issue to us, but I was—I had some other questions of the other witnesses.

Mr. Kammen, you were talking about, you know, fossil fuels, and one of the things you said about fossil fuels being subsidized, one of the things you didn't mention is how we subsidize them militarily, and that is a fairly significant cost.

Dr. KAMMEN. I agree.

Senator ENSIGN. Yes, from the military standpoint. But I was also—there was something that you said about the Government not choosing winners and losers, and I think that that is so important, because we do get messed up. It seems historically what we have learned is when we try to say that, Here is what you are going to

do, and therefore, these are the winners and losers, even when we are trying to do something laudatory like clean up the environment.

I think a really good example is what California did with the MTBE situation, and this is the technology you will use to clean up the air, and, oh, yes, by the way, it does hurt the groundwater. And I think that when we get into situations where we skew the marketplace, we could end up with the most inefficient technology. Could you just further comment on how we make the marketplace determine the winners and losers, not Government and some, you know, favorite senator's program or whatever determine the marketplace.

Dr. KAMMEN. Right. That has been a real challenge, and partially the subsidies that are already on board for existing technologies make it hard to open those new markets up. That has been part of the story.

And the other one, as you say, there has been a number of programs in the past, syn fuels, clean coal. I would argue some of the subsidies that went into nuclear, et cetera, have been ones that were technology-specific, and that hasn't worked very well. I would argue that we are now in a new era, in the sense that many of these renewables are market-competitive or just on the edge right now, and so we can actually use those market tools much more effectively.

The renewables portfolio standard is one that I think does exactly that. It calls for a certain amount of renewable energy in the mix, and it lets the market then look at those options. And the UK has had an interesting experience with their non-fossil fuel obligation, the NFFO. Texas, as was mentioned, has had a very interesting plan that is basically 8 years ahead of schedule.

Those types of programs where you say, We are going to set and stick with a standard, whether it is an approved CAFE standard—and I, for example, support a quite highly increased one, 40 miles a gallon over about a decade—or one with a certain fraction of clean energy in the mix. Two percent, for example, next year is the standard for RPS, which I would ramp up to 10 percent in the year 2010 to 20 percent in 2020.

Those set these clear targets and let the market then select technologies and don't make it a pork or a favorite technology program. And that has been a very important way to do things, and that has been a discovery the last 10 years of programs, a number of them supported by Department of Energy, so I would agree.

Mr. GERMAN. I would just like to say that Honda also definitely supports Senator Ensign's comments about not choosing winners and losers. We are faced with a great example of that right now with the California mandate and electric vehicles, which is a real problem for us, so Honda is very supportive of performance requirements.

Senator ENSIGN. Mr. German, I actually had—just to follow that up with Honda's, I think, very impressive environmental record as far as the type of vehicles that they build, but you mentioned before what Americans are choosing to drive, and I think that the difficulty in all of this is that when you are thinking about—I know certainly when I am thinking about my family—I have a wife and

three small children, and I want something big around them, and it might smash another small car, but I know that they are going to be safer in it.

[Laughter]

And, you know, I mean, everybody looks at these things kind of selfishly. We have three small kids, and when you have three small kids, you don't want a little car because of something called space, and between small children on a trip, it is important.

But how do we get—why doesn't Honda it seems to have built—and you mentioned some of the technologies and some of these high-fuel vehicles or better gas mileage. If it is possible, why aren't the car manufacturers today, Honda and others, making the larger SUVs that just have higher gas mileage? I mean, if we set as—and we close the loophole, is it possible to meet those standards and still give Americans what they want? Is that possible? And if it is possible, why aren't we doing it now?

Mr. GERMAN. You can certainly close some of the loophole. Honda is traditionally cautious about moving into new markets, and we are behind most of the manufacturers on light trucks, but the recent example is our Acura sport utility, the MPX, which is seven-passenger. It has much more interior volume than a Ford Explorer. It also gets much better fuel economy, because we have incorporated a lot of our fuel-efficient technologies into it.

Honda has a philosophy of being an environmentally conscious company and being a technology leader, and we try to bake this into all of our products. And I can't speak for the other manufacturers.

Senator ENSIGN. Mr. Kammen.

Dr. KAMMEN. An interesting feature on that point is that when innovation is directed in these ways, you find that there are impressive benefits. So, for example, over the last five or 6 years, we have seen an increase in the number of different types of air bags, side impact, a whole variety of features that have improved safety. Now, it doesn't solve the problem of three kids and a long drive issue, but it does do the safety things.

And so if you couple in—say, we want to see more efficient vehicles, but vehicles will sell better that are safer, those are the kinds of signals that work together to meet the market-based targets that you are saying, because I certainly think that we could see much more innovation along these lines and convert more of that percent-and-a-half increase in efficiency that Mr. German mentioned into this area.

Mr. GERMAN. I mean, it is just a question of how much you want to spend and the lead time involved.

Senator ENSIGN. Mr. Miller, just one last thing for you, as far as the fuel cells. I think it is kind of interesting. I forget where I was reading the article. I think it might have been Time magazine, and they were talking about fuel cells, and they were using New York City—they were saying that fuel cells in the future may be the PC answer—not politically correct, but computer PC—answer to our power problems, because one of the biggest problems—and we certainly face this in the Western United States—is transmission.

Getting new transmission lines approved are incredibly difficult, and this actually may be a place where, you know, a big part of

the cost in the future for power plants is going to have to be looked as transmission lines, and if you can, in a local area, use at least as far as a new part of the power grid—certainly California doesn't want, you know, new power plants, new power lines, anything being built. It would seem to me that they should be focusing on technology like the fuel cells.

Mr. MILLER. Yes. I think that is a good analogy between mainframe computers and large power generating stations, and PCs and fuel cells. Fuel cells will be distributed power, at homes or in buildings, and will not need as much transmission capacity as presently exists in the United States and around the world. I agree with that.

Senator ENSIGN. And, Mr. Chairman, just my last comment on this. I think it is interesting that we are hearing that new technology is a big part, it looks like, to our answers, and I certainly believe it is to our answers, if we focus that new technology in the right way, to our environmental concerns. But it is also funny that if you look at every one of our—or almost every one of our states, we tax cars, new cars, higher than we tax old cars, and yet new cars produce less pollution.

There was an op ed in our paper today, and it was kind of an interesting—I had never really thought about that before, but we penalize people for being more environmentally friendly today, and maybe it is a policy that we need to look at in the future. Thank you, Mr. Chairman.

Senator KERRY. I think that is a good observation, and I concur completely. I think we learned a number of years ago about the winner/losers issue. We don't want to pick them. We want to create a framework within which people can make their own choices, and capital will move thoughtfully and rapidly in a certain direction. But which particular technology comes out of it, I think the marketplace can often make that decision itself better.

Mr. DUFFY. Senator, I would like to confirm that. Just by way of example, we mentioned a major Massachusetts wind project we are working on. We are doing that for the specific reason that Massachusetts has always, similar to Texas, adopted an RPS standard where they have specific guidelines of percentages, ramping up to 10 percent, for which a number of renewable technologies would be eligible. It could be solar; it could be hydro; it could be wind. We are going forward on the basis of that structure, putting our capital at risk. We know there's others out there, and it is up to the market to see who is actually able to pull the projects off.

Senator KERRY. Absolutely. Obviously the competition is healthy, and presumably there will be several different niches and technologies out there that are in the range, but I think it is helpful for us to try to create the framework to attract that.

I am particularly grateful to all of you. Some of you traveled long distances, and this is very helpful to the Committee. We are going to leave the record open for colleagues who may want to submit some questions in writing over the course of the next 10 days, and I appreciate very much you taking time to be here.

We do have another panel, so I would like to switch panels, if we can, as quick as possible.

[Pause.]

Senator KERRY. Dr. Sandor, you have a flight that you are going to try to get to, and it is out of Dulles, so we are going to lead off with you, and if we have any questions, we will focus in on them.

STATEMENT OF DR. RICHARD L. SANDOR, CHAIRMAN AND CEO, ENVIRONMENTAL FINANCIAL PRODUCTS LLC

Dr. SANDOR. Thank you for the courtesy, Senator. It is a pleasure to be here to talk about a subject which I think is very, very exciting, and that is market-based solutions to environmental problems.

I am chairman of the board and CEO of a small company called Environmental Financial Products, and a visiting scholar at Northwestern University. We professionally design, develop and participate in new markets, and our experience has gone from financial futures in the 1970's to insurance derivatives, hurricane index bonds, earthquake bonds, climate derivatives, and most recently in the SO_2 program which, I know, Senator, you were a key figure in.

In the SO_2 program, we think there is a model that serves very well any inquiry into carbon and carbon trading. As you are well aware, in the late 1980's people talked about $1,500 or $1,800 a ton as the cost of abating SO_2 emissions. As early as 1992, the median levels were $600. At nine auctions at the Chicago Board of Trade since its inception, the costs were roughly $130 a ton, 20 percent of the forecasted levels.

I think we need to get into the practicalities and less talking and more action to really inform the debate. If, in fact, the cost of reducing global warming is very, very low, policy-makers need to have that fact, and the best way to uncover this cost is through practical experience.

We have been involved in carbon markets since Rio in 1992 at Kyoto and The Hague and we are now talking about a pilot trading program. A year and a half ago, we approached the Joyce Foundation, which is a billion-dollar Midwest foundation to see if they would fund the feasibility of developing a climate exchange within the Midwest area (Wisconsin, Minnesota, Iowa, Illinois, Indiana, Michigan, and Ohio).

We undertook that feasibility study. We looked at the size of that particular region, which has roughly $2 trillion GDP. It would rank as the fourth largest country in the world if it were separate entity. It has a broad array of industry, agriculture, forestry, manufacturing, and energy industries.

The results suggest that there is, indeed, a possibility that we could develop a market that had balance and included a wide variety of constituents and a voluntary cap which corporations would take on and ultimately implement through trading. It would include carbon sequestration in agriculture and forestry, landfill gas, wind, and other renewable energy.

At the end of the study, we formed an advisory group, and that advisory group includes former members of the Senate, the House, former governors, Republicans, Democrats, deans at Yale and Northwestern, the former Undersecretary General of the U.N. who was the lead organizer of the Rio summit. We have scientists, the former mayor of Rio de Janeiro and a forestry—sustainable forestry expert. So we were advised by a lot of talented people.

We took it to the field about 3 months ago, and the critical test was: Could you get companies to agree to a voluntary cap, and could you get a broad enough constituency to build a consensus, to develop a market, and could you buildup the monitoring protocols, the verification, the registry.

We had a target, Senator, of five companies. We had hoped to get a couple of utilities, some large agricultural producers, and a landfill gas operator who would help us with these protocols, enough to get a mini-market. Well, we were dead wrong. We ended up with 33 major companies, eight utilities that constitute 20 percent of the total emissions in the Midwest. They range from WEPCO and Cinergy, Midwest Generation, Exelon, PG&E.

We found out the forestry companies were interested as well, including International Paper, Mead, Temple–Inland. We also went to some of the largest corporates in the region. BP, Ford, DuPont, all have joined; Zapco, Waste Management, a wide variety of alternative energy sources, and heavy manufacturers. As a matter of fact, the market capitalization of the companies that are helping us in the design process and have joined the Chicago Climate Exchange is roughly $425 billion. So we have some serious interest.

In the farming sector, we have four farmer cooperatives, including the Iowa Farm Bureau Federation, which has 80,000 members, who farm 25 million acres, which is 85 percent of all of the farms in the state of Iowa.

We are entering the second stage now. We think that there is practicality in this. The companies have agreed to consider a pilot stage emission reduction of 5 percent from 1999 levels, to be phased in from 2002 to 2005. When we complete this market design study, we will begin implementation and trading.

Senator, in conclusion, there are a couple of things which I would like to mention. We need some help at the legislative level. There is a role for early reduction credits and for early action legislation. We need some help with the registry. We need some help in monitoring and verification of soil carbon, and we need some research in those areas. We think if that happens, we will move along.

And, finally, the carbon market is ongoing. Today we are privileged to close a trade between Nuon, one of the largest utilities in Europe, and a New Jersey electric utility for 300,000 tons of carbon, so we have actually been trading already in an over-the-counter market.

Thank you very much.

[The prepared statement of Dr. Sandor follows:]

PREPARED STATEMENT OF DR. RICHARD L. SANDOR, CHAIRMAN AND CEO, ENVIRONMENTAL FINANCIAL PRODUCTS LLC

Feasibility and Initial Architecture of a Voluntary Midwest Greenhouse Gas Reduction and Trading Market

Context

The debate over appropriate actions to address the risks arising from changes in the Earth's climate—the "greenhouse effect"—suffers from two major information gaps. The first is a lack of consensus regarding the damages that could occur to the environment without action to reduce greenhouse gas (GHG) emissions. The scientific process may not precisely predict the nature and implications of climate changes that would occur if society does not make significant changes in energy and

land use patterns associated with higher levels of GHG emissions. That is, the costs of inaction and the benefits of taking mitigation actions are uncertain.

The second information gap is lack of understanding of the monetary costs associated with undertaking mitigation to reduce greenhouse gasses. The absence of hard, proven data on greenhouse gas mitigation costs reduces the quality of the climate policy debate.

The nature of the implied cost-benefit analysis underlying the climate debate suggests that for any particular level of benefits accruing from action to mitigate climate change, a high cost of mitigation will lead policy makers to take less action. If mitigation costs are proven to be low, it appears policy makers would support stronger action to address climate change. At this time, however, we lack the data for realizing the costs involved in pursuing climate mitigation actions.

The ultimate objective of the proposed Chicago Climate Exchange is to generate price information that provides a valid indication of the cost of mitigating greenhouse gases. By closing the information gap on mitigation costs, society and policymakers will be far better prepared to identify and implement optimal policies for managing the risks associated with climate change.

Overview and Methodology

This report presents a feasibility analysis and initial architecture for a voluntary pilot greenhouse gas emissions trading program that would be launched in the Midwest and expanded over time. The objectives of the pilot program—hereafter called the Chicago Climate Exchange (CCX)—are:

Proof of concept:

- demonstrate the ability to cut and trade greenhouse gases in a market system involving multiple industrial sectors, mitigation options and countries;
- initiate greenhouse gas reductions through a modest size but scalable program;
- form a basis of experience and learning for participants;
- introduce a phased, efficient process for achieving additional GHG reductions in the future.

Price discovery:

- provide realistic information signaling the cost of mitigating greenhouse gases;
- enhance the quality of climate policy decision-making by providing hard data on mitigation costs to the public and policymakers.

The strategy used to assess the feasibility of a pilot GHG market relied on several research methodologies. A theoretical economic assessment accompanied by quantified data guided the structure of the study. The proposed market architecture was influenced by lessons from other successful emissions, financial, and commodity markets. The successful USEPA SO_2 emissions trading program to reduce acid rain served as a model for the design of key elements of the Chicago Climate Exchange.

The research is a continuing work in progress. The next step of the process is to incorporate industry input to refine the initial proposed market terms and conditions. This process will yield a working prototype for which an attempt to build a consensus will be initiated. That consensus design would represent a functional architecture for the first phase of a market. Implementing the proposed market design and incorporating lessons from practical experience are core elements of the program.

Market Architecture and Participants: Theory and Design

The negative effects caused by the release of greenhouse gases is currently not priced. Consumers and businesses do not fully take account of such effects in their economic decision-making because there is no price on the use of the atmosphere. The goal of the proposed pilot greenhouse gas trading program is to establish the market for discovering the price for reducing emissions. The core steps are to limit overall consumption of the atmosphere (GHG emissions) and establish trading in instruments that allow participants to find the most cost-effective methods for staying within a target emission limit. The market price of those instruments will represent a value signal that should stimulate new and creative emission reduction strategies and technologies. Emissions trading is a proven tool that works with and harnesses the inventive capabilities of business.

Various market architecture design options were considered. A market could include emission limits taken by fossil fuel producers and processors—the "upstream" entities in the carbon emissions cycle—or by major "downstream" sources that burn fossil fuels, such as electric power generators, factories, and transport firms. An

"intermediary" level approach could focus on firms that produce energy consuming devices, such as automobiles, or other intermediaries such as fuel distributors. Based on responsiveness (the ability of participants to directly cut emissions), administrative costs and existence of successful precedents, the recommended approach is a predominantly "downstream" approach. Accordingly, the research findings suggest the CCX should aim to include participation by large emission sources at the downstream level (e.g. power plants, refineries, factories, vehicle fleets).

In order to incorporate other mitigation projects that add to the flexibility of the market (and which are gaining international recognition as valid projects), the proposed design would also allow crediting for a range of offset projects that encourage micro-level GHG mitigation actions.

Reflecting international consensus and successful precedent, the items to be traded in the pilot market—GHG emission allowances and offsets—are instruments representing one ton of carbon dioxide (CO_2) or their equivalent (CO_2e). For every ton of CO_2 emitted, a participating emission source must relinquish one allowance or offset.

Potential For A Market Initiated in the U.S. Midwest

The Midwest represents a microcosm of the U.S. The region's economy is as large as the economies of the United Kingdom (U.K.) and the Netherlands combined and has annual GHG emissions equal to those of the U.K. plus France (1.375 billion tons CO_2). The region's industrial diversity—including a broad range of energy, heavy manufacturing, transport, agriculture, pharmaceuticals, electronics and forestry—make it well-suited as a starting point for a robust and representative greenhouse gas emissions trading market.

The feasibility analysis suggested a hypothetical target market covering 20% of all Midwest emissions. The scale of such a market and the proposed GHG mitigation goals are summarized in Table A. The Table portrays a proposed GHG reduction schedule calling for emissions in the first year of a pilot market, 2002, to be 2% below 1999 levels (the baseline year) and falling a further 1% each year from 2003 through 2005.

Table A. Scale of a Hypothetical Midwest GHG Market and Mitigation During 2002–2005

(in million metric tons CO_2 equivalent)

Estimated Midwest 1999 emissions	1,375
1999 emissions of a hypothetical 20% coverage market	275
Cumulative *baseline* emissions during 2002–2005 under for the 20% coverage scenario	1,100
Cumulative 2002–2005 CCX emissions *target* for hypothetical 20% coverage program (2% below 1999 levels during 2002, 3% below 1999 in 2003, 4% below in 2004, 5% below in 2005)	1,061.5
Four-year Mitigation Demand (baseline emissions—target)	**38.5 mil. tons CO_2e**

The hypothetical 20% coverage Midwest market appears to provide sufficient scale for a pilot market that could be representative of a larger market. Total emissions covered in such a market would equal the emissions of Scandinavia (Denmark, Finland, Norway and Sweden) and would be more than double the emissions covered in the successful internal GHG market operated by BP-Amoco. While broad coverage is an ultimate goal, the main benefits of a pilot—proof of concept and price discovery—can be realized with a modest size but a diverse set of participants.

Proposed Market Architecture and Mechanics

Table B summarizes the core elements of the proposed market architecture.

Table B. Indicative Term Sheet
Market Architecture for the Chicago Climate Exchange

Geographic Coverage	2002: emission sources and projects in seven Midwest states (IA, IL, IN, MI, MN, OH, WI), offsets accepted from projects in Brazil; 2003–2005: emission sources and projects in U.S., Canada and Mexico, offsets accepted from projects in Brazil.
Greenhouse Gases Covered	Carbon dioxide, methane and all other targeted GHGs
Emission Reduction Targets	2002: 2% below 1999 levels, falling 1% per year through 2005
Industries and Firms Targeted	Primarily "downstream" participants: power plants, refineries, factories, vehicle fleets; approximately 100 firms initially targeted; individual entities or operating groups must produce over 250,000 tons CO_2e to become a participating emission source
Tradable Instruments	Fully interchangeable emission allowances (original issue) and offsets produced by targeted mitigation projects
Eligible Offset Projects	—Carbon sequestration in forests and domestic soils —Renewable energy systems activated after 1998 —Methane destruction in agriculture, landfills and coalbeds —Offset projects must be over 100,000 tons CO_2e; smaller offset projects must aggregate reductions to meet the requirement
Annual Public Auctions	2% of issued allowances withheld and auctioned in "spot" and "forward" auctions, proceeds returned *pro rata*
Central Registry	Central database to record and transfer allowances and offsets; interfaces with emissions database and trading platform
Trading Mechanisms	Standardized CCX Electronic Market, private contracting
Trade Documentation	Uniform documentation provided to facilitate trade
Accounting and Tax Issues	Accounting guidance suggested by generally accepted accounting principles; precedent exists for U.S. tax treatment
Market Governance	Self-governing structure to oversee rules, monitoring and trade

The following summarizes the mechanics of the proposed system:

1. Participating emission sources agree to the prescribed emission limits and standardized emissions monitoring and reporting rules.

2. Participating emission sources receive a four-year stream of emission allowances equal to their target emission level.

3. Emission offsets may be generated by independently verified GHG mitigation projects.

4. Starting in 2002, annual allowances and offset holdings must cover annual emissions.

5. Participants can comply by cutting their own emissions or purchasing emission allowances from those who make extra emission cuts or from offset projects.

6. Failure to fulfill commitments triggers automatic non-compliance penalties.

7. Periodic auctions and organized trading will reveal market prices.

Tradable emission allowances and offsets exist and are transferred as records in a publicly accessible computerized tracking system called the Registry. Each unit is assigned a unique identification number. A variety of best-practice methods for measuring or calculating GHG emissions will be applied, including continuous emissions monitoring, fuel records and mass balance calculations. Methods for addressing new entrants and facilities and partial ownership of emission sources have been proposed but need further refinement based on industry input.

Emission offsets reflect mitigation actions generated by individual projects undertaken by entities not qualified to be emission sources (generate less than 250,000 tons CO_2e emissions reductions per year). When possible, standard rules and conservative reference emission values can be used to determine offset project effectiveness. Offsets are earned by undertaking specified mitigation projects that must be independently verified. Multiple small offset projects will be grouped into 100,000 ton pools. Offset projects must follow standardized registration, reporting and verification processes. This design feature is intended to produce fungible instruments that will be recognized in other emerging carbon markets.

Examples of eligible offset projects include:

- Carbon sequestration from forest expansion, and domestic no-till agricultural soils and agricultural tree and grass plantings;
- Electric power generated by wind, solar and geothermal systems;
- Methane capture and destruction (e.g. from agricultural waste, landfills and coal mines).

Selected categories of offsets can be implemented in Brazil. This feature allows the pilot market participants to develop expertise on issues associated with cross-border transactions, including the opportunity to develop trading across differing legal and regulatory systems. Brazil also represents a natural location as it has extensive linkages to many Midwest businesses, presents a variety of low-cost mitigation opportunities, and its policymakers are actively preparing for the international carbon market.

Annual auctions of emission allowances will be held to help stimulate the market and publicly reveal prices. To complement private contracting, an electronic mechanism for hosting CCX trading will provide a central location that facilitates trading and publicly reveals price information. Several existing trading systems will be considered for use in the CCX market. Trading will be encouraged by provision of uniform trade documentation and by listing standardized spot and forward contracts on the CCX electronic market.

Market Administration Issues, Public Policy Context

Administration of the CCX market by an efficient, corporate style governance system, with an elected Board of Directors and a strong Chief Executive, is recommended. The rules structure and decisions of the governing body should be codified through a Rulebook. Under the guidance of the Board and the Rulebook, a professional staff should be responsible for making most operational decisions and managing outside vendors. In order to assure the market incorporates current best practices, several expert advisory committees will be convened, including committees on rules and enforcement; market operations and technical specifications; and emissions and project monitoring, verification and audits.

The capabilities of various service providers who might construct and/or operate an emissions and emissions trading registry were examined. Discussions have been held with Environmental Resources Trust, Epotec, PricewaterhouseCoopers and the Emissions Trading Group in the U.K. Each group offers potentially attractive features that will be further examined. EFP has also worked to build links to other emerging GHG markets (e.g. the UK), multilateral organizations, national governments, corporations, non-governmental organizations and financial and commodity exchanges.

Professional research on the accounting and tax issues associated with participating in the CCX was conducted under subcontract by PricewaterhouseCoopers LLP. An extensive body of guidance on both accounting and tax issues associated with emissions trading has been established in the U.S. Preliminary indicative guidance is provided on proper accounting and income tax treatment for issues associated with enrollment in the market, trading, swaps, auctions and participation costs.

A variety of legislative proposals have provided further indication that participation in CCX will help position participants to intelligently influence and benefit from possible future regulations. Legislative proposals to require reductions in power plant CO_2 emissions, and to assist or reward farm and forest carbon sequestration, could introduce a policy environment that provides competitive advantages to CCX participants.

Industry Outreach, Response

In order to identify potential CCX participants, a database containing salient information on major Midwest emission sources was assembled and screened based on various criteria. Many Midwest businesses have already initiated climate change programs, and some industries, including the electric power industry, are already involved in emissions trading. Approximately 100 companies met the screening criteria. Additional screening identified forty firms that received first-round invitations to participate in forming the market. Sectors represented in this list include: electric power, auto manufacturers, petroleum refining, transport, pharmaceuticals, forest and paper, chemical manufacturers, and computers and telecommunications.

The broad outreach program also involved development of a CCX website and brochures, thirty conference presentations in eight countries, ten pieces of print media coverage, four electronic media events, and three EFP-authored publications featuring CCX.

Thirteen entities recognized as leaders in their industries provided a positive response to the first round of invitations to participate in CCX. Each entity signed a letter indicating their intent to help form the CCX rules and, if the rules are consistent with their objectives, to participate in the CCX market. Included are major manufacturers such as DuPont and Ford Motor Company, leading diversified energy companies such as Cinergy and Calpine, major international financial entities such as Swiss Re, agricultural businesses such as Growmark and Agriliance, and Zahren Alternative Power, a leading landfill gas energy company. Appendix A provides a brief description of the entities from which a positive response to the first round of invitations has been received to date.

High-Level CCX Advisory Board

A high-level Advisory Board has been formed to receive strategic input from top world experts from the environmental, business, academic and policy-making communities. Members of the Board include internationally recognized environmental leaders such as Maurice Strong and Israel Klabin, former governors of U.S. states (James Thompson and David Boren), and individuals who have served in senior positions in major businesses and academic institutions, such as Donald Jacobs and Jeffrey Garten. The dignitaries serving on this Board can help inform corporate and governmental decision-makers and contribute to the formation of a robust group of CCX market participants. Appendix B provides a brief biographical summary of each of the individuals who have agreed to serve on the CCX Advisory Board.

Next Steps

The report constitutes an initialization of a market architecture. It is the first step of an iterative process to be used in defining and implementing a pilot market. The next step is to build consensus on the initial architecture by further incorporating industry input through a Technical Committee comprised of experts, including representatives of the entities identified in Appendix A. The subsequent step will be preparation and launch of the first phase of the pilot market. Further iteration will involve refinement of market operations based on actual experience with the market, and expansion to allow increased participation and broader geographic coverage.

Detailed discussions with participants and service providers will be undertaken in order to identify a consensus on the market architecture and implementation plan. This effort will aim to finalize emission baselines, targets, timetables, as well as rules on emissions monitoring, non-compliance penalties, new entrants, and jointly owned facilities. Proposed rules must be finalized for emission offset standards, mechanics of aggregating offsets and project verification. A simultaneous effort can be undertaken to select vendors for the registry and trading platform, and to enroll project verifiers. The consensus market design will be codified in the CCX Rulebook, which will also establish the responsibilities and operating procedures of the CCX governance structure.

Pre-launch preparation of the market will entail official enrollment of participating emission sources, activation of the Registry, and placing emission allowances in the accounts of participants. Launch of the market will require initiation of the emission monitoring and reporting procedures, accepting applications from offset projects, and activation of the electronic trading mechanism.

Operation of the market during the first year will include execution of the first auction, acceptance of quarterly emission monitoring reports, issuance first-year offsets based on independent verification reports, and the compliance "true-up" subsequent to year end. A process for expanding the market will be established in order to allow for orderly growth of participation.

Appendix A

Entities that have given early indication of their intent to participate in the CCX market design process

DuPont: DuPont is a manufacturer of diverse products that deliver science-based solutions that make a difference in people's lives in food and nutrition; health care; apparel; home and construction; electronics; and transportation. Founded in 1802, the company operates in 70 countries and has 93,000 employees. DuPont's stated core values reflect a commitment to safety, health and the environment; integrity and high ethical standards; and treating people with fairness and respect.

Ford Motor Company: Ford Motor Company is one of the world's largest automobile manufacturers and marketers. Its brands include Ford, Mercury, Lincoln, Volvo, Jaguar, Land Rover, Aston Martin and TH!NK. The Company and its subsidiaries also engage in other businesses, including financing and renting vehicles and equipment. Hertz Corp., a Ford subsidiary, operates a car rental business, as well as an industrial and construction equipment rental business. Ford's philosophy is that its operations, products and services should accomplish their functions in a manner that takes responsibility for protection of health and the environment.

Alliant Energy: Alliant Energy Corporation is a growing energy-service provider with both domestic and international operations. Headquartered in Madison, WI, Alliant Energy provides electric, natural gas, water and steam services to more than two million customers worldwide. Alliant Energy Resources Inc., the home of the company's non-regulated businesses, has operations and investments throughout the United States, as well as Australia, Brazil, China, Mexico and New Zealand.

Cinergy Corp.: Based in Cincinnati, Ohio, Cinergy Corp. is one of the leading diversified energy companies in the U.S. Its largest operating companies, The Cincinnati Gas & Electric Company (Ohio), Union Light, Heat & Power (Kentucky), Lawrenceburg Gas (Indiana), and PSI Energy, Inc. (Indiana), serve more than 1.5 million electric customers and 500,000 gas customers located in a 25,000-square-mile service territory encompassing portions of Indiana, Ohio and Kentucky. The interconnections of Cinergy's Midwestern transmission assets give it access to 37 percent of the total U.S. energy consumption.

Calpine: Headquartered in San Jose, CA, Calpine has an energy portfolio comprised of 50 energy centers, with net ownership capacity of 5,900 megawatts. Located in key power markets throughout the United States, these centers produce enough energy to meet the electrical needs of close to six million households. Calpine was ranked 25th among FORTUNE magazine's 100 fastest growing companies and it was recently ranked by Business Week as the 3rd best performing stock in the S&P 500.

Energy company "X" (for the time being this company wishes to not make public its intent to participate in CCX): With regional offices from coast to coast, this company is one of the nation's leading competitive power producers, has natural gas facilities that connect major producing regions to some of the fastest-growing markets in North America, and operates one of the top energy trading businesses in the country.

Swiss Re New Markets: Swiss Re is one of the world's largest reinsurance firms. It also owns primary insurance companies in numerous companies. Swiss Re New Markets brings together Swiss Re Group's expertise in alternative risk transfer and

risk financing. Swiss Re New Markets staff includes more than 550 professionals from investment banking, corporate finance, insurance and reinsurance. From locations in Zurich, New York and London, these specialists combine capital market instruments with finite and conventional reinsurance to produce integrated risk management and financial management solutions for large corporations and insurers.

Growmark: The GROWMARK System is a federated farmer cooperative network based out of Bloomington, IL. GROWMARK holds ownership in five interregional farmer cooperatives to ensure a stable and competitive supply of agricultural raw materials, needed services, and research.

Agriliance: Agriliance is a partnership of agricultural producer-owners, local cooperatives and regional cooperatives. Agriliance offers crop nutrients, crop protection products, seeds, information management, and crop technical services to producers and ranchers in all 50 states as well as Canada and Mexico. They have sales and marketing offices in St. Paul, Minn., and Kansas City, Mo. Agriliance, LLC was formed on February 3, 2000, as an agronomy marketing joint venture between Cenex Harvest States Cooperatives, Farmland Industries, Inc. and Land O'Lakes, Inc.

IGF Insurance Company: IGF Insurance Company is the fifth-largest crop insurance company. IGF serves businesses in 48 states and maintains eight service offices nationwide. IGF prides itself in developing niche products for farmers' risk management needs.

Iowa Farm Bureau Federation: Farm Bureau is an independent, nongovernmental, voluntary organization of farm and ranch families united with the freedom to analyze their problems and formulate action to achieve educational improvement, economic opportunity, and social advancement and, thereby, to promote the national well-being. Farm Bureau is local, statewide, national and international in its scope and influence and is nonpartisan, nonsectarian and nonsecret in character.

National Council of Farmer Cooperatives: NCFC's mission is to protect the public policy environment in which farmer-owned cooperative businesses operate, promote their economic well-being, and provide leadership in cooperative education. NCFC remains the only organization serving exclusively as the national representative and advocate for America's farmer-owned cooperative businesses.

ZAPCO: Zahren Alternative Power Corporation (ZAPCO) is among the largest and most respected developers of Landfill Gas (LFG) projects in the United States. Through predecessor subsidiaries and affiliates, including the former Energy Tactics, Inc., ZAPCO has been engaged, since 1981, in the development, financing, and operation of a large and diverse group of LFG-based projects, including waste-to-energy electricity systems.

Appendix B

Biographies of the Advisory Board

David Boren, has been President of The University of Oklahoma since 1994. Under Mr. Boren's leadership, the University has emerged as a recognized "pacesetter in American public higher education," with twenty major new programs initiated in the Arts, Honors College, International Programs and innovative programs to enhance faculty-student relations. Mr. Boren formerly served as a three-term U.S. Senator, where he was Chairman of the Senate Select Committee on Intelligence and a member of the Agriculture Committee. Mr. Boren, a Rhodes scholar, served as a member of the Yale University Board of Directors from 1988 to 1997. Prior to becoming Senator, Mr. Boren served as Governor of Oklahoma and in the state legislature.

Ernst Brugger is Founding Partner and Chairman of Brugger Hanser & Partner Ltd. in Switzerland, a business consulting firm with international experience and range. He is also a professor at the University of Zurich, chairman and member of the board of various companies and a member of the International Committee of the Red Cross (ICRC). Dr. Brugger serves as Chairman of the Board of Directors of Sustainable Performance Group, an investment and risk management company which invests in pioneering and leading companies which have taken up the cause of sustainable business

Jeffrey E. Garten is Dean of the Yale School of Management. Formerly Garten served as undersecretary of commerce for international trade in the first Clinton Administration. He also held senior economic posts in the Ford and Carter administrations. From 1979–1992 he was a managing director first at Lehman Brothers, where he oversaw the firm's Asian investment banking activities from Tokyo, and then at the Blackstone Group. Currently Dr. Garten writes a monthly columnist for Business Week. His latest book is "The Mind of the CEO" (2001).

Donald P. Jacobs is Dean of the Kellogg Graduate School of Management and its Gaylord Freeman Distinguished Professor of Banking. Under his leadership, the

Kellogg School has become a leader in the field of business and finance and is consistently ranked as one of the top five business schools in the United States. Dean Jacobs is a former Chairman of the Board of Amtrak (1975–1979) and currently serves on several corporate boards. His work on banking, corporate governance and international finance has been published in many scholarly journals and he holds several honorary degrees and professional awards.

Dennis Jennings is the Global Risk Management Solutions Leader for PricewaterhouseCoopers' (PwC) Global Energy and Mining Industry Practice. Mr. Jennings previously served as the Dallas/Fort Worth Energy Industry Market Leader; Co-Chairman of the U.S. Oil and Gas Industry Program; and on Steering Committee of the International Energy Practice. His responsibilities have included leading PwC's global risk management practice for the energy and mining industry, providing financial advice and performing due diligence reviews on numerous merger, acquisitions and divestiture efforts by major international corporations.

Joseph P. Kennedy II is Chairman and President of Boston-based Citizens Energy Group. Before returning to Citizens Energy, Mr. Kennedy represented the 8th Congressional District of Massachusetts in the U.S. House of Representatives for 12 years. Mr. Kennedy founded the non-profit company in 1979 to provide low-cost heating oil to the poor and elderly. Under his leadership, Citizens grew to encompass seven separate companies, including the largest energy conservation firm in the U.S. Mr. Kennedy also advises and serves on the boards of several companies in the energy, telecommunications, and health care industries. Mr. Kennedy is the son of the late U.S. Sen. Robert F. Kennedy.

Israel Klabin is the president of the Brazilian Foundation for Sustainable Development, a major Brazilian non-governmental organization devoted to issues of environmental and sustainable development policy. Mr. Klabin is the former chairman of Klabin SA, one of the largest forestry companies in Latin America. He is a former mayor of Rio de Janeiro and was one of the main Brazilian organizers of the United Nations Conference on the Environment (Rio 92). He is also actively involved in several philanthropical activities.

Bill Kurtis has had a distinguished career in broadcasting for over 30 years, as a news anchor in Chicago and later of the national *CBS Morning News.* He started his own company, Kurtis Productions, when he returned to Chicago in the mid 1980's and currently hosts shows on the Arts and Entertainment network. Mr. Kurtis is involved in The National Science Explorers Program, Electronic Field Trips and the Electronic Long Distance Learning Network, all aimed at teaching children about science. Mr. Kurtis and his shows have been the recipients of several awards. He serves on the board of directors of organizations devoted to natural history and the environment, including the National Park Foundation, the Nature Conservancy and the Kansas State Historical Society.

Thomas E. Lovejoy, is a world-renowned tropical and conservation biologist. Dr. Lovejoy is generally credited with having brought the tropical forest problem to the fore as a public issue. In 1987, he was appointed Assistant Secretary for Environmental and External Affairs for the Smithsonian Institution and is Counselor to the Smithsonian's Secretary for Biodiversity and Environmental Affairs. Dr. Lovejoy is also Chief Biodiversity Advisor to the President of the World Bank. From 1989 to 1992, he served on the President's Council of Advisors in Science and Technology (PCAST), and acted as scientific adviser to the Executive Director of the United Nations Environment Programme (1994–97). He was the World Wildlife Fund's Executive Vice President from 1985 to 1987. Dr. Lovejoy is the author of numerous articles and books.

David Moran is vice president of ventures for the Electronic Publishing group of Dow Jones & Company and president of Dow Jones Indexes. Mr. Moran is also President of Dow Jones Indexes, which includes all Dow Jones indexes for countries, regions, sectors and industry groups as well as the world index. He is also chairman of Dow Jones Sustainability Group Index GmbH. Prior to joining Dow Jones, Mr. Moran was an associate with Patterson, Belknap, Webb & Tyler, a New York City law firm, from 1979 to 1985.

Les Rosenthal is a former Chairman of the Chicago Board of Trade (CBOT) and a principal of Rosenthal Collins, a leading Chicago-based commodities and futures trading firm. During his time as member of the Board and Chairman of the CBOT, Mr. Rosenthal was instrumental in advancing the cause of new and innovative exchange-traded products such as Treasury Bond futures and insurance derivatives.

Maurice Strong is a former Secretary General of the 1992 United Nations Conference on Environment and Development (the Rio Earth Summit) and Under-Secretary General of the United Nations. He is currently the Chairman of the Earth Council, a non-governmental organization dedicated to the cause of sustainable development. In June of 1995, he was named Senior Advisor to the President of the

World Bank. From December 1992 until December 1995, Mr. Strong was Chairman and Chief Executive Officer of Ontario Hydro, one of North America's largest utilities. Mr. Strong is an advisor to the United Nations, and has been a director and/or officer of a number of Canadian, U.S. and international corporations.

James R. Thompson is a former four-term Governor of Illinois and currently a managing partner of Winston and Strawn. During his last term as Governor, Mr. Thompson was involved in the implementation of the sulfur dioxide (SO_2) market created by the 1990 Clean Air Act. During his last term as Governor he was the Head of the Global Climate Change Task Force at the National Governors' Association (1988–1989). Governor Thompson is also a director of the Chicago Board of Trade (CBOT).

Brian Williamson is the Chairman of the London International Financial Futures and Options Exchange (LIFFE), one of the world's largest exchanges. Mr. Williamson has been involved in trading financial futures for almost three decades in London, New York and Chicago. He held senior executive positions for prominent trading firms and was a member of the International Advisory Board of the Nasdaq Stock Market, becoming Chairman in 1996. He was also Governor-at-Large of the National Association of Securities Dealers in Washington DC. (1995–1998).

Corporate giants to aid design of US carbon market

Dr. Richard L. Sandor

Environmental Finance—June 2001

As the US enters a major debate on energy use and endeavours to develop a policy to reduce carbon dioxide (CO_2) emissions, a project taking shape in the upper Midwest is poised to test market-based solutions to global warming.

The size, diversity, and volume of emissions (1.375 billion tons of CO_2 per year) from this region—Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio and Wisconsin—make it well-suited as a starting point for a robust and representative greenhouse gas (GHG) emissions trading market expandable to include all of North America. The region's economic output of $2 trillion is equal to that of the UK and the Netherlands combined. A diverse group of major firms has indicated their intent to participate in the design phase of a voluntary pilot trading market for the region, the Chicago Climate Exchange (CCX—see Table 1).

1. Companies participating in the design phase of the CCX

Agriliance	National Council of Farmer Cooperatives
Alliant Energy	NiSource
Calpine	ORMAT
Carr Futures/Crédit Agricole Indosuez	Pinnacle West Capital
Cinergy	PG&E National Energy Group
DuPont	STMicroelectronics
Ford Motor Company	Suncor Energy
GROWMARK	Swiss Re
IGF Insurance	Temple-Inland
International Paper	The Nature Conservancy
Iowa Farm Bureau Federation	Wisconsin Energy
IT Group	ZAPCO
Midwest Generation	

A study of such a market suggests a goal of reducing participants' GHG emissions by 5% below 1999 levels over five years. The feasibility study for the CCX was funded by the Chicago-based Joyce Foundation through a special Millennium Initiative grant to the Kellogg Graduate School of Management at Northwestern University. According to Joyce Foundation president Paula DiPerna, "the CCX would represent a major step forward while an appropriate regulatory framework for greenhouse gases evolves. A regional success on a global challenge like climate change could be transformational. Because of its variety of economic activities, including its strong agricultural sector, the Midwest is the perfect place to begin demonstrating the regional-global interface."

Trading will help reduce GHG emissions cost-effectively and offer new opportunities for environment-based income for farmers, foresters and renewable energy firms.

A high-level advisory board consisting of academic, business, environmental and public sector leaders has been formed with the objective of gathering strategic input (see Table 2).

2. Advisory board members

David Boren	President of The University of Oklahoma; former US Senator and Governor of Oklahoma
Ernst Brugger	Founding Partner and Chairman of Brugger Hanser & Partners
Jeffrey E. Garten	Dean of Yale School of Management
Lucien Y. Bronicki	Chairman of ORMAT International
Donald P. Jacobs	Dean, Kellogg Graduate School of Management, Northwestern University
Dennis Jennings	Global Risk Management Solutions Leader, PricewaterhouseCoopers
Jonathan Lash	President, World Resources Institute
Joseph P. Kennedy II	Chairman and President of Boston-based Citizens Energy Group; former US Congressman
Israel Klabin	President of the Brazilian Foundation for Sustainable Development
Bill Kurtis	National broadcaster, host of Arts& Entertainment cable TV show
Thomas E. Lovejoy	Chief Biodiversity Advisor to the President of the World Bank
David Moran	President of Dow Jones Indexes
Les Rosenthal	Former Chairman, Chicago Board of Trade; principal, Rosenthal Collins
Maurice Strong	Chairman of the Earth Council, former UN Under-Secretary General
James R. Thompson	Former four-term Gov. of Illinois
Brian Williamson	Chairman, London International Financial Futures and Options Exchange (LIFFE)

The notion of trading carbon emissions has long been debated, but the proposed CCX offers the first test of the concept on a scale that has global potential.

As proposed, the exchange could:

- demonstrate that GHG emissions trading can achieve real reductions in emissions across multiple business sectors;
- help discover the price of reducing GHG emissions; and
- develop the frameworks, for monitoring emissions, determining offsets and conducting trades, needed for a successful market.

The study proposes starting the market in the seven Midwest states, including emission offset projects in Brazil, and expanding overtime to include all of the US, Canada and Mexico. Participating companies would be issued tradable emission allowances. Emitting firms would commit to a phased schedule for reducing their emissions by 5% by 2005.They could then either cut their emissions directly, buy allowances from companies that have achieved surplus reductions, or buy credits from agricultural or other offset projects. Potential offset projects would include renewable energy systems and the capture and use of agricultural and landfill methane. Offsets could also be generated by carbon sequestration projects such as forest expansion and conservation soil management, which remove CO_2 from the atmosphere (see Table 3).

3. Proposed market architecture for the Chicago Climate Exchange

Geographic coverage	2002: emission sources and projects in seven Midwest states; 2003–05: emission sources and projects in US, Canada and Mexico; Offsets also accepted from projects in Brazil for both periods.
Greenhouse gases covered	Carbon dioxide, methane and all other targeted GHGs
Emission reduction targets	2002: 2% below 1999 levels, falling 1% per year through 2005
Industries and firms targeted	Primarily "downstream" participants: power plants, refineries, factories, forestry, vehicle fleets; 40 firms initially targeted. Individual entities or co-operating groups of entities must have emissions exceeding 250,000 tons CO_2e in 1999 to become a participating emission source.
Tradable instruments	Fully interchangeable emission allowances (original issue) and offsets produced by targeted mitigation projects
Eligible offset projects	A. Carbon sequestration in forests and domestic soils; B. Renewable energy systems; C. Methane destruction in agriculture, landfills and coalbeds Offsets must be aggregated into pools of 100,000 tons CO_2e per year; Projects placed into service after 1 January 1999 can qualify.
Emissions/project monitoring	Direct measurement (eg CEMs); fuel flows/emission factors; carbon sequestration: standard tables, case-specific estimates, direct measurement.
Provisions for new facilities	Allowance allocations reflect best technology emission rates
Annual public auctions	2% of issued allowances withheld and auctioned in "spot" and "forward" auctions, proceeds returned pro rata
Central registry	Central database to record and transfer allowances and offsets; interfaces with emissions database and trading platform
Trading mechanisms	Standardised CCX Electronic Market, private contracting
Trade documentation	Uniform documentation provided to facilitate trade
Accounting and tax issues	Accounting guidance suggested by generally accepted accounting principles; precedent exists for US tax treatment
Market governance	Self-governing structure to oversee rules, monitoring and trade

The commitment from the advisory committee and the participating companies is to be commended. Their input in the design phase will help formulate the final rules and procedures for the CCX and determine if this regional programme can shape the beginning of a global solution to climate change.

Richard Sandor is chief executive of Environmental Financial Products. He would like to thank Dr. Michael Walsh, Alice LeBlanc, Rafael Marques, and Scott Baron for their invaluable support and intellectual contributions to this feasibility study. With special thanks to the Joyce Foundation and Paula DiPerna, Margaret O'Dell, Mary O'Connell and James Seidita for making all this possible.

The case for coal

Dr. Richard L. Sandor

Environmental Finance—March 2001

Discussions of coal as a viable energy source of the future usually end with cries of concern about its environmental impact. However, these discussions take a different tack when a generating company of the 21st century considers the many factors that affect the cost of producing power. These include the choice of fuel, changes

in technology that alter emissions, and the costs of offsetting carbon dioxide (CO_2), sulphur dioxide (SO_2) and other pollutants. Those in the power business who make informed investment decisions and are environmentally concerned should question the premise that, under all conditions, coal is dead.

Many have long considered coal the least desirable fossil fuel because of its environmental impact. It causes acid rain and contributes to global warming. Some concluded that nothing could improve its status. Then came the US Clean Air Act Amendments of 1990. Emissions trading and the economic viability of low sulphur coal, sulphur scrubbing, and nitrogen oxide (NO_X) controls have altered the belief that the only way to eliminate acid rain is to reject coal as an energy source. But this offered only a temporary respite in the belief that coal was dead. Low gas prices bolstered the argument that there was a clean and cost-effective alternative to coal.

After an extended bull market in gas prices, however, and an energy crisis in California, things are changing. Power plant investment decisions are far more complex today and must account for the costs associated with environmental compliance.

Under what conditions might coal-fired generation remain attractive in the face of strict environmental constraints? To answer this question, we examined the economics of new power plant construction in a manner that creates a special new class of hypothetical power plants: the emission-neutral plant. We assume a new power plant must fully offset its emissions of SO_2, NO_X and CO_2 via assumed cap-and-trade systems. Analysis of the emission-neutral plant reveals some interesting and surprising conclusions about fuel choice and environmental costs.

For example, assume a utility must choose among the following alternative investments for a new power plant: coal; gas combined cycle (CC); gas combustion turbine (CT); wind; and solar. Assume the features of each plant reflect the most efficient and clean technologies that are commercially available.[1] The coal and CC plants are run as baseload units (i.e. they produce 85% and 80% of potential annual production, respectively). The GT plant runs at peak demand with a low capacity factor (15%). The wind and solar plants are smaller in capacity and are assumed to operate at 30% of capacity.

We assume a natural gas cost of $4.00/million BTU and a coal cost of $1.21/million BTU, (today's prices). Table 1 presents the assumed prices for emission allowances.

Table 1. Environmental compliance cost ($/ton)

Commodity	Price
CO_2	$5, $10
SO_2	$160
NO_X	$1,500

SO_2 and NO_X figures reflect market prices. CO_2 price based on projections and early trading experience

The emission rates for each plant type (presented in Table 2) reflect a coal plant that uses low-NO_X burners and selective catalytic reduction technologies to control NO_X (and mercury), and has wet limestone SO_2 scrubbing (95% effectiveness). The CC gas plant also uses low-NO_X burners and selective catalytic reduction technologies to control NO_X while the CT plant uses steam injection.

[1] *Analyzing Electric Power Generation under the CAAA,* Office of Air and Radiation; US EPA, March 1998

Table 2. Emission rates of newly built power plants (lbs/MMBtu)

Plant type	CO_2	SO_2	NO_X
Coal	207	0.08	0.1
Gas	117	0	0.024
Wind/solar	0	0	0

Source: Clean Coal Technology Compendium, EPA, DOE

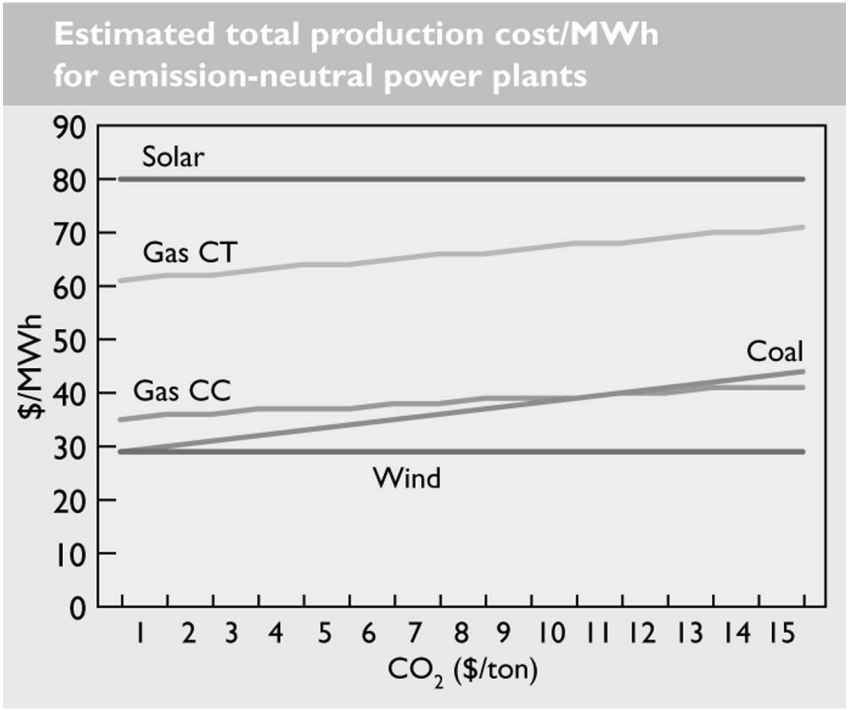
Table 3 presents the capital and operating/maintenance costs reported in the March 1998 EPA study cited in footnote 1. Capital costs are spread evenly over 20 years. The fifth column shows the total cost per megawatt hour of electricity produced by each emission neutral plant assuming a CO_2 price of $5/ton. The last three columns indicate which plant type can produce power at the lowest cost for various CO_2 prices (including $0/ton).

Table 3. Cost estimates for emission-neutral power plants ($/MWh)

Plant type	Levelised capital cost: over 20 yrs ($/Mwh)	O&M costs (variable and fixed) ($/Mwh)	Total fuel price ($/Mwh)*	Total cost† ($/Mwh) ($CO_2$ = $5)	Rank 1 (CO_2 = $0)	Rank 2 (CO_2 = $5)	Rank 3‡ (CO_2 = $10)
Wind (50MW)	19	10	—	29	2	1	1
Coal (400MW)	9	7	11	34	1	2	2
Gas CC (400MW)	4	4	27	37	3	3	2
Gas CT (80MW)	14	2	44	64	4	4	3
Solar (5MW)	77	3	—	80	5	5	4

*Coal price = $1.21/million BTU (about $25/short ton), gas price = $4/million BTU.
†Includes CO_2, SO_2, NO_X costs (see table 2).
‡The costs for operating a coal unit and a CC are approximately equal at $10/ton CO_2.

The chart shows power generation costs ($/MWh) for each of the five plant types for various CO_2 prices, assuming gas prices of $4.00/million BTU. Under our fuel price assumptions, total production costs at an emission-neutral coal-fired plant are below those of a CC gas plant when CO_2 prices are below $10/ton.



In another scenario we find that a $5.00 gas price makes a new emission-neutral coal plant less costly than a CC gas plant if CO_2 prices are below $21. Conversely, a $3.00 gas price would make a CC gas plant the cheapest option. Naturally, volatility of gas prices increases the riskiness of gas plants.

In the hypothetical scenario of emission neutrality for new fossil-fuelled power plants, wind-power is the least-cost option. But, while new technologies are making wind power cost-competitive, even without comprehensive emission offset requirements for fossil plants, it may not be feasible to meet demand growth exclusively with wind facilities. Their production is inherently variable and they are not feasible in all locations. At the best sites, however, wind plants can be expected to achieve a capacity factor of over 30%, which reduces the cost per hour of generation.[2]

In essence, power generators in the 21st century face indifference curves when choosing to build new power plants. Various combinations of fuel prices, emissions prices (and rules) and technologies will yield identical costs of production. A clean-burning gas plant facing high gas prices may have no cost advantage over a coal plant that faces low fuel costs but high environmental costs. Fully-offset coal plants can be the least-cost option in locations such as the western US (eg Montana) where power plants can be built right on top of abundant coal reserves.

New coal-fired plants are a viable option under some circumstances, even when their emissions are fully offset. It is also clear that the choice among alternative plant types is quite complex. For example, our model assumes technology is constant and does not include emissions associated with coal extraction.

With US public policy encouraging reliance on domestic energy and sophisticated private sector investment decisions, we may see more coal-fired power plants in the near future.

Richard Sandor is chairman and chief executive of Environmental Financial Products.

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[2] American Wind Energy Association

Native Americans sell carbon credits from forestry project

David Robson

Sustainable Forestry Management (SFM), a London-based company which invests in forestry projects with environmental and social benefits, has agreed to buy greenhouse gas (GHG) emission reductions equivalent to almost 48,000 tons of carbon dioxide from native Americans in Montana.

SFM is paying the Confederated Salish and Kootenai tribes an undisclosed amount to reforest 100 hectares of their Montana reservation that was hit by forest fires in 1994. In return, the tribes have undertaken to maintain the forest for 100 years and to pass on the associated GHG offsets or 'carbon credits' to SFM for 80 years, explains Michael Walsh, senior vice-president of Chicago-based Environmental Financial Products, which arranged the deal.

The transaction was co-ordinated by the Montana Offset Coalition, an organization which is helping farmers and foresters participate in the emerging carbon markets.

The quantity of GHG offsets is based on conservative growth assumptions, says Walsh, and the deal will also help improve soil quality while providing a revenue stream for local communities, notes SFM.

"This first project will set the stage for a process that will help fund chronically underfunded tribal reforestation projects throughout the west and start the ball rolling on market-based solutions to global warming," says Tom Corse, supervisory forester for the Confederated Salish and Kootenai tribes.

U.S. Landfill Concern, Ontario Utility Agree to Swap Gas-Emission Rights

Peter A. McKay

Staff Reporter of The Wall Street Journal—October 26, 1999

An American landfill company and a Canadian power-generation concern will announce today what experts describe as the largest exchange to date of rights to emit ozone-depleting gases.

Such rights are effectively off-exchange pollution futures.

Officials from both sides said Ontario Power Generation Inc. has bought from Zahren Alternative Power Corp. the rights to emit 2.5 million tons of carbon dioxide—roughly the equivalent released by 550,000 cars in one year.

An adviser to the deal said the total value was less than $25 million—a per-ton rate well below that charged in previous emissions-rights sales.

The deal was structured as a private exchange because it comes before a global treaty is in place for governments to formally recognize such international emissions deals. The companies and their advisers said that in part they wanted to set a precedent for the fledgling "greenhouse-gas" trade, hoping it would demonstrate the need for little regulation to require industry to combat global warming.

"We're hoping this will jump-start the thinking on how to initiate a more formalized process," said Bernie Zahren, president and chief executive of the Avon, Conn., company that bears his name.

Mr. Zahren's firm removes methane gas from landfills, mostly in the Northeast U.S. He said that in the deal, Ontario Power essentially bought the right to 119,000 tons of that methane in exchange for 2.5 million tons of carbon dioxide. That compound is the international standard for measuring reductions of greenhouse gases that many scientists believe contribute to global warming.

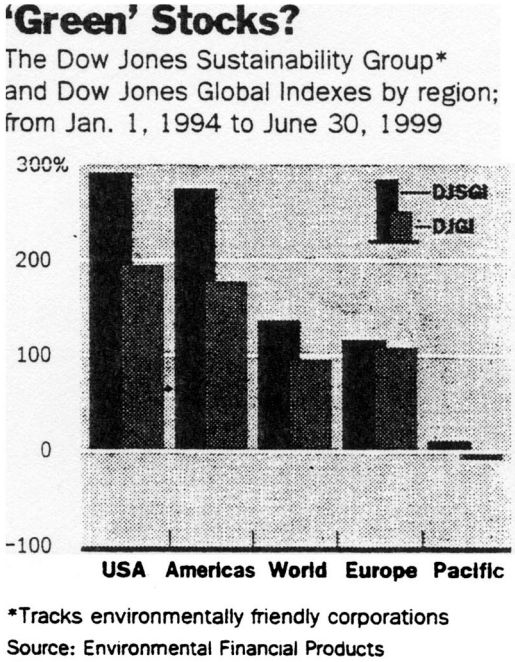
The actual emissions cuts will be reviewed by PricewaterhouseCoopers LLP, said Richard Sandor, chairman of Environmental Financial Products, a Chicago consulting firm that advised both sides.

The deal comes at least nine years ahead of a timetable set by the Kyoto Protocol, a treaty named for the Japanese city where it was negotiated, which will require 37 industrialized nations to reduce greenhouse-gas emissions beginning in 2008.

The treaty hasn't been ratified by the U.S. Senate, nor has it approved a separate congressional bill that would give credit to companies that reduce emissions ahead of schedule, said Andrew Hoffman, a Boston University professor who has studied the trading of emissions credits.

"What you've got here is basically a demonstration product," Mr. Hoffman said. "There are some big questions in creating a global trading system, and this deal seems to be orchestrated to address a lot of them."

That is exactly what Mr. Sandor said he intended the deal to do. A former vice chairman of the Chicago Board of Trade, he said he hopes to establish an exchange-traded market for carbon-dioxide credits similar to one that exists for sulfur dioxide, which is blamed for acid rain.



He estimated that market is valued at about $3 billion.

"We have a whole new avenue that's being opened to us as air and water become scarcer," Mr. Sandor said. "Essentially we have to ration them, or the planet's going to be one big barbecue. And the best way to do that is through the free market, not the government dictating where all the emissions are going to be."

Mr. Hoffman, however, said developing countries could be left behind in such a scenario, because their businesses and governments are less accustomed to U.S.-style financial products such as the emissions derivatives Mr. Sandor envisions.

"Ever since Kyoto, developing countries have been worrying that America and other big countries will just buy their way out of the limitations," Mr. Hoffman said. "If they have to go through a period of adjustment just to figure out how to trade the credits, maybe that would mean being left behind."

Greenhouse Gas Emissions Trading Market Emerges in Chicago

Environment News Service

CHICAGO, Illinois, May 30, 2001 (ENS)—The world's first emissions trading market for greenhouse gases is materializing in Chicago. A diverse group of 25 large corporations and nonprofit organizations has agreed to participate in the design phase of a voluntary pilot trading market, the Chicago Climate Exchange.

The project is spearheaded by Dr. Richard Sandor, CEO of Chicago based *Environmental Financial Products,* who is known for developing innovative commodity and environmental markets and has designed revolutionary market mechanisms for environmental protection programs.

Sandor said today that the results of a feasibility study he conducted to test interest in the *Chicago Climate Exchange* show that a voluntary pilot market starting in seven midwestern states, "is feasible and can be expanded over time."

"The widespread corporate interest in preparing rules and regulations for this voluntary market affirms the private sector's demand for flexible, market based mechanisms to address climate change," Sandor said.

Sandor is a visiting scholar at the Kellogg Graduate School of Management at Northwestern University. The feasibility study was funded by the Chicago based *Joyce Foundation* through a $347,000 Millennium Initiative grant.

The idea of trading carbon emissions has been debated for at least a decade, but the proposed Chicago Climate Exchange offers the first test of the concept on a scale that has global potential.

The Midwest is a promising location for starting the market because of its 20 percent share of the U.S. economy and greenhouse gas emissions, its mix of manufacturing, transport, energy, agriculture and forestry sectors, and its extensive international linkages.

Dr. Sandor's study suggests a goal of reducing participants' emissions of six greenhouse gases, including carbon dioxide, by five percent below 1999 levels over five years. These emissions, created by the combustion of coal, oil and gas, are linked by most scientists to climate change.

This market based approach may be particularly attractive to U.S. corporations after President George W. Bush announced in March that U.S. would not participate in the international agreement governing the emission of these six greenhouse gases known as the Kyoto Protocol.

"Most of the actions needed to begin reducing the risk of climate change will have to be undertaken by the private sector, so a market developed by a private association can be an important part of the overall solution," said Sandor.

Trading would help reduce greenhouse emissions in a cost effective manner and offers new opportunities for environment based income for farmers, foresters and renewable energy firms.

As proposed, the Chicago Climate Exchange could demonstrate that greenhouse gas trading can achieve real reductions in emissions across different business sectors. It could help discover the price of reducing greenhouse gases.

It would develop the standard frameworks for monitoring emissions, determining offsets and conducting trades needed for a successful market.

Sandor's study proposes starting the market in seven Midwest states—Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio and Wisconsin—including emission offset projects in Brazil, and expanding over time.

Participating companies would be issued tradable emission allowances. Emitting firms would commit to a phased schedule for reducing their emissions five percent by 2005.

They could then either directly cut their emissions, or buy allowances from companies that have achieved surplus reductions. Or the market traders could buy credits from agricultural or other projects that produce power without emissions or offset greenhouse gases by holding them out of the atmosphere.

Potential offset projects include renewable energy systems, such as wind and solar power, and capture and use of agricultural and landfill methane. Offsets can also be generated by carbon sequestration projects such as forest expansion and conservation soil management, which remove carbon dioxide from the atmosphere.

Twenty-five companies and non-profits have agreed to participate in the market design phase, including manufacturers, electric utilties, agricultural cooperatives, and conservation groups.

The participants include Ford, DuPont, Suncor Energy, The Nature Conservancy, STMicroelectronics, Temple-Inland, International Paper, the Iowa Farm Bureau Federation, Alliant Energy, Calpine, Cinergy, NiSource, PG&E National Energy Group, Wisconsin Energy, ZAPCO, Agriliance and GROWMARK. (A complete list can be found below.)

An advisory board consisting of academic, business, environmental and public sector leaders has been formed with the objective of gathering strategic input.

Board members include Maurice Strong, former under-secretary general of the United Nations who led the 1992 Earth Summit in Rio de Janeiro; James Thompson, a former four term governor of Illinois; Jonathan Lash, president of the World Resources Institute, a non-profit research organization based in Washington, DC; Joseph P. Kennedy II, chairman and president of the Boston based Citizens Energy Group; Dr. Thomas Lovejoy, a world renowned tropical and conservation biologist, and Israel Klabin, president of the non-governmental Brazilian Foundation for Sustainable Development. (A complete list is given below.)

"The Chicago Climate Exchange would represent a major step forward while an appropriate regulatory framework for greenhouse gases evolves," said Joyce Foundation president Paula DiPerna. "A regional success on a global challenge like climate change could be transformational. Because of its variety of economic activities, including its strong agricultural sector, the Midwest is the perfect place to begin demonstrating the regional-global interface."

The Joyce Foundation has a tradition of catalyzing new ideas, said DiPerna, who acted as vice president of international affairs for the late oceanographer and conservationist Jacques Cousteau.

DiPerna says Dr. Sandor's interest in the trading approach to environmental problems is what attracted the support of the Joyce Foundation.

"He, being a trader par excellence, said we have to discover the price at which greenhouse gas emissions credits will trade," DiPerna told ENS. "The way to do that is to try it and see. We never know if it will work until we try. Now that we know we have enough players in the game, the game will start as early as next year."

The Joyce Foundation is now considering a request to be involved in the second phase of the Chicago Climate Exchange—the phase that would launch the trading.

DiPerna and Sandor believe that a representative carbon trading market can yield lessons that may be relevant for economies worldwide for the next century.

"The beauty of this emissions trading mechanism is that it's both practical and philosophical," DiPerna said. "We must solve the problem in a practical manner and retain the philosophical value that motivates us all."

Companies Participating in the Design Phase of the Chicago Climate Exchange

Agriliance: Agriliance is a partnership of agricultural producer-owners, local cooperatives and regional cooperatives. Agriliance offers crop nutrients, crop protection products, seeds, information management, and crop technical services to producers and ranchers in all 50 states as well as Canada and Mexico.

Alliant Energy: Alliant Energy Corporation is a growing energy service provider with both domestic and international operations. Headquartered in Madison, Wisconsin, Alliant Energy provides electric, natural gas, water and steam services to more than two million customers worldwide. Alliant Energy Resources Inc., the home of the company's non-regulated businesses, has operations and investments in the United States, Australia, Brazil, China, Mexico and New Zealand.

Calpine: Headquartered in San Jose, California, Calpine has an energy portfolio comprised of 50 energy centers, with net ownership capacity of 5,900 megawatts, enough energy to meet the electrical needs of close to six million households. Calpine was ranked 25th among "Fortune" magazine's 100 fastest growing companies and it was recently ranked by "Business Week" as the 3rd best performing stock in the S&P 500.

Carr Futures/Crédit Agricole Indosuez: Carr Futures, a subsidiary of Crédit Agricole Indosuez, is a global institutional brokerage firm headquartered in Chicago. Carr holds memberships on all major futures and equity markets worldwide, and consistently ranks among the largest futures brokerage firms in the world.

Cinergy Corporation: Based in Cincinnati, Ohio, Cinergy is a diversified energy company. Its largest operating companies, The Cincinnati Gas & Electric Company of Ohio, Union Light, Heat & Power of Kentucky, Lawrenceburg Gas of Indiana, and PSI Energy, Inc. of Indiana, serve more than 1.5 million electric customers and 500,000 gas customers. The interconnections of Cinergy's Midwestern transmission assets give it access to 37 percent of the total U.S. energy consumption.

DuPont: DuPont is a science company, delivering science based solutions in the areas of food and nutrition, health care, apparel, home and construction, electronics, and transportation. Founded in 1802, the company operates in 70 countries and has 93,000 employees.

Ford Motor Company: Ford is the world's second largest automotive company. Its Automotive operations include: Ford, Mercury and TH!NK brands; wholly owned subsidiaries Volvo, Jaguar, Aston Martin and Land Rover; Mazda (33 percent ownership); and Quality Care and Kwik-Fit. Ford Financial Services, providing automotive financing and other services, and The Hertz Corporation, providing car rental services, are the other major components of Ford Motor Company.

GROWMARK, Inc.: GROWMARK, headquartered in Bloomington, Illinois, is a federated regional cooperative that provides agriculture related products and services in Illinois, Iowa, Wisconsin and Ontario, Canada. FS brand farm supplies and services are marketed to farmers in these areas by nearly 100 GROWMARK member cooperatives.

IGF Insurance Company: IGF is the fifth largest crop insurance company serving farmers in 46 states from eight service offices nationwide. IGF develops niche products for farmers' risk management needs.

International Paper: With over 12 million acres of land managed in the United States alone, International Paper is one of the world's largest private landowners. International IP has global businesses in paper and paper distribution, packaging, building materials and other forest products.

Iowa Farm Bureau Federation: The Iowa Farm Bureau is a federation of 100 county Farm Bureaus in Iowa. Founded in 1918, it now takes in more than 154,000 member families. Legislative, educational and service programs are provided to help farm families prosper and improve their quality of life. An independent, non-govern-

mental organization, the federation is local, statewide, national and international in scope and is nonpartisan, nonsectarian and nonsecret in character.

IT Group, Inc.: The IT Group is a provider of consulting, engineering and construction, remediation and facilities management services through its group of highly specialized companies. Its broad range of services includes the identification of contaminants in soil, air and water and the design and execution of remedial solutions.

Midwest Generation: Headquartered in Chicago, Midwest Generation, a subsidiary of Edison Mission Energy, owns 13 electricity generating units in Illinois and Pennsylvania with a generating capacity of over 11,400 megawatts, enough power for more than 13 million homes. Midwest Generation sells wholesale power in competitive electricity markets. The company is undertaking a major program to reduce emissions from its coal fired plants.

National Council of Farmer Cooperatives (NCFC): NCFC is the only organization serving exclusively as the national representative and advocate for America's farmer owned cooperative businesses. It aims to protect the public policy environment in which farmer owned cooperative businesses operate, promote their economic well being, and provide leadership in cooperative education.

NiSource Inc.: NiSource is a holding company with headquarters in Merrillville, Indiana, whose operating companies engage in all phases of the natural gas and electric business from exploration and production to transmission, storage and distribution of natural gas, as well as electric generation, transmission and distribution. Its companies provide service to 3.6 million customers from the Gulf of Mexico through the Midwest to New England.

ORMAT: ORMAT is the world leader in distributed reliable remote microturbine power units, also known as Closed Cycle Vapor Turbo Generators. ORMAT's operations use locally available heat sources, including steam and hot water generated by geothermal sources, industrial waste heat, solar energy, biomass, and low grade fuels.

Pinnacle West Capital Corp.: Based in Phoenix, Arizona, Pinnacle West is the parent company of APS and Pinnacle West Energy. APS is Arizona's oldest and largest electric utility, serving more than 857,000 customers, and Pinnacle West Energy is the company's unregulated wholesale generating subsidiary. Among the utilities listed in the S&P 500, Pinnacle West is ranked in the top 10 percent for environmental performance by an international investment advisory firm. "Fortune" magazine ranks the company in the top 10 percent for total shareholder return over the last five years.

PG&E National Energy Group: Headquartered in Bethesda, Maryland, PG&E National Energy Group develops, owns and operates electric generating and gas pipeline facilities and provides energy trading, marketing and risk management services in North America. The National Energy Group operates power production facilities with a capacity of about 7,000 megawatts, with another 10,000 megawatts under development, and more than 1,300 miles of natural gas transmission pipeline with a capacity of 2.7 billion cubic feet per day. PG&E National Energy Group is not the same company as Pacific Gas and Electric Company, the California utility, and is not regulated by the California Public Utilities Comission.

STMicroelectronics: STMicroelectronics is the world's third largest independent semiconductor company. Shares in the company are traded on the New York Stock Exchange, on Euronext Paris and on the Milan Stock Exchange. The company designs, develops, manufactures and markets a broad range of semiconductor integrated circuits and devices used in a wide variety of microelectronic applications, including telecommunications systems, computer systems, consumer products, automotive products and industrial automation and control systems. In 2000, the company's net revenues were $7.8 billion and net earnings were $1.45 billion.

Suncor Energy, Inc.: Suncor is a Canadian integrated energy company that explores for, acquires, produces, and markets crude oil and natural gas, refines crude oil, and markets petroleum and petrochemical products. Suncor has three principal business units: Oil Sands, Exploration and Production, and Sunoco.

Swiss Re: Founded in 1863 in Zurich, Switzerland, Swiss Re is the world's second largest reinsurer, with roughly 9,000 employees and gross premiums in 2000 of US$15.3 billion. Standard & Poor's gives the company its AAA rating; Moody's rates it Aaa. From over 70 offices in 30 countries, Swiss Re offers insurers and corporates classic (re)insurance covers, alternative risk transfer instruments, and supplementary services for comprehensive risk management.

Temple-Inland Inc.: A diversified forestry, forest products and financial services company, the three main operating divisions of Temple-Inland include a paper group, which manufactures corrugated packaging products; a building products group, which manufactures a wide range of building products and manages the

Company's forest resources consisting of approximately 2.2 million acres of timberland in Texas, Louisiana, Georgia and Alabama; and the financial services group, which consists of savings bank, mortgage banking, real estate, and insurance brokerage activities.

The Nature Conservancy: A nonprofit organization founded in 1951, The Nature Conservancy is the world's largest private international conservation group taking in over one million members. The conservancy has protected over 12,089,000 acres of land in the United States.

Wisconsin Energy Corporation: Headquartered in Milwaukee, Wisconsin, Wisconsin Energy Corp. is an $8.4 billion holding company with a portfolio of subsidiaries engaged in electric generation; electric, gas, steam and water distribution; pump manufacturing and other non-utility businesses. The corporation's utilities subsidiaries serve more than one million electric and 950,000 natural gas customers in Wisconsin and Michigan's Upper Peninsula.

ZAPCO: Zahren Alternative Power Corporation (ZAPCO) is among the largest developers of landfill gas projects in the United States. ZAPCO develops, finances, and operates waste-to-energy electricity systems, and has executed international trades of greenhouse gas reductions involving over two million tons CO_2 equivalent. ZAPCO operates 10 of its 27 landfill gas projects in the Midwest.

Chicago Climate Exchange Advisory Board Members

David Boren is the president of the University of Oklahoma. He served as a member of the Oklahoma House of Representatives (1967–1975), Governor of Oklahoma (1975–1977) and as a U.S. Senator (1979–1994). Senator Boren was the longest serving chairman of the Senate's Select Committee on Intelligence. Boren was educated at Yale and attended Oxford University as a Rhodes Scholar and earned a law degree from the University of Oklahoma College of Law.

Lucien Bronicki is the chairman of Ormat International, an Israeli company in the field of innovative technology solutions to geothermal power plants, power generation from industrial waste heat, and solar energy projects. Chairman of Ormat since he founded the company in 1965, Bronicki chairs the World Energy Council's Israeli National Committee, is a member of the Executive Committee of the Weizmann Institute of Science, and member of the board of Ben Gurion University.

Ernst Brugger is founding partner and chairman of Brugger Hanser & Partner Ltd. in Switzerland, a business consulting firm with international experience and range. He is also a professor at the University of Zurich, chairman and member of the board of various companies and a member of the International Committee of the Red Cross (ICRC). Dr. Brugger serves as chairman of the Board of Directors of Sustainable Performance Group, an investment and risk management company which invests in pioneering companies which have taken up the cause of sustainable business.

Jeffrey Garten is Dean of the Yale School of Management. Formerly, Garten served as undersecretary of commerce for international trade in the first Clinton administration and has held senior economic posts in the Ford and Carter administrations. From 1979 to 1992 he was a managing director first at Lehman Brothers, where he oversaw the firm's Asian investment banking activities from Tokyo, and then at the Blackstone Group. Currently Dr. Garten writes a monthly column for "Business Week" magazine. His latest book, "The Mind of the CEO," was published this year.

Donald Jacobs is dean of the Kellogg Graduate School of Management and its Gaylord Freeman Distinguished Professor of Banking. Jacobs is a former chairman of the board of Amtrak and currently serves on several corporate boards. His work on banking, corporate governance and international finance has been published in many scholarly journals and he holds several honorary degrees and professional awards.

Dennis Jennings is the global risk management solutions leader for PricewaterhouseCoopers' global energy and mining industry practice. Jennings previously served as the Dallas/Fort Worth energy industry market leader, co-chairman of the U.S. oil and gas industry program, and on the steering committee of the international energy practice. He handles PwC's global risk management practice for the energy and mining industry, providing financial advice and performing due diligence reviews on merger, acquisitions and divestiture efforts by major international corporations.

Joseph P. Kennedy II is chairman and president of Boston based Citizens Energy Group, a non-profit company he founded in 1979 to provide low-cost heating oil to the poor and elderly. Before returning to Citizens Energy, Kennedy represented the 8th Congressional District of Massachusetts in the U.S. House of Representatives for 12 years. Citizens now encompasses seven separate companies, in-

cluding the largest energy conservation firm in the U.S. Kennedy advises and serves on the boards of companies in the energy, telecommunications, and health care industries. He is the son of the late U.S. Senator and Attorney General Robert Kennedy.

Israel Klabin is the president of the Brazilian Foundation for Sustainable Development, a Brazilian non-governmental organization devoted to issues of environmental and sustainable development policy. He is the former chairman of Klabin SA, one of the largest forestry companies in Latin America. A former mayor of Rio de Janeiro, Klabin was one of the main Brazilian organizers of the 1992 United Nations Conference on the Environment in Rio de Janeiro.

Bill Kurtis has been a broadcaster for over 30 years, as a news anchor in Chicago and on the national CBS Morning News. He founded Kurtis Productions when he returned to Chicago in the mid-1980s and now hosts shows on the Arts and Entertainment network. Kurtis is involved in The National Science Explorers Program, Electronic Field Trips and the Electronic Long Distance Learning Network, and serves on the board of directors of the National Park Foundation, and the Nature Conservancy.

Jonathan Lash is president of the World Resources Institute, a Washington, DC based non-governmental organization. From 1993 until 1999, Lash served as co-chair of the President's Council on Sustainable Development, a group of government, business, labor, civil rights, and environmental leaders that developed recommendations for national strategies to promote sustainable development. From 1987 to 1991, he headed the Vermont Agency of Natural Resources, having served the previous two years as Vermont's Commissioner of Environmental Conservation.

Thomas Lovejoy, is a world renowned tropical and conservation biologist and author generally credited with having brought the tropical forest problem to the fore as a public issue. In 1987, he was appointed assistant secretary for environmental and external affairs for the Smithsonian Institution and is counselor to the Smithsonian's secretary for biodiversity and environmental affairs. Dr. Lovejoy is also chief biodiversity advisor to the president of the World Bank. From 1989 to 1992, he served on the President's Council of Advisors in Science and Technology, and acted as scientific adviser to the executive director of the United Nations Environment Programme from 1994 to 1997.

David Moran is vice president of ventures for the Electronic Publishing group of Dow Jones & Company and president of Dow Jones Indexes. He is president of Dow Jones Indexes, which includes all Dow Jones indexes for countries, regions, sectors and industry groups as well as the world index. He is also chairman of Dow Jones Sustainability Group Index GmbH.

Les Rosenthal is a former chairman of the Chicago Board of Trade and a principal of Rosenthal Collins, a Chicago based commodities and futures trading firm. He has been instrumental in advancing the cause of innovative exchange traded products such as Treasury Bond futures and insurance derivatives.

Maurice Strong is a former secretary general of the 1992 United Nations Conference on Environment and Development, the Rio Earth Summit, and under-secretary general of the United Nations. He is currently the chairman of the Earth Council, a non-governmental organization dedicated to the cause of sustainable development. In June of 1995, he was named senior advisor to the president of the World Bank. From 1992 to 1995, Strong was chairman and CEO of Ontario Hydro, one of North America's largest utilities.

James Thompson is a former four term governor of Illinois and currently a managing partner of Winston and Strawn. During his last term as governor, Thompson was involved in the implementation of the sulfur dioxide (SO_2) market created by the 1990 Clean Air Act and headed the Global Climate Change Task Force at the National Governors' Association. He is a director of the Chicago Board of Trade.

Brian Williamson is the chairman of the London International Financial Futures and Options Exchange, one of the world's largest exchanges. He has been involved in trading financial futures for almost three decades in London, New York and Chicago. He held senior executive positions for prominent trading firms and was a member of the International Advisory Board of the Nasdaq Stock Market, becoming Chairman in 1996. He was also governor-at-large of the National Association of Securities Dealers in Washington, DC from 1995 to 1998.

Senator KERRY. Thank you very much, Dr. Sandor.

Ms. Claussen.

STATEMENT OF EILEEN CLAUSSEN, PRESIDENT, PEW CENTER ON GLOBAL CLIMATE CHANGE

Ms. CLAUSSEN. 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 nonprofit, nonpartisan, and independent organization, dedicated to providing credible information, straight answers, and innovative solutions in the effort to address climate change.

Thirty-six major companies in the Pew Center's Business Environmental Leadership Council, most included in the Fortune 500, work with the Center to advance public policy and educate themselves and the public on the risks, challenges, and solutions to climate change.

Mr. Chairman, I would like to emphasize two points for you today. First, it is our view that the long-term reductions of greenhouse gas emissions needed to truly address global climate change can only be achieved through a comprehensive and binding strategy.

Second, we believe the steps we take to reduce greenhouse gas emissions, especially those promoting the development and use of energy-efficient technologies, will help U.S. industry compete in the international marketplace. Reducing emissions to the levels necessary to prevent serious climate disruption will take decades, because it will essentially require a new industrial revolution, one enabling the broad introduction of low carbon technologies to power a growing global economy.

Much as some would like to believe otherwise, it will be extraordinarily difficult, if not impossible, to muster the kind of global sustained effort that is needed without the force of legally binding commitments. There is little incentive for any country or any company to undertake real action unless ultimately all do and are in some manner held accountable.

Markets, of course, will be instrumental in mobilizing the necessary resources and know-how. Market-based strategies such as emissions trading, will also help deliver emission reductions at the lowest possible costs, but markets could move us in the right direction only if they are given the right signals. In the United States, these signals have neither been fully given nor fully accepted.

Three decades of experience fighting pollution in the U.S. have taught us a great deal about what works best. In general, the most cost-effective approaches allow emitters flexibility to decide how best to meet a given, binding emissions limit, provide early direction so targets can be anticipated and factored into major capital and investment decisions, and employ market mechanisms such as emissions trading to achieve reductions where they cost least.

To ease the transition from established ways of doing business, targets should be realistic and achievable. What is important is that they be strong enough to spur real action and to encourage investment in development of the technology and infrastructure needed to achieve the long-term objectives.

A good first step is to get our house in order by immediately requiring accurate measurement, tracking, and reporting of greenhouse gas emissions. In addition, the Government could enter into

voluntary enforceable agreements with companies or sectors willing to commit to significant reductions.

While such efforts could help get the United States on track, the long-term emission reductions needed can be achieved only with a more comprehensive and binding strategy. Alternative approaches should be closely studied and the results publicly debated. But much of the analysis thus far suggests that a cap-and-trade system, which sets an overall cap on emissions and establishes a market in carbon credits, can provide the private sector the flexibility and incentive to achieve emission reductions at the least possible costs.

As I mentioned earlier, there will be important side benefits to many of these measures. The steps we take to reduce greenhouse gas emissions will help U.S. companies compete in the international marketplace. Improving energy efficiency, for example, makes for good business as well as good economic policy. In key energy-intensive or import-sensitive sectors, energy costs can make or break companies.

ALCOA, for example, has reduced the electricity required to produce a ton of aluminum by 20 percent over the last 20 years, but almost all companies can benefit from aggressive energy-efficiency measures, and many of the best companies already have. IBM saved nearly $50 million in energy bills in the year 2000 alone. Despite the association of energy conservation with the so-called soft path, it is striking the extent to which hard-driving, profitable companies focus on high-tech lighting upgrades, smart systems that precisely match energy availability to energy needs, and new motors.

But energy efficiency is more than a cost reduction strategy. It is also a business opportunity, both here and abroad. Companies like Whirlpool and Maytag focus on producing high efficiency consumer appliances. Toyota recently introduced the Prius, a high-efficiency hybrid electric vehicle.

Two billion people in the world do not yet have access to electricity. Twice as many do not have access to cars, let alone SUVs. Efficiently meeting the world's exploding demand for power and transportation services is a key business strategy for many companies. Global investment in energy between 1990 and 2020 will total some $30 trillion in 1992 dollars.

The number of motor vehicles worldwide is expected to be 816 million by 2010 with enormous growth expected in developing countries where vehicle ownership rates are now quite low. The lure of this market has led a company like ABB, for example, to focus on alternative energy and small-scale distributed power generation, including wind farms, fuel cells, and combined heat and power plants using miniature gas turbines.

In closing, Mr. Chairman, as we address climate change, we will learn as a nation what businesses are already finding, that opportunities and co-benefits abound, that meeting this challenge will not bankrupt our economy but will make it more competitive, and the sooner we move to address it, the better it will be, both for the environment and our economy.

Thank you.

[The prepared statement of Ms. Claussen follows:]

PREPARED STATEMENT OF EILEEN CLAUSSEN, PRESIDENT,
PEW CENTER ON GLOBAL CLIMATE CHANGE

Mr. Chairman and members of the committee, thank you for this opportunity to testify on climate change policy. 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. Thirty-six major companies in the Pew Center's Business Environmental Leadership Council, most included in the Fortune 500, work with the Center to educate the public on the risks, challenges and solutions to climate change. The BELC companies do not contribute financially to the Center.

Mr. Chairman, I would like to emphasize two points for you today. First, it is our view that the long-term reductions of greenhouse gas emissions needed to truly address global climate change can only be achieved through a comprehensive and binding strategy. Second, we believe the steps we take to reduce greenhouse gas emissions—especially those promoting the development and use of energy efficient technologies—will help U.S. industry compete in the international marketplace.

In assessing how the United States can or should proceed to reduce greenhouse gas emissions domestically and, in turn, internationally, it is important to recognize certain defining characteristics of the climate challenge, and what they imply for the effort required to meet it. First, climate change is truly a global challenge: Averting the worst consequences of global warming ultimately requires action by all major emitting nations.

Second, it is a long-term challenge. Reducing emissions to the levels necessary to prevent serious climate disruption will take many decades because it essentially requires a new industrial revolution—one enabling the broad introduction of low-carbon technologies to power a growing global economy.

Much as some would like to believe otherwise, it will be extraordinarily difficult if not impossible to muster the kind of global, sustained effort that is needed without the force of legally binding commitments. There is little incentive for any country—or any company—to undertake real action unless, ultimately, all do, and are in some manner held accountable. Markets, of course, will be instrumental in mobilizing the necessary resources and know-how; market-based strategies such as emissions trading will also help deliver emissions reductions at the lowest possible cost. But markets can move us in the right direction only if they are given the right signals. In the United States, those signals have been neither fully given nor fully accepted.

So what would constitute an effective domestic program to reduce greenhouse gas emissions? To date, efforts to reduce U.S. emissions have been limited almost exclusively to voluntary activities at the federal, state, local, and corporate level. Spurred on by the United Nations Framework Convention on Climate Change, to which the United States is a party, a number of these efforts have resulted in significant emission reductions. For example some companies on our Business Environmental Leadership Council have cut emissions by 10 percent or more from 1990 levels. DuPont has cut its greenhouse gas emissions by 45 percent from 1990 levels. Shell is on track to hit 10 percent by next year (2002).

However, while technology has decreased the energy intensity of products and processes over the last 50 years, the efficiency has been outpaced by increased demand driven by economic expansion, population growth, and changing consumer preferences. In the aggregate, voluntary efforts have not ended overall growth in U.S. emissions. Indeed, U.S. emissions have grown approximately 12 percent over the past decade. The lesson here is clear: voluntary programs can make a contribution, but will not, on their own, be enough.

What will? To effectively address climate change, we need to lower carbon intensity, become more energy efficient, promote carbon sequestration, and find ways to limit emissions of non-CO_2 gases. This will require fundamentally new technologies, as well as dramatic improvements in existing ones. New, less carbon-intensive ways of producing, distributing and using energy will be essential. The redesign of industrial processes, consumer products and agricultural technologies and practices will also be critical. These changes can be introduced over decades as we turn over our existing capital stocks and establish new infrastructure. But we must begin making investments, building institutions, and implementing policies now.

Three decades of experience fighting pollution in the United States have taught us a great deal about what works best. In general, the most cost-effective approaches allow emitters flexibility to decide how best to meet a given, binding emissions limit; provide early direction so targets can be anticipated and factored into

major capital and investment decisions; and employ market mechanisms, such as emissions trading, to achieve reductions where they cost least. To ease the transition from established ways of doing business, targets should be realistic and achievable. What is important is that they be strong enough to spur real action and to encourage investment in development of the technology and infrastructure needed to achieve the long-term objective.

A good first step is to get our house in order by immediately requiring accurate measurement, tracking and reporting of greenhouse gas emissions. Current efforts lack rigorous reporting standards and verification requirements. Public disclosure of the reported data, similar to what is required for certain pollutants under the federal Toxic Release Inventory (TRI) program, would encourage companies to hunt for ways to reduce their greenhouse emissions.

There are other ways we can and should spur companies to act ahead of any mandatory requirements. One is for the government to enter into voluntary enforceable agreements with companies or sectors willing to commit to significant reductions—either in process emissions, or those from the use of products they make (e.g. automobiles or washing machines). In exchange for its commitment to cut emissions, a company or sector should be guaranteed that it would not be bound by subsequent mandates for greenhouse gas controls over the same time period. A similar approach could encourage companies, particularly in the electric utility sector, to cut carbon emissions as they undertake air pollution reductions required by existing law—a more cost-effective way to achieve multiple environmental objectives.

While such efforts can help get the United States on track, the long-term emission reductions needed can be achieved only with a far more comprehensive—and binding—strategy. Alternative approaches should be closely studied, and the results publicly debated. But much of the analysis thus far suggests that a "cap-and-trade" system—which sets an overall cap on emissions and establishes a market in carbon credits—can provide the private sector the flexibility and incentive to achieve emission reductions at the least possible cost. As yet, we do not believe that we have economic models that can accurately predict the long-term costs and benefits of a serious climate strategy. However, the best analyses to date suggest that, with the use of rational strategies, the costs are reasonable, particularly when weighed against the serious and significant costs of not acting.

Also, as I mentioned earlier, there will be important side benefits to many of these measures. The steps we take to reduce greenhouse gas emissions will help U.S. companies compete in the international marketplace. Improving energy efficiency for example, makes good business sense, as well as good economic policy.

Efficiency can mean new kinds of light bulbs that provide better light, waste less energy, and save money over their lifetimes. It can mean new industrial process designs that use less energy, produce more valuable products and produce less waste. It can mean superconductors that dramatically cut electricity transmission losses. Efficiency is not just a short-term solution; it is also a long-term solution. Both the electricity system and the automobile waste most of the energy they produce. In fact, we waste so much energy that the potential for long-term savings is huge.

The California energy crisis has focused all our attention on the critical role that energy plays in U.S. competitiveness. Annual U.S. economy-wide energy expenditures—approximately $567 billion in 1997—are comparable to the total annual federal government consumption and investment expenditures ($538.7 billion in 1997; note that this excludes transfer payments, for example, under entitlement programs). Our increasing dependence on imported oil—we now import over half of the oil we use—has a major impact on our balance of payments, and makes us vulnerable to price volatility in the world oil market. Thus improving energy efficiency means reducing energy bills, freeing up our nation's resources for other activities, and increasing energy security.

The U.S. electricity system wastes two-thirds of the energy it produces—in the form of waste heat at power plants, and energy losses from power lines. Available combined heat and power technologies could recapture most of the power plant losses in a usable form. Distributed generation (power plants located near the point of electricity use) and new kinds of conductors (and ultimately superconductors) could dramatically reduce the distribution and transmission losses that now waste 9 percent of gross electric generation.

Similarly, cars and trucks waste 85% of the energy in each gallon of gasoline. Thus the potential to improve fuel economy with advanced technologies is huge. For example, new materials can reduce vehicle mass and thus the energy required for acceleration. Regenerative braking can recapture energy lost during deceleration. Advanced tires can cut rolling resistance.

In key energy-intensive or import-sensitive sectors, energy costs can make or break companies. Alcoa, for example, has reduced the electricity required to produce

a ton of aluminum by 20% over the last 20 years. But almost all companies can benefit from aggressive energy efficiency measures; and many of the best companies already have. IBM saved $14.8 million in energy bills in the year 2000 alone. Despite the association of energy conservation with the so-called "soft" path, it is striking the extent to which hard-driving, profitable companies focus on high-tech lighting upgrades, "smart" systems that precisely match energy availability to energy needs, and new motors.

But energy efficiency is more than a cost-reduction strategy, it is also a business opportunity, both here and abroad. Companies like Whirlpool and Maytag focus on producing high-efficiency consumer appliances. Toyota recently introduced the Prius, a high efficiency hybrid electric vehicle. Two billion people in the world do not yet have access to electricity; twice as many do not have access to cars (let alone SUVs). Efficiently meeting the world's exploding demand for power and transportation services is a key business strategy for many companies. Global investment in energy between 1990 and 2020 will total some $30 trillion in 1992 dollars. The number of motor vehicles worldwide is expected to be 816 million by 2010, with enormous growth expected in developing countries where vehicle ownership rates are now quite low. The lure of this market has led ABB, for example, to focus on alternative energy and small-scale distributed power generation, including wind farms, fuel cells, and combined heat and power plants using miniature gas turbines. United Technologies' International Fuel Cells subsidiary produces the world's only commercial fuel cell power plants.

In closing, Mr. Chairman, as we address climate change, we will learn as a nation what businesses are already finding—that opportunities and co-benefits abound, that meeting this challenge will not bankrupt our economy, but will make it more competitive. And the sooner we move to address it, the better it will be for both the environment and our economy. Thank you.

Senator KERRY. Thank you very much, Ms. Claussen.

Mr. Hawkins.

STATEMENT OF DAVID G. HAWKINS, DIRECTOR, NATURAL RESOURCES DEFENSE COUNCIL, CLIMATE CENTER

Mr. HAWKINS. Thank you, Mr. Chairman. Good afternoon.

Let me make these points. First, today CO_2 concentrations in the atmosphere are greater than they have been in 400,000 years. We have done this by taking 75 million years' worth of stored carbon and returning it to the atmosphere at about 100,000 times faster than it was stored.

Second, unless we cut emissions, CO_2 concentrations will keep on going up.

Third, to reduce the risks of climate change, we have to stabilize CO_2 concentrations, and the higher our stabilization targets are, the greater the risks there are. Without cuts, CO_2 will go up somewhere between two times and five times preindustrial levels during the next century. They may double before a child born today is eligible for Social Security.

Fourth, once we release CO_2, it is up in the atmosphere for a long time. If we put 1,000 tons in the atmosphere today, a hundred years from now, 400 tons of it are still there. A thousand years from now, 150 tons of it are still there.

Now, these facts mean that delay in taking action is going to cost us more than taking that action now. By failing to cut emissions, we fail to slow the increasing momentum that leads to increasing concentrations that leads to increasing climate risks. And we make it much more difficult to reach any particular stabilization goal. In fact, today we are in danger of passing reasonable stabilization goals and eliminating options for stabilization at lower concentrations for ourselves and for future generations.

Estimates by the Pacific Northwest Labs indicate that to preserve the stabilization goal of 350 parts per million (roughly 30 percent above preindustrial levels), we would have to be cutting global emissions today; not increasing them but cutting them. To preserve the 450 part per million scenario, we would have to be successful in cutting global emissions from business as usual, starting no later than 2007, and for 550, no later than 2013. Now, 2013 may seem like a long way from now. It is in terms of congressional terms or even senatorial terms. But it is not in terms of achieving a real reduction in global emissions.

To cut global emissions 12 years from now, it requires additional research and development, private sector decisions to invest billions of dollars, corporate decisions to deploy those resources, and then actually doing the design work and getting it in the field. You have to start today to accomplish those results. And, unfortunately, we are not starting today.

But fortunately we have a range of policy options before us that would send the right signal. Let me just list some that are pending before Congress, and I mention them in my testimony.

First, the four-pollutant bill for electric generation: caps on pollutants in accord with what previous witnesses have described. This is Senate Bill 556, sponsored by yourself, by Senator Snowe, and others. This can be complemented with a renewable portfolio standard and a public benefits fund in order to help reduce overall emissions in the electric sector, including carbon emissions.

In the vehicle sector, close the SUV loophole and adopt increases in the CAFE standards to the 40-mile-per-gallon. Second, we support the CLEAR Act which provides tax incentives for high-technology vehicles. These programs would also produce substantial cuts from business as usual in the motor vehicle sector.

In the building sector, S. 207 provides tax incentives for buildings. Buildings consume more than a third of the energy in our economy. They are tremendous sources of waste in our economy. We don't get benefits from that wasted energy. We get pollution. We get higher energy bills. We can cut those bills. We can cut the pollution, and we can do it cost-effectively, but we need to deal with market barriers, and the tax incentives in S. 207 would do that.

And finally let me just mention that integrated policies can have tremendous power to deliver benefits, both economically and in terms of pollution reduction, including global warming pollution reduction. This is exemplified in the Clean Energy Futures report that the five labs of the Department of Energy published last November. That report really does show the power of integrated policies that consist of caps on pollution, tax incentives, performance standards, and voluntary agreements.

Now, the suite of measures that these five labs analyzed in that study showed that you could cut carbon emissions from business as usual by the year 2020 by 30 percent, and that you could produce energy bill savings of over $100 billion a year at the same time, as well as cutting conventional pollutants by about 50 percent. These are benefits you get by having an integrated set of policies, ones that support one another in a complementary fashion.

Finally, let me just close by saying that the critical policy need today is to adopt measures that send a clear signal to the private sector that the Government is serious about the issue of climate change. That signal needs to convince the private sector that cutting carbon is good business. If you send that signal, you will harness the private sector's energies. If you don't send that signal, you will send the signal that has been sent for the last 10 years: which is, "The Government is not serious about it," and then the private sector will sit by and wait until the Government is serious.

Thank you.

[The prepared statement of Mr. Hawkins follows:]

PREPARED STATEMENT OF DAVID G. HAWKINS, DIRECTOR, NATURAL RESOURCES DEFENSE COUNCIL, CLIMATE CENTER

My name is David Hawkins, and I am the Director of the Climate Center at the Natural Resources Defense Council. I appreciate the opportunity to appear before you today on the issues of policies to combat the threat posed by climate change or global warming. The Natural Resources Defense Council is a national, non-profit organization of scientists, lawyers, and environmental specialists, dedicated to protecting public health and the environment. Founded in 1970, NRDC serves more than 500,000 members from offices in New York, Washington, Los Angeles, and San Francisco.

My message today is a simple one: the United States should no longer delay the adoption of effective policies to limit emissions of carbon dioxide and other greenhouse gas pollution. Nearly a decade ago, the U.S. and more than 100 other countries ratified a global climate change treaty that should have spurred adoption of serious policies to combat global warming. Instead, we have had a decade of delay, during which U.S. greenhouse emissions have increased by about 14%. Rather than adopt meaningful policies that would have sent an effective signal to the private sector that constraining carbon emissions was a sound course for business planning, we have relied on voluntary pledge programs that have been effective only in communicating to business leaders that the government is not yet serious about limiting global warming pollution.

Mr. Chairman, the first rule for getting out of a hole is to stop digging. Every year that we delay adoption of real global warming policies, we dig ourselves deeper and make our ultimate response programs more costly, disruptive, and risky. The United States is better positioned than any other country in the world to lead the way in showing that economic progress can go hand in hand with controlling global warming pollution. The time for us to exercise that leadership is now.

Global warming is a problem that becomes more difficult to manage the longer we wait to start. Let's review some basic information. Starting about 300 million years ago, for a period spanning about 75 million years, our planet transferred, through geologic processes, vast amounts of carbon from the atmosphere and living organisms to immense underground reserves, producing what we call fossil fuels. Estimates are that some 5 trillion tonnes of carbon were stored in this way. Imagine a 75 million year video documenting the removal of 5 trillion tonnes of material from our global living room and its storage in a remote subterranean repository. Now, imagine running this video in reverse and at hyper speed. That is what we have been doing for the past 150 years.

Since the Industrial Revolution, we have been putting these immense underground carbon stores back into the atmosphere by burning these fuels and we are doing so at ever increasing speed. At current consumption rates, we put back in the air each year about 100,000 years of stored carbon. In the last 150 years we have put about 290 billion tonnes (gigatonnes or Gt) into the air. Amidst the claimed uncertainties about the climate change phenomenon, there is no dispute that these emissions have caused significant increases in atmospheric concentrations of CO_2. Today's CO_2 levels are about 370 parts per million (ppm), about 30% higher than the pre-industrial level of 280 ppm.

Nor is there any dispute that continued emissions of CO_2 from fossil burning will cause concentrations to go still higher. The latest forecasts for global carbon emissions in the 21st century are sobering. The IPCC's most recent report estimates emissions of between 1000 and 2100 Gt of carbon in the next 100 years—or about 3 to 7 times more than we released in the last 150 years. With cumulative emissions in these ranges, atmospheric CO_2 would build up to between 540 and 970 ppm by

the year 2100 and continue to increase unless emissions were cut. Several of the plausible emission scenarios would lead to doubled CO_2 concentrations before a child born today would be eligible for social security.

A final undisputed fact is that once a certain atmospheric concentration is reached, it cannot be significantly reduced for hundreds of years, no matter how drastic a "response program" policymakers decide to put in place. Unfortunately, carbon dioxide's lifetime in the atmosphere is a long one: of each 1000 tons we emit today, 400 of those tons will still be in the air 100 years from now and 150 tons will remain 1000 years from now. So the bed we are making is a procrustean one that we and generations to come must lie on.

As a result of fossil fuel combustion, we already have increased atmospheric CO_2 to levels greater than "at any time during the past 400,000 years," notes the recent National Academy of Sciences report to President Bush. And we are on a path to dramatically higher concentrations in the coming decades. The policy questions this Committee and this Congress must address are whether and when to act to reduce the buildup of CO_2 concentrations in the atmosphere. In NRDC's view the answers are, yes we must act and we should start now.

Yet for more than a decade, fossil-fuel dependent industries have vehemently opposed policies to limit global warming pollution and governments, including the U.S. government, have declined to adopt such policies. One can explain the position of the industrial opponents as driven by the narrow interests of their current business plans but what explains the compliant position of governments, which should show at least some signs of support for the broader public interest. One explanation is the influence of money on politics and enactment of the McCain-Feingold legislation would be a salutary development. A second explanation is that legislators and executive branch officials believe that we can wait until the emergence of greater consensus on the detailed nature of the threats we face from global warming and that acting later will reduce the costs of a response program compared to acting now. NRDC believes this basic assumption—that later is cheaper—is simply wrong.

The basic fact is that further delay in adopting effective policies forecloses options for us and for our children. Further delay will increase the costs of achieving stable atmospheric concentrations at levels less than double or even triple the concentrations under which human societies have evolved. How important is it for us to preserve the option to stabilize greenhouse gas concentrations at these lower levels? The policy dilemma is that we may not know the answers in a manner convincing to all for decades to come. Yet if we delay policy action until we have amassed a more comprehensive and detailed body of evidence of the full range of damages that a changed climate will bring, the planet's growing emissions will have made stabilizing concentrations at levels anywhere near today's levels very much more expensive, if not impossible.

Each year of delay in developing an effective global response program brings us closer to the point of no-return when we lose the ability to limit the increase in greenhouse gas concentrations to lower levels. By failing to act, we are passing these points of no-return without even understanding what we are giving up for ourselves and our descendants. As I mentioned, pre-industrialization levels of CO_2 did not exceed 280 ppm and we are now at 370 ppm, the highest level in 400,000 years. Because the way CO_2 builds up in the atmosphere is well understood, we can determine the cumulative emissions during the next century that allow us to stabilize the atmosphere at various levels, such as 350, 450, 550, 650, or even 750 ppm and experts have done these calculations. The most recent IPCC report summarizes these 21st century emission budgets as follows:

Stabilization target (ppm)	350	450	550	650	750
Cumulative emissions in 21st century (GtC)	280	630	960	1150	1300

The same report forecasts cumulative global emissions during this period, in the absence of effective global warming policies, to range from 1000 to 2100 Gt of carbon. While many members of Congress don't fancy themselves expert in global warming, most have a good understanding of budget fundamentals. In budget terms we are spending at a rate that far exceeds what we can afford if we learn we need to stabilize CO_2 concentrations in the 350 to 550 ppm range. At first glance, these numbers may suggest we still have lots of time to study this issue but consider that to keep the next hundred years' emissions under 300 Gt we would need to cut today's global emissions *immediately* by more than 60% and keep them there while

the world grows in population and affluence. Or we might pursue the cut more gradually but then we must achieve even deeper cuts later to stay within the same budget. While this example is for the 350 ppm option, the same dynamic exists for each of the higher stabilization targets: the longer we delay adoption of policies that limit business as usual growth in emissions, the deeper the cuts the planet must achieve to hit any stabilization target. And if we delay too long, each successive stabilization target becomes impossible to achieve.

Dr. James E. Edmonds of the Department of Energy's Pacific Northwest National Laboratory and colleagues have estimated least-abatement cost schedules for reducing emissions to meet these stabilization targets. He points out that these schedules require global emissions to drop below business as usual paths in the very near future. Here is a summary of this information as he presented it to the Senate Energy Committee on June 28, 2001:

CO_2 Concentration (ppmv)	350	450	550	650	750
Maximum Global CO_2 Emissions (billions of tonnes carbon per year)	8.5	9.5	11.2	12.9	14.0
Year in which Global Emissions Must Break from Present Trends	Today	2007	2013	2018	2023

As can be seen, for the lower targets, the dates for achieving significant global emission reductions are upon us now and the dates for preserving even the higher targets are very close. To appreciate that these dates do not allow time for further delay in adopting policies, consider the sequence of events that must occur to actually succeed in reducing global emissions. Clear public policies must be debated and adopted, not just in the U.S. but in other countries too. The private sector must develop strategies for response to those policies. The strategies must be translated into specific investment decisions needed to carry out the strategies, most likely involving additional development work for certain technologies. The investment decisions must be followed with detailed engineering and planning work. And this work must be followed by deployment of lower-carbon technologies in the field on a sufficient scale to actually reduce global emissions below current forecasted increases. Thus, to reduce global emissions by dates like 2007–2020, we must start today with adoption of effective policies.

Stated another way, further delay in adopting policies to limit global warming pollution means we are discarding the options of stabilizing concentrations at levels closer to the lower end of the range of targets. I cannot prove today that stabilizing CO_2 at 350 ppm is essential for our well-being. But I think it is self-evident that it is not responsible to eliminate this option without any assurance that we can live well with the resulting future. As the National Academy of Sciences panel noted in its report to President Bush, "risk increases with increases in both the rate and the magnitude of climate change." By committing ourselves to ever-higher CO_2 concentrations, we are committing to higher rates and magnitudes of climate change for our descendants and ourselves.

Fortunately, there are no technical or economic impediments to adopting policies today that will restore U.S. leadership on fighting global warming and send important signals to the private sector and to other countries that the time for effective action has arrived. Congress has before it a number of major legislative initiatives that will address the principal sources of global warming pollution in the U.S. in a way that will stimulate the new technology that is essential to meeting the challenges of limiting these emissions during the remainder of this century.

Near-term Domestic Policies to Address Global Warming

A. Comprehensive Power Plant Clean-up Legislation

NRDC supports comprehensive legislation to reduce all four major pollutants from electric generation—sulfur oxides, nitrogen oxides, mercury and carbon dioxide. Electric generation is responsible for 40% of total U.S. CO_2 emissions. We have the technology to make significant reductions in CO_2 from this sector through a combination of efficiency measures on the supply and the demand side, and through increased reliance on cleaner fuels. Enactment of a cap and trade program for CO_2 from the electric sector would produce the needed market signal to all the players in the electric production and consumption sectors that there is value in reducing

carbon emissions. The bipartisan bill, S. 556, the "Clean Power Act," sponsored by Senators Kerry, Lieberman, Collins, Jeffords and Snowe would accomplish this objective and NRDC strongly supports it.

Complementary policies to reduce emissions from electric generation include renewable portfolio standards proposed in the last Congress in S. 1369, to facilitate the deployment of renewable energy resources, a public benefits fund as proposed in last year's S. 1369 and this year's S. 597, to promote continued investments in demand side management programs and net metering provisions (as found in both bills), to promote clean and efficient distributed generation.

B. Policies to Reduce Petroleum Dependence and Protect the Environment and Public Health

1. Close the Light Truck Loophole and Raise Fuel Economy Standards to 40 Miles per Gallon

Incentives for advanced technology vehicles will be most effective if enacted in combination with updated fuel economy standards. This can be accomplished in two steps. First, congress should quickly eliminate the light truck loophole in the current fuel economy standards. The share of new vehicles that are classified as light trucks (SUVs, minivans, and pickups) has increased dramatically from 20 percent of sales when the CAFE law was first enacted in 1975 to nearly 50 percent of the market today. Yet the vast majority of vehicles currently regulated as light trucks are in fact used in exactly the same way as passenger cars. EPA recognized the need to eliminate the light truck loophole in its Tier II tailpipe standards beginning in 2004. Congress should follow this lead and eliminate the light truck loophole in fuel economy regulations in the same time frame. Congress should raise the overall fuel economy standard for the entire light vehicle fleet over a longer time period. A recent report by the Union of Concerned Scientists shows that the fleet average efficiency could be increased to 40 miles per gallon (mpg) by 2012 and 55 miles per gallon by 2020. The 40 mpg standard could be achieved through incremental improvements to vehicles with conventional drive trains, although hybrid and fuel cell vehicles would likely contribute to achieving this efficiency level. The 55 mpg standard could be most easily achieved by applying hybrid technology throughout the vehicle fleet.[1]

Congress should also set standards for replacement tires. It is a little known fact that auto manufacturers use highly-efficient tires to comply with current CAFE requirements, but comparable tires are not available to the consumers as replacements. Congress should require replacement tires to meet the same specifications as those sold on new cars. This measure alone would save over 70% more oil than is likely to be found if drilling were permitted in the Arctic National Wildlife Refuge.

2. Pass the CLEAR Act: Tax Incentives for Advanced Technology Vehicles and Alternative Fuels

The CLEAR Act (S. 760) provides a comprehensive set of performance-based tax incentives to accelerate the commercialization of advanced technology vehicles and alternative fuels. This bill is a major advance over previous vehicle tax credit proposals because it is the first proposal to link publicly-funded incentives directly to the public benefits provided by the vehicles that get the incentive, in this case the amount of petroleum and carbon dioxide displaced. This is accomplished by linking the amount of the tax credit it offers in part to the actual fuel economy of the qualifying vehicles. The bill also includes important provisions to ensure that public support only goes to truly advanced vehicles that reduce local air pollution as well as global warming pollution and petroleum consumption.

The policy advances incorporated into CLEAR reflect the collective advice of a unique coalition of environmental advocates and automakers. Public interest organizations that have joined NRDC in endorsing the CLEAR Act include the Union of Concerned Scientists, Environmental Defense, the American Council for an Energy-Efficient Economy, the Ecology Center of Ann Arbor, Michigan and the Michigan Environmental Council.

3. Establish Incentives to Promote Smart Growth Development Patterns

Gasoline use also can be reduced by directing real estate development away from urban sprawl and toward "smart growth." Smart-growth suburbs reduce the need

[1] Union of Concerned Scientists, *Drilling in Detroit: Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles.* (June 2001). Available from http://www.ucsusa.org/

to drive by 30 percent or more, cutting household expenditures on transportation.[2] An important incentive for smart growth is to establish mortgage qualification rules that recognize the increased affordability of homes that have low transportation costs because they are located in areas with good access to public transportation.

4. Modify the Ethanol Tax Credit to Make it Performance-Based

The largest incentive currently going to alternative fuels is the excise tax credit provided for ethanol. Unfortunately, the environmental benefits generated by this tax credit are limited because it does not currently incorporate performance criteria. Most ethanol is currently produced from corn and requires high levels of chemical and fossil fuel inputs that are almost as great as those for conventional gasoline over the full fuel cycle of production and use. The existing tax incentive for ethanol could be made much more effective by linking the amount of the credit to the net reduction in global warming pollution or fossil fuel consumption achieved by the ethanol producer. This would encourage ethanol producers to shift to less energy intensive feedstocks, such as agricultural wastes and perennial crops, and to improve the efficiency of their conversion processes.

C. Benefits of a Comprehensive Policies to Promote Advanced Technology Vehicles and Alternative Fuels

The economic and environmental benefits of enacting the comprehensive set of policies described here would be profound. EPA estimates that the average light truck on the road today produces 164 pounds of smog-forming pollution (hydrocarbons plus nitrogen oxides) and 8.0 tons of global warming pollution in traveling 14,000 miles each year. This does not include upstream emissions associated with producing the fuel, which would add about 11 pounds of smog-forming pollution and 2 tons of global warming pollution, bring the totals to 175 pounds of smog-forming pollution and 10 tons of global warming pollution. Conventional new vehicles are substantially cleaner than this average with respect to smog-forming pollution, but have roughly the same fuel economy and therefore the same global warming pollution emissions as the vehicle existing vehicle it is likely to replace. For example, a vehicle meeting the National Low Emission Vehicle standard would emit only 12 pounds of smog-forming pollution from its tailpipe, but upstream emissions would still add 11 pounds, bringing its total impact to 23 pounds of smog-forming pollution and 10 tons of global warming pollution. In contrast, a hybrid vehicle qualifying for a $3000 tax credit under the CLEAR Act would emit less than 1 pound of smog-forming pollution from its tailpipe and would use only half as much fuel. As a result, its total impact would be only 6 pounds of smog-forming pollution and 5 tons of global warming pollution.

Aggregating from the vehicle level to the fleet level, the Union of Concerned Scientist (UCS) estimates that the combination of tax incentives and higher fuel economy standards advocated here would save 540 million barrels of oil in the year 2010, reduce upstream smog-forming pollution by 320 million pounds, and reduce global warming pollution by 273 million tons. By 2020 the savings would be even more dramatic: 1.8 billion barrels of oil, 1000 pounds of smog-forming pollution, and 890 million tons of global warming pollution. All of these benefits would be achieved while saving consumers billions of dollars: nearly $10 billion in 2010 and $28 billion in 2020 according to UCS.

D. Legislation to Provide Energy-Efficiency Incentives for the Buildings Sector

The performance based approach adopted in the CLEAR Act should also be applied to the design of tax incentives to promote efficiency in other energy using sectors of our economy. For example, "The Energy-efficient Buildings Incentives Act" (S. 207), introduced by Sens. Robert Smith (R-N.H.) and Diane Feinstein (D-Calif.), would provide tax breaks for building energy-efficient commercial buildings, schools, rental housing and new homes, cutting their energy needs by 30 percent to 50 percent. It also would provide tax incentives for the purchase of energy-efficient air conditioners, heating and cooling systems, and solar water heating and photovoltaic systems.

S. 207 provides tax incentives for energy efficiency in buildings. Buildings are an often-overlooked source of energy waste. They consume over a third of U.S. energy use and account for about a third of total air pollution in the United States. Energy use in buildings can be cut in half or better using cost-effective technologies that are available to those consumers that are willing to search them out.

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[2] David Goldstein, "Mortgages Can Remove the Incentive for Sprawl," *Earthword: The Journal of Environmental and Social Responsibility,* Issue #4.

But in practice most of those technologies simply are not options for energy users, whether consumers or businesses, because they are too hard to find. Economic incentives can cause the entire chain of production and consumption, from the manufacturer to the contractor or vendor to the consumer, to accept new technologies rapidly. In the few cases where utility programs have been consistent enough across the country and long-lasting enough, new products have been introduced that have become or will become the most common product in the marketplace, with reductions in energy use of 30%–60%.

Examples include:

- Refrigerators, where, new products that are available this year consume less than a quarter of the energy of their smaller and less feature-laden counterparts 30 years ago. The last step forward, saving 30%, resulted from a coordinated incentive program, the Super Efficient Refrigerator Program (SERP), which was sponsored by utilities with the advice of the U.S. Environmental Protection Agency.
- Clothes washers, where some 10% of the market now provides cleaner clothes at a reduction in energy use of 60% or more. This gain in efficiency resulted from a program organized by the Consortium for Energy Efficiency (CEE) and supported by Energy Star. New standards adopted by the Department of Energy—and supported by the manufacturers—will bring all of the market to this level by 2007.
- Fluorescent lighting systems, where new technologies that also will be required by manufacturer-supported federal standards will reduce lighting energy consumption by 30% compared to mid-70's practice while improving the performance of the lighting system.

The policies embodied in S. 207 are built on success stories like these.

Manufacturers have pointed out that in order to introduce new technologies that cost more and that are perceived to be risky, they need the assurance that the same product can be sold throughout the country and that the financial incentives will be available for enough time to make it worth investing in production. S. 207 does this by providing nationally uniform performance targets for buildings and equipment that will be eligible for tax incentives for 6 full years.

It's worth mentioning that S. 207 and other policies improving efficiency of electricity and natural gas use have immediate benefits for consumers and the economy. Let's start with the problem of electric reliability. Not only in California and the West, but in other parts of the country, we are facing the risk of electrical blackouts and/or excessively high electricity prices this summer and next. Regions that are confronting these problems are trying to move forward aggressively both on energy efficiency programs and on power plant construction. But the lead times for most actions on the supply side are far too long to provide a solution. And demand-side approaches attempted on a state-by-state level are much less effective than coordinated national activities.

Here, S. 207 could be a critical piece of a national solution. Air conditioners, for example, represent *about 30% of summertime peak electric loads*. Air conditioners that use a third less power can be purchased today, but they are not produced in large enough quantities to make a difference to peak load. If incentives are made available, manufacturers could begin to mass-produce these products in a matter of months, not years. Mass production and increased competition for tax incentives will drive prices sharply lower, so the incentives will be self-sustaining in the long-term. And with 5 million air conditioners being sold every year, a sudden increase in energy efficiency could have a significant effect in balancing electricity supply and demand even after less than a year.

Another peak power efficiency measure with a very short lead time is installing energy-efficient lighting systems—either new or retrofit—in commercial buildings. Some 15% of electrical peak power results from lighting in commercial buildings. Efficient installations, such as those NRDC designed and installed in our own four offices, can cut peak power demand by over two-thirds while improving lighting quality. Lighting systems are designed and installed with a lead time of months, so incentives for efficient lightings as provided in S. 207 could begin to mitigate electric reliability problems as soon as next summer.

The second major new problem is the skyrocketing cost of natural gas, which caused heating bills throughout the country to increase last winter. Improved energy efficiency can cut gas use for the major uses—heating and water heating—by 30%–50%. Much of this potential could be achieved in the short term, because water heaters need replacement about every ten years, and are the second largest user

of natural gas in a typical household (and largest gas user in households living in efficient homes or in warm areas).

These types of quick-acting incentives help consumers in two different ways: first, they provide new choices that are not now available in practice for families and businesses that want to cut their own energy costs while obtaining tax relief. But they also help the non-participants, because reduced demand cuts prices for everyone.

E. Benefits of Integrated Policies to Promote Efficiency, Renewable Energy and Limit Carbon Emissions

The beneficial impacts of policies like those described above are magnified when assembled into an integrated program that combines incentives for energy efficiency and renewable energy and explicit measures to limit carbon emissions. An example of such an integrated program can be found in the November 2000, Department of Energy Report, "Scenarios for a Clean Energy Future." The policies described in the Clean Energy Future report include greatly expanded research and development funding for energy efficiency and renewable energy breakthroughs, a renewable energy portfolio standard, incentives for renewable energy production and suites of performance standards and incentives for the vehicles, buildings, and industrial sectors. DOE's report forecasts that together, these policies would avoid the need for construction of over 60 percent of the nation's base-case predicted need for new electric power plants over the next 20 years. The policies also would lower Americans' electric bills by over $120 billion per year, cut CO_2 pollution by one-third, and slash emissions of other pollutants in half. These policies are not the imaginings of wild-eyed dreamers. In many cases they amount to expanding programs that have proven to work well already: cap and trade emissions programs; tax incentives; appliance standards; targeted research and development programs; and well-structured voluntary performance commitment programs. Adoption of such programs now is feasible and we urge members of the Committee to lend their support to early enactment of each of these measures.

Senator KERRY. Thank you very much, Mr. Hawkins.

Mr. Cassidy.

STATEMENT OF FRANK CASSIDY, PRESIDENT AND CHIEF OPERATING OFFICER, PSEG POWER LLC

Mr. CASSIDY. Thank you, Mr. Chairman, Senator.

I am pleased and honored to appear before you this afternoon to represent my company, Public Service Enterprise Group, and our coalition, the Clean Energy Group. The Clean Energy Group members are Consolidated Edison, KeySpan Energy, Northeast Utilities, Conectiv, Exelon, PG&E National Energy Group, Sempra Energy, as well as my own company, PSEG.

Members of our coalition share a number of significant attributes and principles. We operate and are developing power plants in almost every region of the United States. We operate coal, gas, and oil-fired fossil fuel generating plants and nuclear-powered facilities. We believe in responsible environmental stewardship. We are committed to working cooperatively with the environmental community, Government, and other stakeholders to promote adoption of progressive policies that provide meaningful environmental improvements on an economically sound and sustainable basis.

There is no question that the issues of environmental policy, climate change, and carbon dioxide reductions present tremendous challenges to our industry. Members of our coalition share the view that the scientific evidence on climate change has progressed to the point where prudent action on reducing greenhouse gas emissions is warranted. We also share the concerns expressed by Members of Congress, President Bush, and members of his administration

about the necessity of maintaining a secure, diverse, reliable, and affordable electric energy supply.

We believe we can make progress on reducing carbon dioxide and other greenhouse gas emissions without bankrupting the economy or eliminating coal as a viable fuel supply. One of the key questions I and my industry colleagues confront is how best to accommodate the requirement for environmental improvements as we make business decisions that involve billions of dollars and affect the lives and livelihoods of hundreds of thousands of investors and employees.

The Clean Energy Group believes the best way to provide business certainty on which to base these decisions is through an integrated environmental strategy and a multi-pollutant approach that includes carbon. The Clean Energy Group has developed a legislative proposal that would deliver significant reductions in power plant emissions of nitrogen oxide, sulfur dioxide, and mercury, and implement mandatory carbon dioxide reductions in a manner that will not compromise the reliability, fuel diversity, or affordability of the nation's energy supply.

The legislation calls for mandatory emission caps to be achieved on established timetables and use of emissions trading and other cost-effective market-based compliance techniques that will allow industry to meet the emission caps efficiently and at low cost.

I have attached a copy of the Clean Energy Group's legislative proposal to my written testimony, and we look forward to discussing it with interested members and staff at any time. We believe the legislation will provide real and significant environmental benefits. However, there is also a strong business rationale for an integrated approach and for establishing a clear policy on carbon reductions now.

Our industry needs to know now what the future environmental requirements will be in terms of the amount of reductions and the timetable. The issue boils down to one of business certainty for both the electric power industry and the capital markets we turn to for financing of new generation projects.

We don't want to confront a situation in which we are forced to waste or put at risk large-scale investments predicated on one set of assumptions, only to have the rules changed a few years down the road. Our view is that the best and most prudent course of action and the one that will foster investment in new energy technologies and the electric energy infrastructure our country needs is a comprehensive program that establishes clear, unambiguous environmental targets and timetables over the next 15 years.

We also believe that such a program should be mandatory. If a goal is to provide business certainty, our view is that only a mandatory program in which all participants in the electric generating industry are required to internalize the cost of making necessary reductions will work. This is especially relevant in the highly competitive wholesale power market in which even small cost differentials can provide a material competitive advantage for those who choose not to participate in a voluntary program.

Again, I am honored by the opportunity to make this statement on behalf of my company and the Clean Energy Group, and I would be happy to respond to your questions.

[The prepared statement of Mr. Cassidy follows:]

PREPARED STATEMENT OF FRANK CASSIDY, PRESIDENT AND CHIEF OPERATING OFFICER, PSEG POWER LLC

Mr. Chairman and Members of the Committee, I am pleased and honored to appear before you this morning to represent my company, Public Service Enterprise Group Incorporated (PSEG), and our coalition, the Clean Energy Group.

PSEG is a diversified energy holding company based in New Jersey with assets and operations overseas as well as in the United States. The company, I head is PSEG Power, a subsidiary of PSEG, and an independent power producer and energy trading company. We have more than 17,000 megawatts of electric generating capacity in operation, construction, or advanced development and our energy trading business is the 15th largest by volume in the country. PSEG's other subsidiaries include Public Service Electric and Gas Company (PSE&G), one of the nation's largest combined electric and gas utilities, and PSEG Global which develops and operates energy production and distribution facilities internationally.

The Clean Energy Group members are Consolidated Edison Company, KeySpan Energy, Northeast Utilities, Conectiv, Exelon Corporation, Northeast Utilities, PG&E National Energy Group, Sempra Energy, and my company, PSEG.

Members of coalition share a number of significant attributes and principles:

- We operate and are developing power plants in almost every region of the United States.
- We operate coal, gas, and oil-fired fossil-fueled generating plants and nuclear-powered facilities.
- We believe in responsible environmental stewardship.
- We are committed to working cooperatively with the environmental community, government, and other stakeholders to promote adoption of progressive policies that provide meaningful environmental improvements on an economically sound and sustainable basis.

There is no question the issues of environmental policy, climate change and carbon dioxide reductions present tremendous challenges to our industry. Members of our coalition share the view that the scientific evidence on climate change has progressed to the point where prudent action on reducing greenhouse gas emissions is warranted. We also share the concerns expressed by Members of Congress, President Bush, and members of his Administration about the necessity of maintaining a secure, diverse, reliable, and affordable electric energy supply.

We believe we can make progress on reducing carbon dioxide and other greenhouse gas emissions without bankrupting the economy or eliminating coal as a viable fuel supply.

Our industry is in the process of fundamental change. My company, PSEG Power, was created just about two years ago as a result of these changes. We own and operate generating facilities that were formerly part of an integrated, regulated utility in New Jersey. We are now one of the largest unregulated independent power producers in the U.S. with an aggressive growth plan that involves entering new markets and building new facilities.

One of the key questions I and my industry colleagues confront is how best to accommodate the requirement for environmental improvements as we make business decisions that involve billions of dollars and affect the lives and livelihoods of hundreds of thousands of investors and employees.

The Clean Energy Group believes the best way to provide the business certainty on which to base these decisions is through an integrated environmental strategy and a multi-pollutant approach that includes carbon.

The Clean Energy Group has developed a legislative proposal that would deliver significant reductions in power plant emissions of nitrogen oxide, sulfur dioxide, and mercury, and implement mandatory carbon dioxide reductions in a manner that will not compromise the reliability, fuel-source diversity, or affordability of the nation's electric energy supply.

The legislation calls for mandatory emissions caps to be achieved on established timetables and use of emissions trading and other cost-effective, market-based compliance techniques that will allow industry to meet the emissions caps efficiently and at low cost.

I've attached a copy of the Clean Energy Group's legislative proposal to my written testimony. We would look forward to discussing it with interested Members and staff at any time.

We believe the legislation will provide real and significant environmental benefits. However, there also is a strong business rationale for an integrated approach and for establishing a clear policy on carbon reductions now.

Our industry needs to know now what the future environmental requirements will be in terms of the amount of reductions and the timetable.

The issue boils down to one of business certainty for both the electric power industry and the capital markets we turn to for financing of new generating projects. We don't want to confront a situation in which we are forced to waste or put at risk large-scale investments predicated on one set of requirements only to have the rules changed a few years down the road.

Our view is that the best and most prudent course of action—and the one that will foster investment in new energy technologies and the electric energy infrastructure our country needs—is a comprehensive, program that establishes a clear, unambiguous environmental targets and timetables over the next fifteen years.

We also believe such a program should be mandatory.

Clean Energy Group companies have participated in a number of voluntary programs in the past that helped developed emissions trading protocols for ozone precursor pollutants. These programs have been useful tools for the industry. However, if a goal is to provide business certainty, our view is that only a mandatory program in which all participants in the electric generating industry are required to internalize the cost of making necessary reductions will work. This is especially relevant in the highly competitive wholesale power market in which even small cost differentials can provide a material competitive advantage for those who choose not to participate in a voluntary program.

Again, I am honored by the opportunity to make this statement on behalf of my company and the Clean Energy Group. We look forward to working with Congress and the Administration to craft the policies under which our industry will make substantial environmental progress while it fulfills its mission of providing a secure, reliable, and affordable supply of electric energy. I would be happy to respond to your questions.

CLEAN ENERGY GROUP'S LEGISLATIVE PROPOSAL

107th CONGRESS

1st Session

Bill Number

To establish a national uniform multiple air pollutant regulatory program for the electric power generation sector

IN THE HOUSE OF REPRESENTATIVES or THE SENATE OF THE UNITED STATES

Date Introduced

Sponsor(s)
Referred to **Name of Committee**

A BILL

To establish a national uniform multiple air pollutant regulatory program for the electric power generation sector

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

SECTION 1. SHORT TITLE; TABLE OF CONTENTS

(a) SHORT TITLE—This Act may be cited as the Integrated Air Quality Planning Act.

(b) TABLE OF CONTENTS—

SECTION 2. FINDINGS AND PURPOSE

(a) FINDINGS—Congress finds that—

(1) fossil fuel-fired power plants, consisting of plants fueled by coal, fuel oil, and natural gas, produce nearly two-thirds of the electricity generated in the United States;

(2) fossil-fuel fired power plants account for approximately two-thirds of the total SO_2 emissions, one-third of total NO_X emissions, one-third of total CO_2 emissions and are a leading source of anthropogenic mercury emissions in the U.S.;

(3) many generating units have been exempt from emissions limitations applicable to new units based on the expectation that over time these units would be retired or updated with new pollution control equipment. However, many of these units continue to operate and emit at relatively high rates;

(4) pollution from existing power plants can be reduced effectively through adoption of modern technologies and practices;

(5) the electricity industry is being restructured with the objective of providing lower electricity rates and higher quality services to consumers;

(6) the full benefits of competition will not be realized if environmental impact costs are not uniformly internalized;

(7) the ability of power plant owners to effectively plan for the future is impeded by the uncertainties surrounding future environmental regulatory requirements that are imposed inefficiently on a piecemeal basis.

(b) PURPOSES—The purposes of this Act are—

(1) to protect and preserve the environment and safeguard health by ensuring that substantial emissions reductions are achieved at fossil fuel-fired generating facilities;

(2) to greatly reduce the quantities of mercury, CO_2, SO_2, and NO_X entering the environment from the combustion of fossil fuels;

(3) to internalize the cost of protecting the values of public health, air, land and water quality in the context of a competitive market in electricity;

(4) to assure fair competition among participants in the market in electric power that will result from fully restructuring the electric industry;

(5) to provide a period of environmental regulatory stability for owners/operators of electric generating facilities for improved management of existing assets and new capital investments;

(6) to achieve emissions reductions from electric generating facilities in a cost-effective manner.

SECTION 3. DEFINITIONS

(1) Act—"Act" means the Integrated Air Quality Planning Act.

(2) Administrator—"Administrator" means the Administrator of the U.S. Environmental Protection Agency.

(3) Affected unit, for the purpose of the tonnage caps in Section 4 and the emission reduction program provisions under Sections 5, 6 and 7, shall have the following meaning—

(a) With respect to SO_2, the term "affected unit" has the same meaning as in Section 402 of the Clean Air Act.

(b) With respect to mercury, the term "affected unit" means a coal-fired electric generating facility with a nameplate capacity greater than 25 megawatts that uses a combustion device primarily to generate electricity for sale, and with respect to NO_X and CO_2, the term "affected unit" means a fossil fuel-fired electric generating facility with a nameplate capacity

greater than 25 megawatts that uses a combustion device primarily to generate electricity for sale, including any unit that—

(i) co-generates steam and electricity if it supplies more than one-third of its potential capacity and more than 25 megawatts of electrical output to the electric power grid;

(ii) serves a closed district heating and cooling system that, on an aggregate basis, supplies more than one-third of its potential capacity and more than 25 megawatts of electrical output to the electric grid.

(4) Allowance—The term "allowance" means an authorization allocated by the Administrator under this Act to authorize emissions during or after a specified calendar year, as follows—

(a) NO_X allowance shall mean an authorization to emit one ton of NO_X;

(b) SO_2 allowance is defined at paragraph 5(b) of this Act;

(c) CO_2 allowance shall mean an authorization to emit one ton of CO_2;

(d) Mercury allowance shall mean an authorization to emit one pound of mercury.

(5) Eligible electric power generating unit—The term "eligible electric power generating unit" means incremental increases in generation (in megawatt hours) relative to 1990 levels produced by nuclear generating units, and generation produced by renewable energy sources, as defined herein.

(6) Greenhouse gas—The term "greenhouse gas" or "GHG" means (a) carbon dioxide, (b) methane, (c) nitrous oxide, (d) hydroflourocarbons, (e) perflourocarbons and (f) sulfur hexaflouride.

(7) New unit—For the purpose of the allocation provisions under Sections 6 and 7, the term "new unit" means an affected unit that has not operated for a sufficient period of time following commencement of operation to receive allocations under the following provisions of this Act—

(a) paragraph 6(c)(1) for the NO_X and mercury provisions, and

(b) paragraph 7(c)(1) for the CO_2 provisions.

(8) Renewable energy or renewable energy sources—The term "renewable energy" or "renewable energy sources" means electricity generated from wind, organic waste (excluding incinerated municipal solid waste), biomass (including anaerobic digestion from farm systems and landfill gas recovery), hydroelectric, geothermal, solar thermal, photovoltaic, fuel cells and other sources, all as designated by rule by the Administrator.

(9) Sequestration—The term "sequestration" means the action of sequestering carbon, either through enhancing natural sinks (e.g., afforestation), or by capturing the CO_2 emitted from fossil fuel based energy systems and storing it in geologic formations or the deep ocean, or converting it to benign solid materials through biological or chemical processes.

SECTION 4. NATIONAL POLLUTANT TONNAGE CAPS

A new Title XII is added to the Clean Air Act entitled "National Pollutant Caps for the Electric Generating Sector" comprised of the following provisions—

(a) NITROGEN OXIDES (NO_X)

(1) Annual Tonnage Cap—Effective January 1, 2008, the annual tonnage cap for emissions of nitrogen oxides from affected units in the continental U.S. shall be 2.11 million tons.

(b) SULFUR DIOXIDE (SO_2)

(1) Annual Tonnage Cap—Effective January 1, 2008, the annual tonnage cap for emissions of sulfur dioxide from affected units in the continental U.S. shall be 4.45 million tons.

(c) CARBON DIOXIDE (CO_2)

(1) Annual Tonnage Cap—

(A) From January 1, 2008 until December 31, 2011, the annual tonnage cap for emissions of CO_2 from affected units in the U.S. shall be the amount

of emissions emitted from electric generating facilities in calendar year 2000, as determined by the Administrator.

(B) On and after January 1, 2012, the annual tonnage cap for emissions of CO_2 from affected units shall be 1.925 billion tons.

(d) MERCURY

(1) Annual Tonnage Cap—

(A) For calendar years 2008-2011 (inclusive), the annual tonnage cap for emissions of mercury from coal-fired generating units in the continental U.S. shall equal a 50 percent reduction from baseline mercury emission levels, as determined by the Administrator.

(B) For calendar year 2012, and each year thereafter, the annual tonnage cap for mercury shall equal a 70 to 90 percent reduction from baseline mercury emission levels, the exact percentage reduction to be determined by the Administrator by January 1, 2004 based on the best scientific data available at the time.

(e) REVIEW OF POLLUTANT CAPS

(1) The pollutant tonnage caps established under paragraphs 4(a), 4(b), 4(c) and 4(d) shall remain in effect until [*insert date 15 years from date of enactment*].

(2) Not later than *[insert date thirteen years from date of enactment]* the Administrator shall determine, based on air quality and cost considerations, whether one or more of the national pollutant caps should be revised.

(3) If, based on the assessment conducted in accordance with paragraph 4(e)(2), it is determined by the Administrator that no revisions to any of the pollutant caps are warranted, a notice of this determination, and the supporting rationale, shall be published in the Federal Register.

(4) If, based on the assessment conducted in accordance with paragraph 4(e)(2), it is determined by the Administrator that revisions to one or more of the national pollutant caps are warranted, a proposed rulemaking reflecting such revisions shall be published in the Federal Register no later than *[insert date 13 years and 6 months from date of enactment].* A final rulemaking shall be promulgated no later than *[insert date fourteen years from date of enactment]* and the revisions to the pollutant cap(s) shall become effective no later than *[insert date fifteen years from date of enactment].*

(5) Determinations made under this paragraph by the Administrator shall remain in effect for another 15-year period, wherein the review cycle established under this paragraph shall be repeated (i.e., EPA will determine if the caps need to be adjusted again by December 31, 2027; if not, the determination shall be noticed in the Federal Register; if so, a proposed rule shall be published by June 30, 2028; etc.).

(6) Notwithstanding the national pollutant caps established pursuant to this section, emissions from individual sources may be ordered reduced by federal or state authorities to address local air quality problems.

SECTION 5. IMPLEMENTATION: SULFUR DIOXIDE REDUCTION PROGRAM REVISIONS

(a) REGULATIONS—Not later than January 1, 2004, the Administrator shall promulgate revisions to its regulations implementing Title IV of the Clean Air Act as deemed necessary to implement the provisions of this section.
Section 402 of the Clean Air Act is amended by striking paragraph (3) thereof and inserting the following—

(b) ALLOWANCE—the term "allowance" means an authorization, allocated to an affected unit by the Administrator under this title, to emit, during or after a specified calendar year—

(1) in the case of allowances allocated for calendar years 1995 through 2007, one ton of sulfur dioxide; and

(2) in the case of allowances allocated for calendar year 2008, and each year thereafter, an amount of SO_2 determined by the Administrator and set forth in the regulations promulgated pursuant to paragraph 5(a) that is consistent with

the new national sulfur dioxide tonnage cap established under paragraph 4(b)(1).

SECTION 6. IMPLEMENTATION: NITROGEN OXIDES AND MERCURY ALLOWANCE TRADING PROGRAMS

The Clean Air Act is amended by striking Section 407. A new Title XIII is added to the Clean Air Act, entitled "Nitrogen Oxides and Mercury Allowance Reduction Program for the Electric Utility Sector" comprised of the following provisions—

(a) REGULATIONS—Not later than January 1, 2004, the Administrator shall promulgate regulations establishing an allowance trading program for NO_X and an allowance trading program for mercury for affected units in the continental U.S. Such regulations shall establish the allowance system prescribed under this section, including, but not limited to, the allocation, issuance recording, tracking, transfer and use of allowances, and the public availability of all such information that is not confidential. These regulations shall also establish the requirements governing affected unit compliance with allowance limits, the monitoring and reporting of emissions and the provisions for excess emission penalties.

(b) NEW UNIT RESERVES—The Administrator shall establish through rulemaking a reserve of NO_X and of mercury allowances set aside for use by new affected units.

(1) The Administrator in consultation with the Department of Energy shall determine the size of the new unit reserves based upon projections of generation output for new affected units—

(A) not later than June 30, 2004, the new unit reserves for 2008 through 2012;

(B) not later than June 30, every five years thereafter, the new unit reserves for the next five-year control period.

(c) NO_X AND MERCURY BUDGETS AND ALLOWANCE ALLOCATIONS

(1) Distribution to affected units

(A) NO_X allowances shall be distributed to affected units—

(i) not later than December 31, 2004, for calendar year 2008;

(ii) by December 31 of each calendar year after 2004, for the year that begins 36 months thereafter.

(B) Subject to paragraph 6(b), the Administrator shall distribute NO_X allowances to affected units on a generation *output* basis in accordance with the following formula—

1.5 lbs NO_X/megawatt hour, multiplied by the affected unit's highest calendar year net electricity generation (in megawatt hours during the most recent three-year period, on a rolling annual basis), divided by 2000 lbs/ton.

(C) Subject to paragraph 6(b), the Administrator shall distribute mercury allowances to affected units on a generation *output* basis in accordance with the following formula—

[0.0000227 lbs mercury/megawatthour, multiplied by the affected unit's highest calendar year net electricity generation (in megawatt hours during the most recent 3 year period, on a rolling annual basis).]

If total allocations based on this formula exceed or fall short of the applicable caps specified in Section 4 minus the new unit reserves for that year, allocations to affected units will be adjusted on a pro rata basis to equal the applicable caps specified in Section 4.

(D) An allowance shall not be considered a property right. Notwithstanding any other provision of law, the Administrator may terminate or limit an allowance.

(E) A distribution of allowances by the Administrator under paragraph 6(c)(1) shall not be subject to judicial review.

(2) Distribution to new affected units—

(A) The Administrator shall promulgate regulations that establish a methodology for distributing allowances to new affected units.

(B) The number of allowances available to a new unit shall be based on actual generation output times the permitted emission rate.

(d) NO_X AND MERCURY ALLOWANCE TRANSFER SYSTEM

(1) Use of Allowances—The regulations promulgated pursuant to this section shall—

(A) prohibit the use (but not the transfer in accordance with paragraph 6(d)) of any allowance before the calendar year for which the allowance is allocated;

(B) provide that unused allowances may be carried forward and added to allowances allocated for subsequent years;

(C) provide that such allowances may be transferred by the person to whom allocated or to any other person. Any person to whom such allowances have been transferred may use the allowances in the control period for which the allowances were allocated or in a subsequent control period to demonstrate compliance with paragraph (6)(e)(i) or may transfer such allowances to any other person for such purposes.

(2) Certification of Transfer—A transfer of an allowance shall not be effective until a written certification of the transfer, authorized by a responsible official of the person making the transfer, is received and recorded by the Administrator.

(3) Permit Requirements—An allowance allocation or transfer shall, upon recording by the Administrator, be considered a part of each unit's operating permit requirements, without a requirement for any further permit review or revision.

(e) COMPLIANCE AND ENFORCEMENT—

(1) Compliance With Allowance Limits—For each calendar year beginning after December 31, 2007, the operator of each affected unit shall surrender to the Administrator a number of allowances for NO_X equal to the total tons of NO_X emitted by that unit during the calendar year, and a number of allowances for mercury equal to the total pounds of mercury emitted by that unit during the calendar year.

(2) Monitoring System—The Administrator shall promulgate regulations requiring the accurate monitoring of the quantities of NO_X and mercury that are emitted at each affected unit.

(3) Reporting—

(A) In general—Not less than quarterly, the owner or operator of an affected unit shall submit NO_X and mercury monitoring reports to the Administrator.

(B) Authorization—Each report required under paragraph 6(e)(3)(A) shall be authorized by a responsible official of the affected unit, who shall certify the accuracy of the report.

(C) Public Reporting—The Administrator shall make available to the public, through one or more published reports and one or more forms of electronic media, unit-specific emission data for each affected unit for NO_X and mercury.

(4) Excess Emissions—The owner or operator of any affected unit that emits NO_X or mercury in excess of the allowances the owner or operator holds for use for the unit for the calendar year shall be liable for the payment of an excess emissions penalty, and shall be liable to offset the excess emissions by an equal amount in the following calendar year or such other period as the Administrator shall prescribe. The excess emissions penalty for NO_X shall be calculated on the basis of the number of tons emitted in excess of the total number of allowances held, multiplied by $5,000, indexed by inflation under rules promulgated by the Administrator. The excess emissions penalty for mercury shall be calculated on the basis of the number of pounds emitted in excess of the total number of allowances held, multiplied by $10,000, indexed by inflation under rules promulgated by the Administrator.

SECTION 7. IMPLEMENTATION: CO_2 ALLOWANCE TRADING SYSTEM

A new Title XIV is added to the Clean Air Act entitled "Greenhouse Gas Reduction Program for the Electric Utility Sector" comprised of the following provisions—

(a) REGULATIONS—Not later than January 1, 2004, the Administrator shall promulgate regulations establishing a CO_2 allowance trading program for affected units and eligible electric power generating units operating in the U.S. Such regulations shall establish the allowance system prescribed under this section, including, but not limited to, the allocation, generation, issuance recording, tracking, transfer and use of CO_2 allowances, and the public availability of all such information that is not confidential. These regulations shall also establish the requirements governing affected unit compliance with allowance limits, the monitoring and reporting of emissions and the provisions for excess emission penalties. In addition, the regulations adopted by the Administrator under this section shall establish standards, guidelines and procedures governing the creation, certification and use of additional allowances requested under the flexibility mechanism provisions of paragraph 7(d) of this Act.

(b) NEW UNIT RESERVE—The Administrator shall establish through rulemaking a reserve of CO_2 allowances set aside for use by new affected units.

(1) The Administrator in consultation with the Department of Energy shall determine the size of the new unit reserve based upon projections of generation output for new affected units—

(A) not later than June 30, 2004, the new unit reserve for 2008 through 2012;

(B) not later than June 30, every five years thereafter, the new unit reserve for the next five-year control period.

(c) CO_2 BUDGETS AND ALLOWANCE ALLOCATION

(1) Distribution of CO_2 allowances

(A) CO_2 allowances shall be distributed—

(i) not later than December 31, 2004, for calendar year 2008;

(ii) by December 31 of each calendar year after 2004, for the year that begins 36 months thereafter.

(B) The Administrator shall distribute CO_2 allowances to affected units and eligible electric power generating units in proportion to each such unit's share of the total electric power generation attributable to the generation of affected units and eligible electric power generating units. The distribution shall not exceed the CO_2 tonnage budget established in paragraph (4)(c) minus the new unit reserve established under paragraph (7)(b).

Alternative allocation option:

(B) The Administrator shall distribute CO_2 allowances to affected units and non-fossil fired generating units serving the grid, including accepted energy efficiency projects that reduce electricity demand from the grid. CO_2 allowances shall be distributed in proportion to each unit's or projects' share of the total electric power generation and, in the case of energy efficiency projects, accepted energy efficiency projects' contribution to reductions in electricity demand. The distribution shall not exceed the CO_2 tonnage budget established in paragraph (4)(c) minus the new unit reserve established under paragraph (7)(b).

For this section, the term "accepted energy efficiency project" means any end use energy efficiency projects as defined by the Independent Review Board as referenced in subsection (d) of this section.

(C) In determining a unit's share of total electric power generation, the Administrator shall consider the unit's highest utilization level, in mega-

watt hours, during the most recent three-year period, on a rolling annual basis.

(D) A CO_2 allowance shall not be considered a property right. Notwithstanding any other provision of law, the Administrator may terminate or limit a CO_2 allowance.

(E) A distribution of CO_2 allowances by the Administrator under paragraph 7(c)(1) shall not be subject to judicial review.

(2) Distribution to new affected units—

(A) The Administrator shall promulgate regulations that establish a methodology for distributing CO_2 allowances to new affected units.

(B) The amount of CO_2 allowances available to a new unit shall be based on actual generation output times the permitted emission rate.

(d) COMPLIANCE FLEXIBILITY MECHANISMS

(1) Independent Review Board—An Independent Review Board shall be established to assist EPA's implementation of the flexibility mechanisms provided for under this section. Requirements related to the creation, composition, duties, responsibilities and other aspects of the Independent Review Board shall be included in the regulations developed by the Administrator under paragraph (7)(a).

(A) The Board shall be comprised of 11 members—one representative of EPA (who shall also serve as chairperson of the Board), one representative from the Department of Energy, three representatives from state government, three representatives from the electric generating sector and three representatives from the environmental community. The Review Board shall report to the Administrator, who shall provide staff and other resources to the Board as necessary. The Administrator will respond promptly to requests for support.

(B) The Board shall promulgate guidelines for certifying the additional allowances. The guidelines shall be promulgated by (i) January 1, 2003 for allowances generated pursuant to paragraph C(i) below, and (ii) January 1, 2005 for allowances generated pursuant to paragraph C(ii). The Board shall be responsible for periodically updating these guidelines as appropriate.

Placeholder: Pending the outcome of analysis of the economic impacts of the unconstrained creation of off-site and off-sector allowances, CEG will determine whether there should be language placing constraints in this section.

(C) The Board shall be responsible for certifying additional allowances requested, pursuant to the following—

(i) For actions completed on or after January 1, 1990 and prior to January 1, 2008, allowances for early action, limited to 10 percent of the tonnage cap of 1.925 billion tons established in Section 4, will be granted for the following types of projects—

(a) domestic and international projects that effectively sequester carbon;

(b) projects reported under Section 1605 of the Energy Policy Act of 1992;

(c) domestic and international projects that reduce greenhouse gas emissions.

(ii) For actions completed on or after January 1, 2008, allowances will be granted for the following types of projects—

(a) domestic and international projects that effectively sequester carbon;

(b) CO_2 reductions from greenhouse gas sources not meeting the definition of an affected unit.

(iii) For CO_2 reductions achieved from investments in new renewable energy projects and for investments in energy efficiency projects, allowances will be granted according to the following guidelines—

(a) Between January 1, 2002 and December 31, 2007, one allowance shall be granted to applicants for every $15 invested in a certified new renewable energy project or efficiency project.

(b) Between January 1, 2007 and December 31, 2014, one allowance shall be granted to applicants for every $25 invested in a certified new renewable energy project or energy efficiency project.

(c) No CO_2 allowances will be granted for investments made in renewable energy projects or energy efficiency projects after December 31, 2014.

(2) The Issuance and Use of Allowances

(A) The Administrator shall make available allowances to projects that receive certification by the Independent Review Board. The allowance shall be in addition to the tonnage budget set forth in paragraph 4(c).

(B) The regulations promulgated pursuant to paragraph 7(a) shall allow sources to purchase and use CO_2 allowances that are traded under other domestic or internationally recognized CO_2 reduction program and to use these allowances as a compliance option for the domestic program created by this Act.

(e) CO_2 ALLOWANCE TRANSFER

(1) Use of CO_2 Allowances—The regulations promulgated pursuant to this section shall—

(A) prohibit the use (but not the transfer in accordance with paragraph 7(e)(2)) of any CO_2 allowance allocated by the Administrator before the calendar year for which the CO_2 allowance is allocated;

(B) provide that unused CO_2 allowances allocated by the Administrator may be carried forward and added to CO_2 allowances allocated for subsequent years;

(C) provide that such allowances may be transferred by the person to whom allocated or by any other person. Any person to whom such allowances have been transferred may use the allowances in the control period for which the allowances were allocated or in a subsequent control period to demonstrate compliance with paragraph (7)(f)(2), or may transfer such allowances to any other person for such purposes;

(D) provide that allowances originally allocated and transferred pursuant to this section may be transferred into any other market-based CO_2 emissions trading program approved by the President and implemented pursuant to regulations developed by the Administrator or other federal agency.

(2) Certification of Transfer—A transfer of a CO_2 allowance shall not be effective until a written certification of the transfer, authorized by a responsible official of the person making the transfer, is received and recorded by the Administrator.

(3) Permit Requirements—A CO_2 allowance allocation or transfer to an affected unit shall, upon recording by the Administrator, be considered a part of each affected unit's operating permit requirements, without a requirement for any further permit review or revision.

(f) COMPLIANCE AND ENFORCEMENT—

(1) Compliance with the CO_2 cap can be achieved as follows—

(A) From 2008 through 2014 inclusive, compliance may be demonstrated though the use of CO_2 allowances distributed under paragraph 7(c) or 7(d).

(B) After 2014, compliance may be demonstrated though the use of CO_2 allowances distributed under paragraph 7(c), or any internationally recognized flexibility mechanisms in place at the time.

(2) Compliance With Allowance Limits—For each calendar year beginning after December 31, 2007, the operator of each affected unit shall surrender to

the Administrator a number of allowances for CO_2 equal to the total tons of CO_2 emitted by that unit during the calendar year.

(3) Monitoring System—The Administrator shall promulgate regulations requiring the accurate monitoring of the quantity of CO_2 that is emitted at each affected unit.

(4) Reporting—

(A) In general—Not less than quarterly, the owner or operator of an affected unit shall submit a report on CO_2 emissions from the unit.

(B) Authorization—Each report required under paragraph (A) shall be authorized by a responsible official of the generating unit, who shall certify the accuracy of the report.

(C) Public Reporting—The Administrator shall make available to the public, through one or more published reports and one or more forms of electronic media, CO_2 emissions data for each affected unit.

(5) Excess Emissions—The owner or operator of any affected unit that emits CO_2 in excess of the allowances the owner or operator holds for use for the unit for the calendar year shall be liable for the payment of an excess emissions penalty, and shall be liable to offset the excess emissions by an equal amount in the following calendar year or such other period as the Administrator shall prescribe. The excess emissions penalty shall be calculated on the basis of the number of tons emitted in excess of the total number of allowances held, multiplied by $100, indexed by inflation under rules promulgated by the Administrator.

SECTION 8. NEW SOURCE REVIEW PROGRAM REVISIONS

Section 165 of the Clean Air Act is amended by the following—

The Administrator shall promulgate revisions to its New Source Review (NSR) regulations, including its Prevention of Significant Deterioration (PSD) requirements.

(a) The regulations shall revise the NSR/PSD applicability criteria for affected units under either Section 4(a) or (b) such that—

(1) Physical changes or changes in the method of operation at affected units shall not be subject to the NSR/PSD regulations and are not subject to EPA approval if—

(A) the project does not meet the definition of the term "reconstruction" as defined in 40 CFR 60.15, or

(B) the project does not result in an increase of the affected unit's emission rate on a lbs/megawatt hour basis.

(2) Projects that do not meet the criteria set forth in paragraph 8(a)(1) shall be subject to the existing NSR/PSD applicability provisions and general requirements.

(b) The regulations shall continue to apply NSR/PSD to proposed new units, with the following changes—

(1) New sources locating in non-attainment areas shall not be required to obtain emission offsets.

(2) The definition of "Lowest Achievable Emission Rate (LAER)" technology shall be revised to allow costs to be considered in the determination of what constitutes LAER, such that new sources will not be required to install LAER technology if the cost exceeds a threshold amount (in dollars per ton) to be determined by the Administrator. This LAER cost threshold amount may not be less than twice the amount of the BACT cost guideline.

SECTION 9. SAVINGS PROVISIONS

Except as specifically provided herein, nothing in this section—

(1) affects the permitting, monitoring and enforcement obligations of the Administrator under the Clean Air Act (42 U.S.C. 7401 et seq.) and the remedies provided thereunder;

(2) affects the requirements and liabilities of an affected facility under the Clean Air Act;

(3) requires a change in, affects, or limits any state law regulating electric utility rates or charges, including prudency review under state law; or

(4) precludes a state or political subdivision of a state from adopting and enforcing any requirement for the control or abatement of air pollution, except that a state or political subdivision may not adopt or enforce any emission standard or limitation that is less stringent than the requirements imposed under the Clean Air Act.

Senator KERRY. Well, thank you very much. I want to thank all four of you. We had some very helpful and very important testimony, each point of view contributing significantly to the way in which we could start to think about this constructively.

Mr. Cassidy, let me just ask you quickly since you just finished. Vice President Cheney has said that we need to build 1,300 electric power plants over the next 20 years. Yet last year the Department of Energy reported that energy efficiency in renewable power sources could meet 60 percent of the nation's need for new power plants.

What is PSEG's view with respect to these differing points of view? What is your view?

Mr. CASSIDY. I can't, in my head, Mr. Chairman, do the math as between whether 60 percent of requirements can be met by renewables and efficiency in new power plants. I would say, as you said earlier today, that an approach that is going to work has to emphasize new technology, efficiency standards, and the construction of new environmentally efficient plants replacing older inefficient plants.

Senator KERRY. Well, is PSEG diversifying into renewable power?

Mr. CASSIDY. We are always on the lookout for new investments that make sense. We have done quite a bit of work on landfill and natural gas projects in the state of New Jersey. Other members of our coalition have made similar investments.

Senator KERRY. What was your reaction to the preceding panel, to both the fuel cells and wind power discussions?

Mr. CASSIDY. My reaction is that they are—that both wind power and fuel cells will need to be a part of solving the carbon problem that we are trying to solve. I don't believe that efficiency and renewables alone can be the total solution.

Senator KERRY. Mr. Hawkins, what is your reaction to that?

Mr. HAWKINS. Well, I think the administration is really a prisoner of its own assumptions. They started with adding up the current supply, and then they looked at forecasts of what future demand for total energy might be—and then the next step they took was where they went wrong. Basically you can fill that gap between supply and demand with either clean resources or dirty resources, and they basically assumed that it was all going to have to be filled with conventional dirty resources, more fossil, more nuclear, and they didn't look at the option of filling as much of that gap with clean resources.

The analysis that did look at the clean resource option was the Clean Energy Futures report by the Department of Energy, and what that analysis indicated (using the metric that Vice President Cheney uses of 1,300 power plants)—it indicated that of those 1,300 power plants, 600 could be avoided by improving efficiency,

so that you would get the same energy services, but you wouldn't need to build as many power plants to deliver those energy services.

Two hundred additional of those power plants would be fueled by renewable resources rather than fossil resources. It is that difference in approach that produces a different result. You can start by filling up the gap with dirty resources and then say, Oh, let's add something in on efficiency and renewables, so that we can say we have a balanced package, or whether you prioritize it the other way and say, OK, let's see how much we can deliver with the cleanest resources first, and then meet remaining needs with the dirtier resources.

Senator KERRY. And when you talk about those 200 renewable plants, is that based on current rate of deployment of existing technology, or is that looking down the road?

Mr. HAWKINS. No. That is based on the adoption of policies that would develop additional renewal resources, create tax incentives, create performance objectives, and otherwise provide more incentives for efficiency and renewable energy. It is also influenced by the adoption of policies that would provide an economic reward for renewable energy resources, specifically caps on carbon emissions in the electric sector.

If you put a cap on carbon emissions from the electric sector, as Frank Cassidy has indicated, you send a signal to the market. You make it economically more attractive at the margin for a power plant developer to build a power plant that runs on renewable energy rather than one that runs on fossil energy, because the renewable fuel power plant won't have to get carbon permits from the market.

Senator KERRY. Now, with respect to what you heard in the discussion I had with Dr. Evans at the very beginning, he made a point of separating what he can recommend in the context of the realities of the science, versus making a policy judgment. What is it that compels you, based on the science you've seen, to make the judgment you make that you need to move authoritatively to deal with this now?

Mr. HAWKINS. Well, it is this momentum of the system, the fact that we are inevitably and irretrievably building up carbon concentrations in the atmosphere. We know those increased carbon dioxide concentrations are linked to increasingly higher risks of climate change. We know that those potential climate changes are ones that haven't been experienced in the evolutionary history of the living systems that surround all of us. They certainly haven't been experienced in the history of human societies that have developed, and we know that we are sticking ourselves and our children with the consequences of those things.

So from a standpoint of prudent behavior, if we don't understand the magnitude of the harm that we may be inflicting and we know that we are creating centuries' worth of harm by continuing on this current pace, we are leaving behind options to reduce the risk. Our current approach is a gamble and that is a winning strategy only if you are sure you are going to win. You know, if you have got a flip of the coin, if you want to maximize your income, if you are sure you are going to win, you bet all your assets on heads. And

if you are sure it is going to be heads, but that is only a winning strategy if you are sure it is heads.

Now, is there reason to believe the effects of increasing carbon dioxide concentrations will be trivial or beneficial? We have no basis for believing that at all, and we shouldn't be betting our economies on that assumption.

Senator KERRY. Well, isn't it, in fact, more than that. You do not have a basis for not knowing it won't be beneficial, but you have a basis for knowing it is, in fact, going to be negative, isn't it?

Mr. HAWKINS. All of the plausible information is that these will be harmful effects. All of the analyses that have been done say that the higher probability outcome of these increased concentrations is to produce climate changes that are not going to be beneficial to the planet as a whole, are going to be highly detrimental to lots of places, lots of ecosystems, lots of people. Unfortunately, the poorest people in the world may suffer the most, because they are least able to adapt and because they are living in fairly extreme circumstances to begin with.

So, yes. All of these factors point to the need for action to reduce emissions. My attempt was to be extremely generous to the other side's premises in answering your question.

Senator KERRY. I see. In other words, you are just leaving it out there. Fair enough. I understand. I want to ask Ms. Claussen the same thing, but let me just ask you very quickly, Mr. Hawkins, before I do. In reading the energy policy of President Bush, he suggests the answer is in voluntary action, noting that the carbon intensity of the U.S. economy, quote, "declined 15 percent during the 1990's." And I don't understand that. Last year, U.S. carbon emissions increased 2.7 percent in that 1 year alone. Can you address that discrepancy?

Mr. HAWKINS. The rate of carbon emissions per unit of gross national product went down modestly during the last decade. Unfortunately, the atmosphere really doesn't care about that. What the atmosphere cares about is the tons of emissions, and the tons of emissions went up by 16 percent.

Senator KERRY. So in other words, a game is being played essentially in the way in which it is being reported.

Mr. HAWKINS. Yes. The relevant environmental statistic is how much did the tons of pollution go up, and the tons of carbon pollution from the U.S. economy went up by 16 percent.

Senator KERRY. Ms. Claussen, did you want to comment on the previous question asked? If you didn't, I do have a question I wanted to ask you.

Ms. CLAUSSEN. I did, because I thought David Hawkins was being so conservative. I think if you look at the results of the Intergovernmental Panel on Climate Change, if you look at the report from the National Academy that the President asked for, if you look at all the reports that we have done using, I think, some of the best scientists in this country, looking at environmental impacts in this country, I think there is no question that we are talking about something that will have negative environmental impacts, whether it is sea level rise or ecosystem destruction or effects on water resources or effects on agriculture.

And I think it is not only prudent but it is really important that we figure out how to reduce our emissions of greenhouse gases and how to sequester those that we do put up there, and I think we should use every tool that we can. Whether it is energy efficiency or it is new technologies or it is new less-carbon-intensive power plants or whether it is carbon sequestration, it seems to me that all the tools in the tool box are ones that ought to be used.

Senator KERRY. Now, can you share with the Committee—you have been a leader in trying to bring corporate leaders, CEOs, to the table, and, we keep being given, I think, a false presentation of this entire problem, suggesting such draconian negative impacts on business and the economy, et cetera.

But on the other hand, you have corporations and industry leaders who have come together with you to take action as part of the Pew Center's Business Environmental Leadership Council. Thirty-three of the largest and most successful U.S. corporations have stated that the Kyoto agreement is a first step in addressing climate change, and, in fact, more must be done.

What is it that your corporations see? Maybe you would say who they are, what are they seeing, and why do they feel compelled to move, while others are somehow trying to avoid this and go in a different direction?

Just share your experience with us.

Ms. CLAUSSEN. Sure. let me first say that—I am happy to say that it is now 36 rather than 33, because I think we are continuing to add companies who share the view that the science is sufficient to take some action, and——

Senator KERRY. What kind of companies? What are you talking about?

Ms. CLAUSSEN. Well, let me give you some ideas. I mean, we have got aluminum companies like ALCOA. We have electric generators like American Electric Power and Cinergy and Pacific Gas and Electric and Wisconsin Energy. We have got aircraft companies like Boeing, United Technologies and Lockheed–Martin. We have got cement companies like Holnam and California Portland Cement Co. We have got forest products companies like Georgia Pacific and Weyerhauser; appliance companies like Whirlpool and Maytag, Intel and IBM. So, I mean, it is a real range among these 36. We cover almost all sectors. We have even got a diesel engine manufacturer, Cummins, and obviously DuPont and companies like that.

It is a real mix, and I think they have come together, one, because they think there is sufficient science; two, because they think they can do something about it, and 16 of these companies have already set internal targets to reduce their emissions and put in place programs to do it, and because they think there is a real need for public policy to help move this in the right direction.

And I think if you look at what they are doing, these are not foolish companies. These are companies who are in business to make a profit, who want to look ahead to what the world is going to be like in ten or twenty or thirty years from now, and who want to be there with the new technologies and the new systems, and who are trying everything out right now as they get ready for this, because they think it is something that has to be done.

And so, I mean, sure there are companies who are on the other side of this. I mean, we have got some oil companies, but there are oil companies who have a different point of view. I think these are the most forward-looking companies, and I think most of those who are, quote, on the other side, end of quote, are sort of worried about what happens to them tomorrow, and there are legitimate issues about what happens to them tomorrow. If you are a coal company, you may wonder.

But I have to say that we have now got a big mining company, a global mining company, with substantial coal resources in the United States, and they think this is a serious problem, that something needs to be done, and they agree with us that we need some kind of a mandatory program, and so even companies who mine coal, let alone burn it, because we have got some of those, too, believe that something has to be done here.

Senator KERRY. Dr. Sandor, you have been waiting patiently.

Dr. SANDOR. Yes. To make one point, the purpose of a market is really to help you understand the winners and losers and not to pick them. That is the whole purpose of the debate. The question of renewables is very easy to answer once you price carbon. For example, at the low end of the scale of current forecasts, that is, as low as $20 per ton carbon, you change the dynamics, and you would probably get rid of all the landfill methane leakage in the United States.

Some economists are saying carbon prices may be $200 a ton. At $200 a ton, you basically would turn the U.S. agricultural sector entirely into sequestration and add $60 billion in net farm income. The best step we can take is to implement and to get those numbers. The actors can take advantage of the investment opportunities. We could avoid policies which subsidize a particular technology because the market will, indeed, reveal to you what farmers should be doing, what solar power companies should be doing.

And with all due respect, comments about support for action on global warming can really be implemented much better by joining an exchange, putting a cap-and-trade system in place, and executing and informing the debate, and that is the critical part. There is far too much talk about the subject and no action. The action and activity of markets will bring you the information that one needs to make the decisions.

So I just don't get it. We talk about it. I think the companies that have bought into the climate exchange are going to do something. They are actually going to do it. They are not going to say, "We worry about global warming." They are going to talk and implement. Those that join are going to do something and take a positive action. The talk doesn't help us in the debate. We have got to become numerate and not just literate.

Senator KERRY. Senator Brownback.

STATEMENT OF HON. SAM BROWNBACK,
U.S. SENATOR FROM KANSAS

Senator BROWNBACK. That is, I think, an excellent comment, Dr. Sandor. One of our former colleagues that was here has commented to me previously that until we find a way to measure something, we don't really know how to change it. We have got to be able to

put a quantifiable figure on it, and then we can move from that point in time. And I think that is a good way of looking at it.

As I understand the panel, if I have heard your testimony correct, you all support some sort of trading system—and from that, then, to a cap-and-trading system. Is that correct? Dr. Sandor, in particular, I want to understand this. Is that your position, that you feel like we should have a mandatory, federally set capping system, then the trade from that?

Dr. SANDOR. Yes. The system that we have implemented is a cap-and-trade system.

Senator BROWNBACK. OK. So everybody on the panel does support some form of cap-and-trade type of system. Dr. Sandor, to move your concept forward, what sort of Federal actions would be required? You would have to set a cap and then I presume some form of measurement where there is a definable measurement that is traded, or can the marketplace establish that?

Dr. SANDOR. The Chicago Climate Exchange is voluntary, so in the absence of a mandated cap, there is a significant amount of help that you can give us. You can give us an allowance tracking system; measurement help for companies in the industrial sector; the power sector; and in the soil sequestration. Anything that will facilitate the measurement process and develop an inventory level of emissions and offsets and how they occur wil help the market.

You can help us in terms of distributing educational information to the agricultural community. For example, options for changes in tillage practices and how they impact soil sequestration, so we can take advantage and add another crop for farmers.

You can, in fact, help support education and work on verification. Things like the Jet Propulsion Laboratory, which is doing flyovers with radar and other technologies to measure forests with satellite sensing systems. All these are new technologies, by the way, which are exportable. I think it is amusing that we have been involved in three carbon trades. One is a reforestation project of the Salish and Kootenai tribes in Montana. Another is landfill gases throughout the United States, and a third one is the Nuon trade. In all cases, American companies exported their environmental services and credits abroad. I find that an interesting anecdotal note.

So you could give us the verification skills, the monitoring skills, the tracking, and most importantly, you can give companies who trade some baseline protection, that is, credit for early action. This, to me, is a key driver, and so——

Senator BROWNBACK. Let's expand that. By credit for early action, you are saying that if they take action now, they will be given credit for this, under any sort of regime that follows.

Dr. SANDOR. Yes.

Senator BROWNBACK. National or international.

Dr. SANDOR. Yes. And these companies now are drivers. they are motivated to join this exchange for several reasons. One of them, there are great states like Massachusetts that are already implementing a cap-and-trade program, so there will be state efforts. And in the West, there are also some efforts. There is a Danish program. There is a UK program coming next year. All of the companies that may comply as multi-nationals should be protected or given credit for any action they take now, in spite of the fact that

there is no mandate, so we can encourage them to continue to do this.

Senator BROWNBACK. Mr. Hawkins, if we could, or any other panelist if you would like to respond to this, it seems to me if we go toward a cap-and-trade type system, that it answers a lot of the questions that you have put forward of moving us toward renewables and carbon sequestration, because you put an environmental cost onto carbon. It seems to me, rather than going through a number of tax credits, that you are just better off putting in place a market mechanism here, and letting the market then sort those factors out.

How would you respond to that?

Mr. HAWKINS. Well, I think I would respond that there unfortunately is often a difference between the theoretical ideal and what Congress is actually able to legislate, and my hunch is that this Congress is probably not going to legislate a cap at a level that is going to be sufficient to send a signal to all sectors of the economy, that this is a serious effort. I certainly hope that this Congress will do so, but I think that we need a more robust and diverse portfolio approach politically to this question.

There are a number of techniques which can enjoy broad support in Congress that would apply differently to different sectors, and I think that is the principal value of moving forward with some tax incentive programs, with some sector-specific programs like the CAFE standards for the vehicle sector, and with a cap-and-trade program for the electric sector. It is a mix of strategies. It allows members to mix and match in terms of their own policy preferences and needs, and still gets the job done. It ain't perfect; it ain't the theoretical ideal, but that doesn't often happen in this town.

Senator BROWNBACK. What if you are able to put forward, Mr. Hawkins or Ms. Claussen, a system where you were able to just simply bank greenhouse gas credits? Something that could get through in your more practical model of Congress, a system of allowing companies to take credit for early action at this point in time?

Ms. CLAUSSEN. Let me try to answer that a little bit. I think that is a very important first step, because some of these companies have actually started to do some really terrific things, and I think it is really important that they not be penalized for the things that they have done. In fact, you want them to continue doing it, and you want others to do it as well, so putting in some kind of baseline protection, some kind of recognition for what they have done, some kind of credit for early action, I think, is really important.

But in the end, I think what you need is some combination of carrots and sticks. I think you do need some incentives to move the technology. I think you do want to have some kind of a mandatory cap. I don't think it has to be that stringent when you are getting started. I think you can put something in place that starts to send the right signals and that gradually over time becomes more and more stringent.

So, you know, the idea of voluntary versus mandatory—mandatory doesn't mean so stringent that it breaks the bank. It just means something that is real and something that is spread across the country, not just in a few people who actually choose to do it.

So I am sort of favorably inclined toward something that maybe is relatively modest, but something that sort of puts in place the right things to get us moving. And I think once we start moving, we will find that we can really move pretty fast and pretty far.

Senator BROWNBACK. Dr. Sandor, you wanted to respond.

Dr. SANDOR. Yes. I would respectfully disagree with the comments about a variety of regulatory approaches and this body's ability to pass legislation. I have a great deal of faith in this body, the Senate's ability to do it. I think the SO_2 program is a perfect example. The same sorts of criticisms were leveled at it. It wasn't stringent; it only had 100-plus facilities; it was terrible; it was a camel, which is a horse designed by a committee; it wasn't ever going to fly, and it wasn't going to work.

This past year, the total cost of the program—and it is in its second, more stringent phase, as Ms. Claussen indicated, which was supposed to be the back-breaker of U.S. industry, cost $2 billion per year, and the reduced medical costs associated with lung disease alone were $12–$40 billion per year. This was called a terrible program that the Senate designed; some said it would never work, but now we know all of the social benefits are there, and all of the economics are there. So please keep at it, gentlemen.

Senator BROWNBACK. Yes, Mr. Hawkins.

Mr. HAWKINS. I wanted to followup to your earlier question, but first let me be sure to say that I was one of the strong supporters of the 1990 acid rain legislation, both on its introduction and its passage, and I think it has——

Senator BROWNBACK. You picked a good horse.

Mr. HAWKINS. It has been a great success. On the question of the early action credits, I want to flag a concern that adopting an early action credit policy without a cap invites strategic game-playing. It invites the kind of problems we have seen with the existing registry of the Department of Energy, the 1605(b) program where people basically create their own baselines to maximize the number of credits in their account. This in turn can establish, in effect, a lien on future policy decisions, because you have all these entitlement holders, and you haven't made a policy to actually limit carbon emissions.

The dynamic changes in the right direction if you have an early action credit policy combined with a cap. So, for example, if we adopt—if we enact S. 556, the cap program for power plants, it doesn't impose immediate caps on the power sector. The caps kick in some years down the road. But there may be some entities in the sector that want to move sooner and are able to move sooner. They should get credit for doing so, but those are going to be real tons, because they know they are going to be accountable in the cap system, so you avoid the problem of "play money" credits that you create if you have an early action credit scheme and no cap.

Senator BROWNBACK. That is a good comment.

Mr. Cassidy.

Mr. CASSIDY. I just reinforce Ms. Claussen's comment that a mandatory system doesn't have to be a straightjacket. Our own legislative proposal features steadily more stringent caps and steadily less flexible trading and incentive mechanisms, and we think that

is the approach that makes for the most efficient and effective implementation.

Senator BROWNBACK. Mr. Chairman, I want to thank you for holding the hearing and particularly for this panel. I think there are a number of things that can be agreed upon and that we can move forward on. I don't think we can do the whole thing. I don't think we should do the whole thing at once, but I think there are some pretty sensible mechanisms.

I have visited one place in Brazil earlier this year where a group of companies and environmental groups purchased nearly 75,000 acres of land to reforest for carbon benefits. This is a beautiful project that they are working on, good local input. Some of these things, I think, can really solve a couple of problems and they amount to a no-regrets policy. I am not sure if somebody in an earlier panel mentioned that, but I think there are some steps that can be made that make good sense.

There is no regret on this, regardless of how things move on forward, and you create some business certainty out here for people that Mr. Cassidy and others represent that need that in long-term planning, need a 20-year horizon to be able to know if the type of investment they are taking is going to be stable or if it is going to be undercut by changes in laws that could occur. I think those involve some form of trading system and some form of banking system, where we can figure out what is a carbon credit.

Mr. Hawkins' point, I think, is a valid one. People just kind of create on their own types of carbon credits for down the road, and say, "Well, I have got 20 of my carbon credits; how many do you have of yours?" Instead, we can create a standardized carbon credit, and that probably, Dr. Sandor, would help enormously in your market mechanisms as well, even if we did that simple step this year. And I think there would be a broad base of support for that so I think there are a number of items there we can move foward.

I am appreciative of this panel and appreciative of your leadership in working on the topic.

[The prepared statement of Senator Brownback follows:]

PREPARED STATEMENT OF HON. SAM BROWNBACK,
U.S. SENATOR FROM KANSAS

Mr. Chairman—I thank you for calling this hearing to investigate the new technologies on the horizon that will help us deal with the significant problem of global climate change. I commend the positive approach this hearing is taking in looking for solutions—areas of agreement, rather than focusing on that which divides us. I know of the chair's personal interest and commitment to this issue and I thank him for this opportunity.

The issue of global climate change has been controversial as long as its been an issue. Is the Earth's climate changing to a less hospitable place to live? At what rate is this change occurring? Is mankind responsible for some or a large part? How can you solve a problem that is global and involves the changing one of the basic economic engines of most economies—a cheap and abundant energy supply? How do we engage developing countries who will soon surpass the U.S. as largest greenhouse gas emitters?

Invariably, there are more questions than answers to this complicated issue. But, just because there are difficult and sometimes incomplete answers, does not mean we should continue to avoid the questions. We need to find ways to address this problem that avoid the traditional approach to environmental problems of assigning winners and losers. There are numerous promising technologies and new uses for old measures—such as conservation and carbon sequestration, that can bring progress forward without inflicting economic burdens. It is certainly more flashy to

cast this problem in terms of all or nothing solutions—but that is never how true progress is achieved.

Some of my colleagues are pushing for more research. I agree, this is a needed piece of the puzzle. But we can and should do more than that. We should be encouraging an aggressive investment in new cleaner technologies—which will, over time, create the economic means for us to tackle this problem in a more complete way than merely imposing punishing controls. But if we are to avoid arbitrary caps and burdens to industry, then industry must step forward and address the growing concerns posed by greenhouse gases. I am pleased that in my work on this issue, I have met with numerous companies who have accepted this challenge—specifically American Electric Power and BP have done pioneering work in finding cost effective ways to bring down or offset emissions.

I look forward to hearing more about the technological approaches being pursued and ways in which this body can assist in bringing these promises to fruition.

Senator KERRY. Well, Senator Brownback, I thank you very much, and I know you have been interested in this, and you have traveled to a number of the meetings, and it is going to be important to have your participation in it, and I certainly look forward to trying to do that.

I do think, if you listened to Dr. Evans who spoke on behalf of the administration, I presume, because he was the only witness we could get here from them, his testimony made it very clear that we have got to have a policy of no net emissions at some point. And every panelist has essentially agreed that the goal here is to try to get to a point where the science says unequivocally, that you can't keep adding CO_2 to the atmosphere.

The second panel presented a very interesting set of possibilities for ways in which you can avoid some of the hysteria that has surrounded this so-called debate. There are draconian pictures drawn that are just not what we face when you look at some of the things happening in the marketplace already, when you look at some of the technologies that are readily available, when you look at the narrowing down of the cost per kilowatt hour between what is dirty and what is clean. It is so close at this point in some regards that shame on us if we don't find a way to try to not pick a particular technology, but to create a framework where the marketplace is going to be able to decide which one of those works best and how.

I do think that Ms. Claussen's point about some kind of target is very realistic. None of us want to create a draconian outcome here that requires something unrealistic or has implications that can't be enforced or that disadvantages the United States relative to what others are being asked to do or are doing. But I think most people are looking at some potential goals and targets here that could at least create a mind-set, send a message that would establish our bona fides with respect to the others that we are trying to negotiate with and create a global partnership with in this effort.

And I think that it would have a profound impact on the marketplace, so that without ever getting draconian, we could excite the marketplace to recognize how serious it is. I mean, Ms. Claussen has these 36 companies—Intel, IBM is moving, ALCOA is moving, Polaroid. I mean, these are New York Stock Exchange major companies in the U.S. constellation of corporate excellence, and I think given their participation, what you would send to the rest of the marketplace is a message that could perhaps obviate Congress having to get its tentacles too much involved here.

So I think there are great possibilities, and I certainly look forward to working with you, Senator Brownback, Senator McCain, Senator Hagel, and others, and see if we couldn't come up with something reasonable, which I think would do us all credit.

I am particularly grateful to everyone on this panel for your extra patience in hanging in here, and the quality of the testimony here today, I think, speaks for itself. But I thank you on behalf of the Committee for sharing with us these important thoughts.

And the record will remain open for the 10-days that I suggested, and with that, we stand adjourned. Thank you.

[Whereupon, at 1 p.m., the hearing was adjourned.]

APPENDIX

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO FRANK CASSIDY

Question 1. You stated that your group of companies does not want to confront a situation in which you are forced to waste or put at risk large scale investments predicated on one set of requirements only to have the rules changed a few years down the road. For many older, existing facilities this is their concern about going to a mandatory system for carbon dioxide reductions today. What would you tell them to ease their fears about a mandatory system?

Answer. The only way to provide assurance that just such a scenario doesn't take place is by including mandatory requirements for carbon dioxide reductions in an integrated, comprehensive approach to power plant environmental performance. Including mandatory carbon controls in such a program will provide the industry with regulatory certainty on which to base decisions about investment in new facilities as well as how and whether to modify existing generating capacity.

The electric power industry has made considerable improvement in its environmental performance since the Clean Air Act became law 30 years ago. However, most of the improvements have resulted from regulations implemented on a pollutant-by-pollutant basis. The key public policy question is how best to deliver substantial additional emissions reductions necessary to protect public health at a time when continued supplies of safe, reliable, and affordable electric energy require considerable investment to rebuild an aging energy infrastructure.

It's my view that our industry and the capital markets on which we depend will respond more favorably to the certainty provided by an integrated approach than continuation of a piecemeal, pollutant-by-pollutant regulatory agenda. A multi-pollutant strategy with firm emissions caps will create a more stable environment for capital investment by providing long-term certainty about what the future demands on the industry will be in terms of environmental performance. Companies will be better able to develop strategies and justify investment in new and existing electric generating capacity with a clear understanding of future compliance obligations.

Question 2. Your proposed legislation for a mandatory cap involves timetables for implementation. How important are these timetables for the overall success of the effort?

Answer. I think it's very important from both the standpoint of environmental management and business certainty to establish clear and unambiguous requirements for the amount of emissions reductions and a timetable for delivering the reductions. I want to know what the targets are and when I have to meet them in order to develop a coherent action plan. And I also want to know that my competitors are obligated to meet the same set of requirements.

The timetables called for in the proposed legislation, in concert with predictable and reasonable emissions reductions targets and flexible and cost-effective compliance mechanisms, will deliver the benefits associated with reductions in the four targeted pollutants on an economically sound and sustainable basis.

I fully understand the concerns about the cost impact of making the reductions in the prescribed timetables called for in the legislation and the potential impact on the future of coal-fired electric generating capacity. I believe very strongly that continued use of coal for electricity generation is critical for maintaining fuel diversity, minimizing volatility in electricity prices, and protecting long-term energy security.

I also believe very strongly that the proposed legislation will not compromise the use of coal as an electric generating fuel, and in fact, the regulatory certainty and compliance flexibility called for in the legislation, will reduce barriers to investment in new, clean electric generation sources including coal.

Recent studies conducted by the Energy Information Administration and the EPA provide evidence that new power plant emissions requirements for nitrogen oxide, sulfur dioxide, and mercury would not significantly affect electricity prices or displace existing coal-fired generation. The flexibility mechanisms and timetables for

meeting carbon dioxide requirements included in the proposed legislation supports continued operation of existing coal-fired capacity as well as deployment of new technologies including advanced coal-generation technologies.

This issue is critical to evaluating the policy options and benefits associated with an integrated multi-pollution approach. The Clean Energy Group is close to completing an economic analysis of the costs associated with complying with the proposed legislation, and the preliminary results are encouraging. I would be pleased to provide the report to Senator McCain, other Committee Members, and appropriate staff when the analysis is completed, and would welcome the opportunity to meet with Senators and their staffs to discuss our analysis.

Question 3. The President has said he will pursue a voluntary approach at this time. What are your concerns from an environmental perspective with this decision?

Answer. A voluntary program, no matter how attractive, will allow certain companies to avoid internalizing the cost of carbon, placing those that "volunteer" at a competitive disadvantage relative to those who choose to continue to sit on the sideline. In a highly competitive wholesale power generation market, even small cost differentials can make a material difference, almost guaranteeing a race to the bottom.

I am hard-pressed to think of what "incentives" might be offered (including New Source Review flexibility) which would compensate a company like ours for taking a limitation on carbon in the absence of an industry-wide commitment. We'd be doing a disservice to federal policymakers if we ignored or understated this point.

We have been faithful participants in the U.S. Department of Energy's 1605b process from its inception; PSEG was, in fact, the first utility company in the nation to volunteer. Industry experience with this program, however, does little to engender confidence in the efficacy of voluntary approaches. I think most people recognize that the 1605b inventory of reductions is grossly inflated and fraught with inconsistencies in accounting, baseline measurements, and other measurement parameters.

The single greatest motivator for participation in a voluntary carbon program would be assurance that competitors in the wholesale generation market are also participants. As I have stated, we remain highly skeptical that a voluntary program can be crafted to achieve both real greenhouse gas reductions and 100% participation by our industry. This skepticism is part of what motivates us to continue to advocate a reasonable, mandatory greenhouse gas reduction program in the context of a four-pollutant/NSR reform legislative package for our industry.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ERNEST F. HOLLINGS TO EILEEN CLAUSSEN

Economic Benefits of Renewables Energy

Question 1. Ms. Claussen, a few years ago Ross Gelbspan made the following statements on the potential economic benefits to the US of investment in renewables.

"While the climate crisis contains staggering destructive potential, it also contain an extraordinary opportunity to expand the wealth and stability of the global economy."

"In a very few years the renewables industry could eclipse high technology as potentially the most powerful engine of the global economy."

Do you agree?

Answer. I disagree that this will happen within a few years. Most analysts believe that "greenhouse-friendly" technologies such as nuclear, solar, wind, biomass, hydro, and conservation will continue to improve and achieve larger market shares in the future. But an energy revolution will take time: it has taken on average a century for the global market share of every major energy technology—from wood to coal to oil—to rise from 1 percent to 50 percent of global consumption.

Question 2. What are the other economic benefits to the US of reducing emissions through technology?

Answer. Prominent economists such as Robert Solow have noted the importance of technological change as the major long-term determinant of continued increases in the standard of living.

Specific to greenhouse gas emissions, technological change can: (1) make carbon-based fuels less expensive (e.g., through improvement in the efficiency of fossil fuel extraction); (2) affect the overall rate of growth of the economy through improvements in labor productivity; (3) increase the rate of improvement in alternatives to carbon-emitting energy technologies; (4) increase the rate of improvement in the efficiency with which carbon-based fuels are used.

Question 3. Are there trade export opportunities that we are missing under the current approach articulated by President Bush and the Administration's Energy Policy?

Answer. Yes, I think so. The Administration's energy policy does not provide sufficient support for innovative clean energy technologies. The World Energy Council estimates that global investment in energy between 1990 and 2020 will be about $30 trillion in 1992 dollars. Two billion people in the world now lack access to electricity; and the developing world faces enormous environmental challenges. This presents enormous opportunities to export innovative clean energy technologies that can help the developing world "leapfrog" past some of the less efficient technological investments in the developed world. If U.S. companies develop these technologies here at home, and receive the support that they need in terms of research and development, and other domestic policies that encourage innovation, U.S. businesses and workers will reap the benefits of this huge export market. This will in turn enhance the long-term markets for other U.S. exports by building the energy basis for sustainable economic prosperity in other countries.

Question 4. Ms. Claussen, you say that the science is telling us we need to reduce greenhouse gas emissions over the long term, and that to do this we need "a new industrial revolution" that will involve introducing low-carbon energy efficiency technologies to the global economy. I am all in favor of improving U.S. competitiveness, but I see that many of the companies you represent have—in service of this "global economy"—sent may U.S. jobs overseas.

How will this industrial revolution help build U.S. jobs and improve U.S. exports?

Answer. See previous response.

Question 5. How far behind other countries is the U.S. in developing these technologies?

Answer. It is hard to say. The United States is ahead in some areas and behind in others. For example, U.S. energy companies have a significant market share of highly efficient gas-fired power plants worldwide. On the other hand, U.S. auto companies have focused innovative efforts on producing large and powerful, but fuel-inefficient vehicles, and are behind foreign manufacturers in producing highly efficient and hybrid-electric vehicles. United States companies face strong competition from European and Japanese companies in solar photovoltaic (PV) technologies.

Question 6. How do we ensure that U.S. technologies are on the leading edge and that jobs stay in the US over the long term—do your companies have a commitment to supporting US technologies?

Answer. We need a two-pronged approach. First, we need to promote a domestic market for these technologies through government policies, such as tax credits, efficiency standards, labeling, and federal procurement. The domestic market is key to a domestic industry's success in developing export markets. In other countries where gasoline is taxed heavily and is thus relatively expensive, consumers demand more efficient vehicles. Most of the U.S. solar photovoltaic industry's markets are now outside the United States, where the industry faces strong competition from European and Japanese manufacturers. The fastest growing market segment is for applications that connect directly into the electricity grid in Europe and Japan, both of which are promoting these applications through government policies.

Second, we need to increase energy R&D funding, through public-private partnerships and tax credits, based on a dedicated funding source. A sustained effort over many years is needed. This means that we must begin making investments and implementing policies now. It means we must develop institutions and funding mechanisms that will stand the test of time. It means that we must take a portfolio management approach—casting the net broadly for technology options, investing most heavily in the most promising approaches, and shifting our priorities over time as we learn what works and what doesn't, both in the research laboratory and in the marketplace.

The government has an important role in marshalling public resources, establishing goals and performance criteria, and providing incentives. But in the end, it is non-governmental innovators—scientists in search of knowledge, businesses in search of profits, non-governmental organizations in search of societal benefits—who will find most of the technological solutions.

The companies associated with the Pew Center have a huge presence in the United States, and would like to continue to prosper here. However, the greater the divergence between the United States market and that of the rest of the world, the more difficult it becomes for them to compete successfully both here and abroad.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO EILEEN CLAUSSEN

Question 1. What would it mean to U.S. competitiveness if the rest of the world signs the Kyoto agreement without the U.S. and thereby establishing key International environmental regulations?

Answer. In the short-run, the lack of U.S. action on climate change (and lack of participation in the Kyoto process) may appear a competitive advantage for companies here not having to operate under emissions caps. However, any short-term advantage will not be sustainable as the global marketplace moves toward more efficient, low-carbon technologies. Companies operating in areas governed by greenhouse gas (GHG) reduction requirements will likely be at the forefront of developing these technologies that can ultimately be exported to the rest of the world, and will be ahead of the curve in buying and selling emissions credits. Further, by leaving the design of the international trading system to others, we are missing opportunities to structure it to the advantage of U.S. companies. The uncertainty regarding future GHG restrictions will also make it difficult for United States companies to make important investment decisions, and they will need to operate under very different regimes here and abroad. Finally, the possibility of boycotts for U.S. products grows over time if the U.S. chooses not to participate in a global approach to addressing climate change.

Question 2. Do you feel that voluntary trading systems will fail without any eventual mandatory emission caps?

Answer. To date, efforts to limit GHG emissions in the United States have been limited almost exclusively to voluntary activities. Though some voluntary efforts have been successful, these reductions in GHGs have been more than offset by increased emissions associated with economic and population growth, resulting in overall growth in U.S. GHG emissions (an increase of 12 percent over the past decade). Voluntary programs can make an important contribution to a domestic climate change program, and can provide valuable experience for designing future mandatory efforts, but they cannot stimulate the broad engagement that will be required to achieve the level of emissions reductions necessary to stabilize the global climate.

Because a voluntary trading program does not have the certainty associated with it that a government program would, and because it would not require participation of all important sectors, it remains unclear how such nascent programs could relate to an eventual domestic and/or international trading system. A voluntary trading approach cannot realize the full environmental and economic benefits of a fully integrated, economy-wide (or even better, an international) GHG market.

Ultimately, an effective and affordable emissions reduction program must couple mandatory GHG reductions with technology development and market mechanisms.

Question 3. Can you comment on whether increasing energy efficiency often means increasing costs, at least initially, and whether US industries are willing to make that initial investment?

Answer. There are many ways in which U.S. companies can begin to increase their energy efficiency with practices that require very minimal investment and earn much greater savings. For example, United Technologies Corporation—one of the Pew Center's Business Environmental Leadership Council (BELC) companies—made an investment in $5,000 for computer labels that resulted in an annual savings of more than $225,000 at one facility simply by reminding employees to turn off their computers at night. Also, the EPA's Energy Star program has resulted in U.S. greenhouse gas reductions in the year 2000 equivalent to taking ten million cars off the road. 864 billion pounds of carbon dioxide emissions have been prevented due to Energy Star commitments to date, with cumulative energy bill savings of $60 billion through 2010.

Of course, more significant and permanent reductions will require greater investment, but announcing a policy and allowing time for capital stock to turnover to more efficient technologies will be key to ensuring that transformation to a lower-carbon economy is done in a cost-effective manner. Certainly, providing emissions trading opportunities also allows for the most-efficient reductions to take place first.

Many U.S. industries are already willing to make investments in more efficient and climate-friendly technologies and practices. The 36 members of the BELC are evidence of that commitment—not only through reducing their own on-site energy use, but also in making more efficient products and appliances. For example, in 2000, 91 percent of IBM personal computers and 100 percent of monitors qualified for the EPA Energy Star label. Through its new silicon-on-insulator technology, IBM has increased the performance of computer chips by about one-third while using up to three times less power. Likewise, Intel has developed a technology that allows

PCs to run more efficiently while reducing energy use by 60 percent. Total energy saved from this technology will reduce carbon emissions at Intel by 19.5 million metric tons over the next five years. (See the Pew Center website, http://www.pewclimate.org, for more information on BELC company initiatives.)

Question 4. You have stated that efforts to reduce U.S. emissions have been reduced to voluntary efforts. Mr. Hawkins does not seem to support voluntary efforts. In your opinion, how helpful are voluntary programs, such as the Chicago Climate Exchange, in reducing greenhouse gas emissions?

Answer. As mentioned above, voluntary programs can make important contributions to a domestic climate change program. To date, however, voluntary programs have not been sufficient to curb or stabilize U.S. greenhouse gas emissions. Internal emissions trading programs such as those initiated by BP and DuPont and intercompany pilot trading programs serve as useful laboratories and are obtaining early and cost-effective GHG reductions. However, such programs are not a substitute for a domestic economy-wide program that would have the backing of the federal government and yield significant and verifiable emissions reductions across all sectors.

Question 5. You state that U.S. companies will find the production of energy efficient products to be a business opportunity. Yet, in the last panel, Mr. German seemed to say that there was not a large consumer demand for efficient technologies. Is there global demand for energy efficient technologies, and what can U.S. firms do to stimulate this demand?

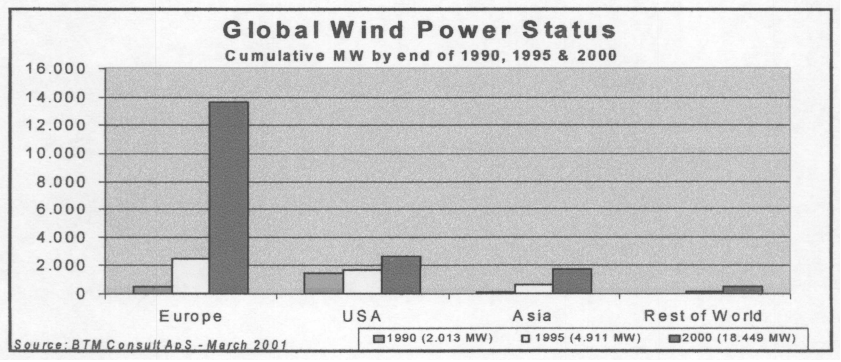
Answer. As EPA Administrator Christine Todd Whitman said in a recent press release regarding the Energy Star program's expansion into Canada, "Energy efficiency, through technology and innovation will be crucial to our energy security, as well as our quality of life, in the 21st century." (July 19, 2001, see http://www.epa.gov.) Demand for Energy Star-labeled products and buildings has grown. For example, by December of 1996, over 200 Energy Star homes had been built; by December of 2000, over 24,000 of these homes had been constructed. One way firms can stimulate demand in energy efficient products is through implementing education and product advertisement programs that demonstrate the annual energy cost savings of using more efficient appliances and other products.

The Pew Center's research has found that government can aid in expanding this market through incentives aimed at product manufacturers. Coupled with product efficiency standards, labeling requirements, and efforts to train appliance salesmen, builders, etc., the market for efficient products could indeed be a lively and vigorous one.

Response to Written Questions Submitted by Hon. John McCain to Dennis J. Duffy

Question 1. Who are the leading countries in the utilization of wind power? Where does the U.S. stand relative to these countries?

Answer. Currently, the leading countries in aggregate installed wind power are Germany (6,107 mw), Spain (2,836 mw), United States (2,610 mw), Denmark (2,341 mw), India (1,220 mw) and the Netherlands (473 mw). *World Market Update*, BTM Consult Aps. With respect to wind power as a percentage of overall supply, however, the U.S. is well behind many other nations. Denmark, which is half the size of Indiana, has nearly as much wind energy installed as the entire U.S., and wind currently supplies more than 15 percent of its electricity needs. Germany, which is half the size of Texas, has over 2,000 more megawatts of installed wind energy than the entire U.S. Further, the rate of annual growth (1999–2000) in wind energy for the U.S. (6.8%), falls well behind the growth rates of many nations of the industrialized world, such as Germany (37.5%), Spain (56.6%), the United Kingdom (17.4%), Denmark (34.7%), Italy (53%) and China (34.4%). Id. The relative volumes and growth trends for the past decade are set forth in the following graph:



Question 2. You mention in your written statement that wind units have a marginal cost of zero. Can you explain this further?

Answer. "Marginal cost" refers to the additional costs incurred in the production of a specific increment of a commodity, which would not otherwise have been incurred. In the electricity business, the marginal costs of production for most technologies consists primarily of the cost of fuel consumed in the process of generation, as well as any incremental O&M costs that would not have been incurred had the generation facility not been dispatched. In contrast to traditional combustion technologies, wind generation has "marginal costs" of close to zero, since there is no fuel costs and only insignificant O&M costs associated with any incremental production.

It is this ability of wind power to generate electricity without marginal costs that would cause consumers in deregulated power pools to see substantial reductions in their overall power costs. All sellers into these deregulated pools are paid the same "clearing price" reflecting the marginal costs of the last (and highest marginal cost) generating unit dispatched in any hour. The underlying theory is that overall efficiencies are achieved by dispatching pool resources according to their marginal costs in "economic merit" order, from the lowest to highest marginal costs. Because wind units have a marginal cost of zero, they are among the first units dispatched in every hour, with the result being that other units with higher marginal costs that would otherwise have been dispatched and set the clearing price are displaced from the economic dispatch and are not run. The clearing price for the entire pool is thus set by a unit with a lower marginal cost bid than would otherwise been the case. Because the resulting reduction in clearing prices is then applied to *the entire volume* of electricity traded in the pool, there is a multiplier savings effect, such that amounts extended to support a relatively small volume of wind power results in far greater costs savings through the reduction of generally applicable clearing prices.

Question 3. If wind power is as cost effective as you have stated, why are government subsidies so vital?

Answer. Although the cost per kilowatthour of wind energy has been reduced substantially in recent years, the capital cost of wind generation remains at a level where the growth of the U.S. wind industry still requires economic and regulatory market support. It must also be noted that the capital cost of wind generation (and hence the degree of support required) varies greatly amongst regions of the country, with such differential driven largely by varying transmission and construction costs and wind quality. In the Northeast, for example, the viable development of wind resources of substantial scale is limited to areas in mountainous terrain or offshore, both of which involve substantial construction challenges, as well as the requirement of new transmission lines in order to interconnect and deliver electricity to customer load centers. In any event, it is our belief that the relatively high capital costs of wind facilities would make them economically infeasible in most scenarios in the U.S. market absent continuing market support.

This is not to imply, however, that support for the wind industry would cause the public to pay any more for its power. To the contrary (and as noted in the response above), the price for power in deregulated pools is driven solely by bids reflecting the *marginal* costs of the last unit dispatched in any interval, such that initiatives to support the capital costs of relatively small volumes of wind generation are offset many times over by the resulting suppression of the energy prices applicable to the

entire volumes traded within the respective pools. I also note that the European nations that have taken the lead in wind development have done so with continuing market supports.

Question 4. Why are utilities not considering long-term purchases of renewable energy as part of their overall portfolio planning?

Answer. When most regions of the country undertook deregulation of their electricity markets, there was a common presumption that traditional utilities would continue to sell electricity at retail at a far lesser degree than had formerly been the case. The belief was that, upon the opening of deregulated markets, the bulk of retail customers would migrate to retail sales provided by competitive marketers unaffiliated with the traditional utilities. Thus, in many regions, the continuing role of utilities in retail sales was to be a "last resort" supplier, with rates reflecting current (*i.e.*, short-term) market prices which would serve as a benchmark against which competitive suppliers would propose sales to the public. Indeed, in some regions utilities were required to make all of their wholesale purchases in the spot markets and numerous jurisdictions still require utilities to make most of their wholesale purchases for durations of one year or less. Thus, many traditional utilities are reluctant to, and some cases precluded from, proposals for longer-term sales from wind generators, even if it can be demonstrated that such generation, through its lack of any marginal costs, would lead to substantial overall reductions in the price of electricity in the associated power pool.

Although competitive marketers are not so limited by regulatory policy, many are similarly reluctant to enter into long-term contracts for wind power, a reluctance which may be explained in part by uncertainties as to long-term regulatory policies and market conditions. In any event, the reluctance of purchasers to entertain long-term arrangements is a serious problem, for which the requirement of stated renewable portfolio standards ("RPS") percentages are an important market support structure. Such long-term RPS requirements are particularly important, since short-term pricing does not capture the full economic value of the economic hedge against fuel price volatility provided by wind energy.

Question 5. One constant criticism of wind power has been the reliability of the technology. However, Dr. Kammen has described a revolution in this technology. What recent developments have there been to improve wind technology?

Answer. Improved design of mechanical and electrical components has proven to be a major factor in augmenting performance, increasing turbine lifetime and reliability, and reducing cost. Structural engineers are today designing turbines that are both stronger and lighter in weight than their predecessors. They perform better, and they cost less to produce because they use fewer materials than heavier structures. These new designs reduce stress by flexing, rather then rigidly withstanding harmful loads such as those caused by turbulence. Likewise, engineers have developed new, flexible mechanical components, such as teetered hubs, which reduce these loads by allowing the rotor to pivot away from turbulent winds and thus relieve stress. Electrical components such as generators continue to improve dramatically. For example, some new turbines come equipped with variable-speed generators (and drives) with power electronics. Other advances include a low-speed generator that will eliminate the need for a mechanical gearbox, reducing costs accordingly.

Engineers at NREL and Sandia National Laboratories located in Albuquerque, New Mexico, have also developed a series of computer programs for designing state-of-the-art wind turbines. Using these programs, turbine designers can test new design ideas using sophisticated computer systems to model how they will perform and hold up under operating stresses before building expensive hardware. These codes lie at the heart of modern technological innovation, especially for using new lightweight materials.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ERNEST F. HOLLINGS TO DR. DAVID L. EVANS

Question 1. Dr. Evans, how well are we monitoring our carbon emissions?

Answer.

- Carbon emissions from various sources (industrial, transportation, agriculture, forestry, etc.) are monitored and estimated by different methods. The accuracy of these estimates varies by sector. U.S. aggregate greenhouse gas emissions are estimated by both the Environmental Protection Agency (EPA) and the Department of Energy's Energy Information Administration (EIA). Under an interagency agreement, the EIA, provides energy and energy-related carbon dioxide

emission estimates to the EPA. EPA uses these data, as well as estimates of methane, nitrous oxide and halogenated substances emissions, to compile the official U.S. inventory of greenhouse gases submitted under the UN Framework Convention on Climate Change in EPA's publication, "Inventory of U.S. Greenhouse Gas Emissions and Sinks." The information is available on the EPA website: *http://www.epa.gov/globalwarming/emissions/national/index.html.* EPA also receives highly accurate carbon dioxide emissions data from continuous emissions monitors directly from electric utilities as required under Title V of the Clean Air Act.

- EIA, as required by Section 1605(a) of the Energy Policy Act, also compiles annual estimates of greenhouse gases (carbon dioxide, methane, nitrous oxide and halogenated substances). These estimates can be found in EIA's publication "Emissions of Greenhouse Gases in the United States," and the information is provided by EIA on their website: *http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html.*
- The net effect of these emissions on the atmosphere can be monitored through atmospheric measurements. NOAA operates a global atmospheric carbon dioxide and methane monitoring program, collecting air samples from about 50 sites. This allows the determination of how much carbon dioxide remains in the atmosphere each year. When atmospheric carbon dioxide changes are compared with data on annual emissions, a composite estimate can be made (by subtraction) of how much carbon has been taken up by the oceans, plants, and soils. Since samples can only be collected once per week at present, and since the number of measurement sites is currently limited, the temporal and spatial resolution of such measurements is at best annual and global with resolution of the two hemispheres possible. In order to accurately monitor the atmospheric effect of carbon emissions on a regional basis, the number of measurement sites would have to be increased considerably.

Question 2. How can we engage in "Carbon Management" through limits, targets, early action, or credits if we don't know where our carbon is going?

Answer. NOAA is currently working to estimate how much carbon is going into the oceans and how much is going into the terrestrial biosphere (trees, plants and soils as a single entity) globally on an annual basis. However, the present atmospheric measurement network is adequate to do this partitioning only on a hemispheric basis. Regional data are currently derived primarily from inventories and mapping conducted by other agencies, such as the U.S. Department of Agriculture (USDA), the U.S. Geological Survey (USGS), and the National Aeronautics and Space Administration (NASA). The federal agencies of the U.S. Global Change Research Program (USGCRP) are working together through the U.S. Carbon Cycle Science plan to develop methods and tools that will improve the accuracy and effectiveness of carbon measurement and monitoring.

Question 3. What role could the Department of Commerce—NIST, NOAA, Commercial Services, International Trade Administration—play in the following domestic or international carbon management areas: (1) monitoring and adaptive management; (2) verification; (3) registry; (4) coordination; (5) trading; and (6) technology transfer?

Answer. NIST measurements and standards laboratories can play a central role in carbon management, specifically in the area of carbon monitoring. The proper NIST role would be to work with climate change experts in determining the proper measurements for carbon monitoring, to work with policy experts to determine the most effective monitoring network for total U.S. Carbon Emissions Management, work with national and international organizations and measurement experts in developing accurate and cost-effective measurement standards that support the U.S. interests and assure global acceptance of U.S. carbon monitoring results, to develop a nation-wide monitoring strategy and system and to work with state and local authorities to implement a cost-effective carbon monitoring system. NIST could play a continuing role in measurement quality assurance and conformity assessment throughout the United States.

ITA can advance U.S. objectives regarding carbon management and climate change by actively facilitating international trade of environmental technologies goods and services and attendant technology transfer. ITA works on behalf of U.S. environmental technologies providers and supports multilateral and bilateral liberalization of environmental technology trade, improved protection of intellectual property rights, as well as bilateral environmental technology cooperation. ITA also provides the full range of trade development and trade promotion services to U.S. environmental technology providers.

NOAA also has a strong role in global monitoring of greenhouse gases, particularly those involved in the carbon cycle. NOAA's Climate Monitoring and Diagnostics Laboratory makes ongoing discrete measurements from land and sea surface sites and aircraft, and continuous measurements from baseline observatories and tall towers. These measurements document the spatial and temporal distributions of carbon cycle gases and provide essential constraints to our understanding of the global carbon cycle. The measurement program includes air samples collected approximately weekly from a globally distributed network of sites. We also develop several products and services to make this information available to the public.

In addition, many U.S. climate change activities in developing countries and economies in transition are undertaken by USAID. Therefore, Commerce has worked with USAID, as well as with EPA and other agencies, to share information and coordinate efforts where appropriate.

Question 4. What role do you see the Advanced Technology Program and NIST as a whole playing in the development of new energy efficient technologies and advancing technologies to support renewable energies?

Answer. Facilitating the development and advancement of new technologies is at the core of the NIST mission. NIST sees an increasing demand for improved measurements, as well as the characterization of new energy efficient technologies, and technologies that support renewable energy. The development, acceptance, and usage of new technologies will not happen without the underpinning measurements that facilitate the selection and application of new materials, demonstrate their fit for purpose, or demonstrate increased energy efficiency or other advantages, such as reduced emissions.

The NIST Measurements and Standards Laboratories provide this critical measurement infrastructure. For example, NIST is making significant contributions to the acceptance and use of alternative refrigerants to replace the ozone-depleting chlorofluorocarbons. The NIST program is comprehensive and includes: industrial consultation on exploratory materials and newly commercialized fluids; thermophysical measurements and critical data evaluation; theoretical modeling; establishment and promulgation of international standards; and dissemination of the critical data to the private sector. This data is fundamental to the design of efficient refrigeration systems and is used by industries worldwide.

As further examples, NIST's work on the properties of advanced ceramics is aimed at the development of very high efficiency combustion engines; work on materials for solid-state lighting systems is aimed at developing next-generation energy-efficient lighting; development of standard reference data on the thermodynamics of bioprocessing that are critical for engineering biocatalytic processes used in manufacturing with renewable and/or more environmentally-friendly resources; and collaborations with our industrial partners on advanced fuel cell design will help develop cleaner, more fuel efficient vehicles. NIST and Advanced Technology Program (ATP) are participating in the Biomass R&D Board, a technical advisory committee of the Biomass Research and Development Advisory Committee, with the USDA, DOE, EPA, and other agencies, that was enacted under The Biomass Research and Development Act of 2000 and Executive Order 13134: Developing and Promoting Biobased Products and Bioenergy of 1999.

The NIST Advanced Technology Program cost-shares research in advanced technologies across several sectors that directly and indirectly impact energy efficiency and global climate change. The Advanced Technology Program directly impacts energy efficiency by funding projects focused on reduced fuel consumption, the development of alternative sources of energy, and more efficient processes for current energy technologies. For example, under an Advanced Technology Program project, Cargill-Dow LLC developed critical process technology that permitted them to recently launch a new $200M manufacturing facility to convert corn into plastics for consumer items. In FY 2000, thirty-five projects directly related to energy production or storage were part of ATP's active portfolio—the outlays totaled $30M.

The Advanced Technology Program funds projects that have a significant secondary impact on energy efficiency and environmental emissions, for example, through improved or alternative manufacturing processes and equipment in the chemical and transportation sectors. These secondary technologies include: sensors, software for industrial design and process control, composites, super alloys, hard coats for machine tools, catalysts, and refrigeration. For example, BalaDyne Corporation developed a vibration control technology to enable mass balancing of high-speed machining tools which could in turn enable companies to increase the quality and precision of parts for automobiles and other products, thereby improving downstream energy efficiency.

Industry feedback indicates that an increasing need for new technologies applied to energy efficiency and renewable energy will drive future investment opportunities in the Advanced Technology Program.

Question 5. Would you not agree that NIST's Advanced Technology Program would be the best vehicle to create and promote these innovative partnerships between science and industry?

Answer. The NIST Advanced Technology Program cost-shares high-risk research in public-private partnerships and accelerates the development of new technologies to generate widespread benefits for the Nation. One of the Advanced Technology Program's missions is to support and facilitate partnerships with the private sector, universities, non-profit organizations, and other Federal agencies. The Advanced Technology Program also has a long history of working synergistically with the mission-oriented agencies of the Federal government in areas where ATP can support high-risk applied research efforts that are either not within the mission of the other agencies or, though high risk, could enable later research by the mission agencies.

RESPONSE TO QUESTION ASKED AT HEARING BY HON. JOHN MCCAIN TO DR. DAVID L. EVANS

Question. What percent of the coral reefs in the oceans of the world are dying, in your estimation?

Answer. Dr. Donna Turgeon, a marine ecologist with the NOAA National Ocean Service, has just completed a draft report, "The Health of US Coral Reef Ecosystems: 2001," that is now under review with over 100 U.S. managers and scientists. According to Dr. Turgeon's report, ". . . [t]he scientific evidence is regarding worldwide degradation of coral reefs over the past decade . . . 36% of all reefs globally were classified as threatened by over exploitation, 30% by coastal development, 22% by inland pollution and erosion, and 12% by marine pollution. When these threats were combined, 58% of the world's reefs are potentially threatened by human activity ranging from coastal development and destructive fishing practices to over exploitation of resources, marine pollution, and runoff from inland deforestation and farming. [A]bout 10% of the world's coral reefs may already have degraded beyond recovery and another 30% are likely to decline seriously within the next 20 years. Further, the Global Coral Reef Monitoring Network (2000) reported coral reefs have continued to decline since its 1998 report. An estimated 27% of the world's reefs have been effectively lost, with the largest single cause being an extensive climate-related coral bleaching event in 1998."

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO DR. DAVID L. EVANS

Question 1. Recent National Academy of Science recommendations include the establishment of a National Climate Service which would focus on the weather monitoring as opposed to weather predicting. Can you highlight the distinction between weather monitoring and predictions? Also, how would a National Climate Service differ from the National Weather Service?

Answer. Most of our current observing systems were designed to provide input into forecasting daily weather events, i.e., storms, temperature and rainfall extremes. These systems are designed to monitor daily large environmental changes. As the data needs are more immediate in nature, new instruments that are brought online may not be calibrated to collect data consistent with older tools for long-term observations. Climate applications require data sets that document small changes in the environment occurring over seasons to decades, i.e., monitoring how the planet is changing. This places a premium on accuracy and consistency over time. Climate observation needs special data sets not needed for weather forecasts. The changing forcing of the planet by changes in greenhouse gases, aerosols, and solar radiation requires that well-calibrated observing systems for these be established.

The primary use of weather information is in the protection of lives and property. On seasonal to decadal timescales climate information is used for economic and long-range disaster planning, e.g., will there be more storms, what are the heating/cooling requirements this next season, will there be a drought, how to manage water resources, what crops to plant, etc. Climate forecast models also require a more interdisciplinary basis than is needed for weather forecasts in order to accurately incorporate factors such as chemical processes, carbon cycles, ocean dynamics, changes in land cover and surface albedo, and hydrologic processes. On multi-decadal to centennial timescales, climate information is input for policy decisions by

governments and the private sector: how large should emission reductions be; what new energy technologies should be invested in; what are the societal threats; and what carbon sequestration strategies might be pursued.

The different customer bases, e.g., economic and policy vs. protection of life and property, plus the need for new types of global observations and higher standards and uses for weather data, argue for the establishment of a Climate Service. Climate forecasts models also have to include more interdisciplinary physics, i.e., chemistry, interactive carbon cycles, global ocean dynamics, than are needed for weather forecasts. The need to run multi-decadal to centennial forecasts requires supercomputer resources that rival or exceed those needed for weather forecasts.

However, there are advantages to have a Climate Service closely linked to the National Weather Service (NWS). The Weather Service provides much of the data infrastructure. The forecast dissemination infrastructure of the NWS can be leveraged to provide links to the user communities. The modeling advances from each can be leveraged to make improvements to both kinds of forecasts.

Question 2. Do you feel that climate-related technologies are being efficiently transferred from the government sponsored research programs into the market place such that their real potential may be fully realized?

Answer. NOAA's climate-related activities are predominantly in the areas of research, observation and modeling. Technological advances have improved our climate observation systems. Computer simulation is one of the most important components of a comprehensive climate research program. The climate research community has made significant progress over the past 20 years, continuing the development and application of climate models. Efforts are planned within the U.S. modeling structure to more fully support the delivery of products critical for making climate simulation and prediction more usable and applicable to the broader research, assessment and policy communities.

As noted in the National Academy of Science report *Climate Change Science: An Analysis of Some Key Questions,* future climate change will depend on technological developments that may allow reductions of greenhouse gas emissions or the capturing and sequestering of these gases. However, technology transfer activities related to greenhouse gases are found primarily at other federal agencies, including the DOE, EPA, and USDA. Within the Department of Commerce, the NIST Advanced Technology Program has funded research into technologies aimed at improving energy efficiency and increasing the use of low carbon fuels. Federal programs within EPA and DOE promote greenhouse gas reductions through the development of cleaner, more efficient technologies for electricity generation and transmission. Internationally, USAID undertakes programs to help disseminate these clean technologies to developing country markets through pilot demonstration projects and structural reform initiatives. The Department of Energy's Carbon Sequestration Program, which focuses on ways to capture greenhouse gases and either store them or recycle them into useful products, has evolved into larger scale partnerships with private research institutions, industries, and universities sharing a major portion of the research costs. The private co-sponsors of these projects contribute an average of 40 percent of the total project costs, well above the Department's minimum requirement of 20 percent. This significant cost share will help ensure that climate related technologies are efficiently transferred into the market place.

Question 3. The President has requested the Secretary of Commerce to set priorities for additional investments in climate change research, to review such investments, and to maximize coordination among federal agencies. Can you comment on how those responsibilities may be distributed within the Department?

Answer. A well-coordinated interagency and interdisciplinary approach is critical for setting appropriate priorities and for addressing the complex issues of climate change research. The Secretary of Commerce is reviewing existing programs and developing recommendations for the President. Environmental data collection related to climate change research is a part of NOAA's mission. NIST is responsible for the national standards of measurements used by outside agencies to study some elements of climate change. Together, these two agencies provide critical components needed to effectively study and understand climate change in an interagency environment.

As with the other global change-related research carried out by the U.S. government, the resulting activity may also include additional Federal agencies, including those that currently participated in the U.S. Global Change Research Program.

Question 4. Do you feel that the uncertainties in the science discussed in the National Academy report on Climate Change is sufficient to justify waiting to take legislative action?

Answer. The scientific uncertainties identified by the National Academy have not in any way discouraged a strong national policy response to climate change, but have instead informed and directed the response appropriately toward enhanced scientific and technology research, development and application. The ongoing cabinet-level review of this important long-term policy challenge may result in additional policy options for legislation, in addition to the substantial measures announced by the President on June 11. Working closely with the Congress, the Administration will propose any new legislation that may be needed to implement the President's initiatives, when the interagency reviews and recommendations are completed.

Question 5. How has the ATP contributed to climate change research? How much funding has been spent in this area?

Answer. ATP's historical commitments in the generation and storage of electrical power and in environmental technologies total over $180M in high-risk enabling research projects. These technologies will directly impact energy efficiency and global climate change through reduced fuel consumption, development of alternative sources of energy, and more efficient processes for current energy technologies. In FY 2000, thirty-five projects directly related to energy production or storage were part of ATP's active portfolio—the outlays totaled $30M. The areas of research include oil and gas, batteries and super-capacitors, energy conservation, wind and solar, fuel cells, and motors and generators.

In addition, other ATP projects will have indirect impacts on energy and the environment as their technologies become distributed into manufacturing and other energy-intensive sectors. These technology development activities include high risk research in sensors, software for industrial design and process control, composites, alloys, hard coatings for tools, catalysts and biocatalysts, chemical separations, and refrigeration. Together, these additional technology developments will significantly increase the energy efficiency and reduce the emissions of manufacturing in the chemicals, materials, and transportation sectors.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. OLYMPIA J. SNOWE TO DR. DAVID L. EVANS

Question 1. NOAA has recorded a rise in sea temperatures. Presuming that this trend continues and is accompanied by an elevation of sea level, how is NOAA planning for such an occurrence? Are various NOAA programs for fisheries and coastal zone management incorporating this information into both short- and long-term planning and management processes?

Answer. According to the Intergovernmental Panel on Climate Change (IPCC), there has been a 10–20 cm rise in sea level over the last century globally. NOAA is responsible for maintaining the National Water Level Observation Network (NWLON) at approximately 190 stations around the U.S. coasts. The long-term measurements collected as part of NOAA's NWLON help provide the basis through which the rate of sea level rise can be determined.

NOAA has been active in assessing the potential impacts of sea level rise on the U.S., examining the potential for erosion, wetland habitat loss, and increased vulnerability of coastal regions to storm surge as a result of sea level rise.

The National Marine Fisheries Service (NMFS) has been involved in studying the potential impacts of global climate change on fisheries since the early 1990s. NMFS scientists co-chaired and co-authored the Fisheries Chapter of the 1995 IPCC Volume. The IPCC provides a status of global climate change research every five years. The volumes are compiled by teams of international scientists and broadly reviewed by the scientific community. NMFS also prepared a compilation volume on polar climate change impacts drawn from the 1995 IPCC volumes. By the very nature of the polar regions, impacts on fisheries were a significant portion of the work. NMFS scientists were technical reviewers of the recent 2001 IPCC volumes that updated the 1995 volume, but from a regional perspective. Similarly, NMFS provided technical review and comments on the recent National Assessment of climate change impacts coordinated by the USGCRP.

NMFS has maintained sections of headquarters and field websites focused on the potential impacts of climate change and the existing research that contributes to this understanding. An initiative has been developed to work with coastal communities to determine their concerns about impacts of climate change on their economies, ecology, and way of life. The initial regional workshops would serve as a coordinated discussion to make the most recent information about climate change available to communities but also to ensure that future research by NMFS would be directed toward the expressed needs of our constituencies. While funding has not been identified to implement the full initiative, NMFS scientists have been working

with the private sector to begin the efforts using private funding from competitive proposals. The Steering Committee is working with staff at local universities and calling on expertise across disciplines to help guide the discussions. NMFS' contribution will be to provide personnel, scientific expertise and contacts, and other in-kind services. The first workshop is being organized in Maine to look at the best estimates of climate change impacts on Maine fisheries and economies, to identify potential responses, and to determine if existing situations could be used as case studies to design innovative solutions that could provide guidance for communities in a changing climate scenario. NFMS is also working with other parts of NOAA and the U.S. Fish and Wildlife Service to investigate how data on sea level rise and associated alterations of coastal habitat can be used to guide habitat protection and restoration efforts.

Finally, NMFS scientists participate on a variety of committees and review processes to ensure that climate change impacts on fisheries and on coastal economies dependent upon marine fish and their habitat are addressed in ongoing research and assessments.

Question 2. How would an integrated network of ocean observatories aid NOAA's climate change research and modeling capabilities? What would be required to create such a network?

Answer. The integrated global ocean observing system for climate consists of in situ (fixed platforms [moorings and flux reference sites]; profiling floats; submarine cables; drifting buoys; shipboard [research and voluntary] observations such as expendable bathythermograph observations, thermosalinographs, and atmospheric observations, including precipitation; repeat oceanographic sections; and sea level gauges) and remotely sensed observations (satellite altimetry and scatterometry; coastal radars). It also includes satellite communications to transmit these data; support of shipboard operations; development of a real-time data management system; and the development of basic techniques to assimilate these data.

The overall ocean observing system should provide a four-dimensional (i.e., include spatial and temporal data) description of the oceanic variables of climatic and societal relevance. Fixed-point observations are required to resolve the variability associated with processes such as biological productivity relative to the carbon cycle, ocean bottom biogeochemical cycles; and air-sea interactions. Moorings are uniquely suited for sampling dynamic areas of the ocean such as high latitude regions and the deep ocean during adverse weather conditions. Fixed-point observations from moorings and observatories are an essential element of the required observing system because:

- they are uniquely suited for sampling two dimensions (depth and time), thus complementing other components of the observing system (satellites, drifting buoys, Argo floats, high frequency radars in coastal regions, etc.). They resolve temporal variability and are capable of sampling the entire water column, including the ocean bottom;
- fixed-point observations are the only approach for resolving multidisciplinary variability and processes such as biological productivity and the cycle of CO_2, ocean bottom processes, and air-sea interactions; and
- moorings are uniquely suited for sampling critical or adverse regions or periods such as boundary current regions, the deep ocean, and observations during storm seasons.

The observatory system would be multidisciplinary in nature, providing physical, meteorological, chemical, biological and geophysical time-series observations. The data would be publically available as soon as received and quality-controlled by the owner/operator. An international science team would provide guidance, coordination, outreach, and oversight for the implementation, data management, and capacity building. The initial implementation would consist of all operating sites (e.g., Bermuda Atlantic Timer Series, Tropical Atmosphere-Ocean Array, etc.) and those planned to be established within five years, subject to evaluation in terms of the qualifying criteria by the science team. This would initiate a pilot phase approximately five years in duration. During this pilot phase, the international science team and those that deploy and maintain sites will:

- identify gaps in the system and encourage filling those gaps;
- develop new technology for sensors and moorings;
- address implementation of the more challenging sites of critical importance, including multi-community and multi-national efforts;

- identify products and end users and establish routine provision of data from the sites to users;
- establish capacity building programs to enable participation in the observatory system;
- review all operating sites after five years, accept the ones proven useful into the longer-term system, add new sites for a new trial phase;
- complete the deployment of the global array using the new capabilities developed and reviews conducted; and
- work toward a transition to operational status.

An international effort is underway to develop the global array. Sites throughout the world's oceans, some already in operation, have been identified for potential implementation based on critical oceanic regions for climate purposes and ecosystem observations. International partners are evaluating their potential roles in implementing these sites.

Question 3. Should the Administration have a designated Office of Climate Change within the White House? Would this help to coordinate the science and the policy for U.S. climate change activities through the various departments and agencies involved?

Answer. In April, President Bush convened a cabinet-level policy review of this serious, long-term issue. That group has met many times to hear from leading experts on the issue and developed initial policy recommendations that the President announced on June 11. Specifically, the President announced the U.S. Climate Change Research Initiative and the National Climate Change Technology Initiative that will produce focused, prioritized and coordinated plans for federal scientific research in the next five years and significantly enhance research, development and deployment of advanced energy and sequestration technologies. Our success in developing those technologies will determine how effectively we can reduce the projected growth in greenhouse gases in the United States and internationally. The cabinet-level review group has continued to meet and plans to continue to do so in the near future, in order to continue evaluating additional national and international policy options to address climate change.

This ongoing cabinet-level policy review, along with the initiatives President Bush has announced to date, demonstrate that he recognizes the seriousness of climate change issues and that a coordinated response to these issues will have continuing high prioritization within the Administration. Within the Executive Office of the President, the Office of Science and Technology Policy and the Council on Environmental Quality provide ongoing coordination for program planning and implementation of climate change research, monitoring and technology activities at the interagency level. It is therefore unclear that creation of a designated Office of Climate Change within the White House would result in better coordination of U.S. climate change science and policy.

Question 4. How should any climate change policy be coordinated with the Energy Policy Development Group?

Answer. The President's high-level climate change working group has overlapping membership with the Energy Policy Development Group, which ensures coordination and consistency between the Administration's energy and climate change policies. In fact, the May 2001 report of the National Energy Policy Development Group specifically recognized the linkage between the policies, addressing the policy challenge of climate change directly in chapters 3 and 8. In chapter 3, for example, the report states: "Scientists continue to learn more about global climate change, its causes, potential impacts, and possible solutions. The United States recognizes the seriousness of this global issue as scientists attempt to learn more about climate change... .The United States has reduced greenhouse gas emissions by promoting energy efficiency and the broader use of renewable energy through a wide range of public-private partnership programs. These programs save energy, cut energy bills, enhance economic growth, and reduce emissions of conventional air pollutants as well as greenhouse gases. Industry and the federal government are researching various new technologies that will reduce greenhouse gas emissions or sequester those emissions, in geologic formations, oceans and elsewhere."

And in chapter 8, the NEPD Group recommended "that the President direct federal agencies to support continued research into global climate change; continue efforts to identify environmentally and cost-effective ways to use market mechanisms and incentives; continue development of new technologies; and cooperate with allies, including through international processes, to develop technologies, market-based in-

centives, and other innovative approaches to address the issue of global climate change." Importantly, in chapter 8, the NEPD affirmed that "the President is committed to addressing the issue of global climate change in a manner that protects our environment and economy."

Question 5. Are there current attempts at the President's Cabinet level and at the White House Office for Science and Technology Policy to coordinate both energy and climate change policies for both domestic and international environmental and energy strategies? If so, how is this being carried out and by whom?

Answer. The President's high-level climate change working group has overlapping membership with the Energy Policy Development Group, which should facilitate coordination between energy policy and climate change policy.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ERNEST F. HOLLINGS TO DAVID G. HAWKINS

Questions. Mr. Hawkins, the Bush Administration appears to be looking at ocean "sequestration" of carbon as a solution to the climate change and greenhouse gas emissions problem. Some have suggested that carbon could be taken up by increasing primary production of the oceans. Others have proposed that carbon be "buried" below the mixing zone of the oceans. This sounds a little like ocean "disposal" to me—but maybe I'm missing something.

- "What is your understanding of the sophistication of this technology?
- "How much can we rely on these technologies as a permanent way of taking carbon out of the atmosphere? How much carbon can oceans absorb?
- "The oceans have warmed substantially all over the world in the past 50 years. What would putting carbon into the oceans do to ocean temperatures?"

Answers. NRDC opposes the use of the oceans as disposal sites for carbon dioxide for a number of reasons. Science is still in the early stages of understanding the details of ocean ecosystems. Consequently, we have no idea what might be the ecosystem implications of large scale disposal of CO_2 into the oceans. Second, because we have only limited understanding of the movement of currents through the oceans of the world, we do not have a robust basis to conclude that disposal of CO_2 into oceans would keep those gases out of the atmosphere even for hundreds of years.

With respect to the effect of CO_2 disposal on ocean temperature, there would likely be some highly localized cooling of surrounding waters in zones where liquefied CO_2 is disposed. A more important temperature effect is that as warming penetrates the deep ocean, the capacity of the ocean to hold CO_2 is reduced, resulting in release of CO_2 back to the atmosphere.

There is another fundamental flaw in using the ocean as a disposal site. For any given amount of carbon in the biosphere, the total carbon will be partitioned between four major areas: the atmosphere, soils, forests and other vegetation, and the ocean. Absent continued increases in emissions from human activities, the carbon in the biosphere would equilibrate over thousands to tens of thousands of years based on the relative concentrations of CO_2 in the ocean and the atmosphere. If we continue to take carbon from the biologically isolated reserves of fossil fuels and "dispose" of it in the ocean, we will unavoidably increase the long-term concentration of CO_2 in the atmosphere because the resulting higher concentrations of CO_2 in the ocean will increase the concentrations at which the atmosphere and the ocean equilibrate. More CO_2 in the ocean means more CO_2 in the atmosphere as the ocean-atmosphere interface approaches equilibrium.

A final point worth noting is that most if not all forms of ocean disposal would violate the London Dumping Convention.

In contrast to ocean disposal, deep geological injection of CO_2 may hold promise as a technique for true long-term storage of significant amounts of greenhouse gases. Much evaluation work on the physical integrity of potential storage sites remains to be done but if pursued as one element of a portfolio of strategies to combat climate change, geologic storage may prove important as a bridging technique while world energy systems evolve to zero or minimal carbon options. Geological storage should not be regarded as a substitute for the critical work of improving the efficiency of energy production and use and increasing the penetration of renewable energy resources. But geologic storage may hold promise as a supplement to efficiency and renewable energy programs.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO DAVID G. HAWKINS

Question 1. What value or weight does the NRDC give to economic impact in its decision to support immediate action on the emissions reductions of carbon dioxide?

Answer. NRDC places great weight on the issue of the economic impacts of strategies to reduce carbon dioxide. We recognize that if policymakers believe that efforts to take action now to reduce carbon dioxide will be economically ruinous, they will resist taking action. We support action now because we believe that very substantial cuts in carbon dioxide will be required over the long term and to minimize both compliance costs and risks to the environment over the long term it is critical to send an unmistakable signal to the private sector now that carbon mitigation must be incorporated into investment and business planning decisions.

We believe that the more sound analyses show that the costs of taking action now to achieve limited but significant cuts in carbon, such as those called for the 1997 Kyoto Protocol to the Framework Convention on Climate Change, can be achieved without harming the US economy. Indeed, the Department of Energy's "Clean Energy Futures" study, released in November 2000, shows that an integrated program of caps on carbon emissions combined with policies to enhance reliance on renewable energy sources and programs to improve efficiency of energy production and use can cut carbon emissions dramatically and lower Americans' total energy bills by more than $100 billion per year.

In addition, we believe that establishing a requirement to reduce carbon emissions, when combined with appropriate flexible compliance mechanisms, will unleash massive cost minimizing innovations in the private sector as it seeks to find least cost ways to meet the carbon reduction obligation. The experience of the 1990 acid rain program crafted by the first President Bush is instructive. That program, which capped SO_2 emissions from the electric generating industry at levels about 50% below historic highs, was also opposed as being too costly to adopt when it was proposed. Estimates were made by industry and government studies that SO_2 allowances might cost more than $1000 per ton. Once enacted, however, the law stimulated efforts in industry to find least-cost compliance options and the result was a range of prices below $100 per ton for much of the program's first decade and still now below $200 per ton.

Initial cost estimates for new programs are always high because the regulated community does not set its best and brightest minds to work figuring out how to minimize compliance costs until the programs become a reality.

Question 2. You have stated some disdain for voluntary pledge to reduce emissions in your testimony. What do you think about voluntary carbon exchange systems, such as the Chicago Climate Exchange? Do you believe that these type of programs can be helpful in reducing greenhouse gas emissions"

Answer. Institutions like the Chicago Climate Exchange (CCX) are helpful in developing and testing the mechanisms that are likely to be relied on extensively in domestic and international programs to reduce greenhouse gas emissions. Under a program that caps emissions and allows participants to exchange or trade emissions to meet their obligations, there will be a need for efficient systems to register offers and carry out trading transactions. CCX can help develop and test such systems.

In addition, as with other pilot programs, CCX provides a forum for firms that decide to volunteer with an opportunity to gain experience not just with internal efforts to reduce greenhouse gas emissions but with real world operation of a sophisticated trading system for such gases.

While CCX may be successful in creating a pilot market for greenhouse gas trading, it is important to keep in mind that the market is the means to an objective, not the objective itself. In this case, the objective is to achieve significant reductions in greenhouse gas emissions. CCX can provide a vehicle for carrying out the objective but it cannot provide the motivation for a sufficient number of actors to use the vehicle.

For markets to sustain themselves, there must be a scarcity of the goods that are trading in the market. As long as greenhouse gas emitters can release their emissions to the atmosphere without cost to the emitter, there will be a sharp limit on the number of firms that will be willing to commit to a reduction in their emissions and pay a cost for not meeting that commitment.

Public policy action is needed to create a robust market in greenhouse gases that can accomplish a significant reduction in emissions. By capping allowable greenhouse gas emissions from the important emitting sectors of the economy, Congress can create the market conditions of a scarce (and therefore valuable) resource that a voluntary system cannot create.

Bills like S. 556, The Clean Power Act of 2001, would cap carbon dioxide and other major air pollutant emissions from the electric generating sector in a manner similar to the successful acid rain provisions of the 1990 Clean Air Act amendments. Under S.556 a market for trading carbon dioxide emissions would rapidly emerge and in contrast to a voluntary program, large-scale participation and effectiveness in achieving the objective of reducing emissions by a targeted amount would be assured.

Thus, the benefits of programs like CCX will be enhanced by policy actions to establish limits on the amount of greenhouse gases that can be freely emitted.

Question 3. An earlier panel discussed different types of renewable energy resources that can be used to reduce greenhouse gas emissions. Based on your studies, which resources show the most promise for widespread adoption and effective greenhouse gas reduction?

Answer. NRDC believes that increased reliance on renewable energy sources is an essential component of an effective strategy to reduce emissions of greenhouse gases, in particular carbon dioxide. Solar technologies and wind power, as well as biomass energy sources all have the promise to become a much larger part of the U.S. energy mix and NRDC supports efforts to break down market barriers to greater penetration of these resources. One important barrier is that the market does not value today the fact that these technologies do not contribute to the buildup of greenhouse gases in the atmosphere. This market barrier could be removed by adopting caps on emissions of greenhouse gases from the energy sector, such as S.556 would do. Integrating caps with policies to accelerate the expansion of available and affordable renewable resources would lower the overall costs of complying with the caps. Accordingly, NRDC supports an integrated policy suite of emission caps, a renewable portfolio standard, and a public benefits fund that would provide financial resources for greater reliance on efficiency and renewable energy sources.

Question 4. Some industry representatives have argued that caps on emissions will create reduced productivity, economic hardship, and increased unemployment. What is your response to these concerns?"

Answer. As I noted in my answer to question 1, when new policies are being debated, Congress is typically confronted with estimates that the policies will be ruinously expensive. History has demonstrated that the actual expense of implementing reform programs is usually significantly less than pre-enactment estimates for the very good reason that the entities whose behavior is changed under the reform program do not make significant efforts to minimize the costs of compliance until the policymakers have decided to adopt the reforms.

The current failure of the Congress and the administration to move forward with effective policies to require mandatory reductions in greenhouse gas emissions will encourage a "wait and see" attitude among many firms as long as this indecision persists. NRDC hopes that Congress will act soon to adopt greenhouse gas reduction programs. We are confident that the response of the private sector to adoption of such programs will be to dramatically expand the attention and resources it devotes to minimizing the costs of reducing greenhouse gases.

There is ample evidence that it is technically feasible to achieve major reductions of greenhouse gas emissions from key sectors like electric generators and motor vehicles without harm to the U.S. economy. As noted above, the Clean Energy Futures study by DOE concluded that an integrated policy set of emission caps, renewable energy programs, and advanced supply and demand-side efficiency programs can reduce consumers' energy bills by over $100 billion per year and cut carbon dioxide emissions by 30% from business as usual forecasts.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ERNEST F. HOLLINGS TO DR. DANIEL M. KAMMEN

Benefits to the U.S. Economy from Technology Development

Question 1. What kinds of technologies are our best bet for technology transfer and export advancement over the next 10 years.

Answer. Changes in the economies of both developed and developing nations over the next decade are likely to only accelerate the trends of: (1) the need for far greater flexibility in the security of energy services; (2) the need for energy services tailored to fit the needs of individual businesses, homes, and vehicles. Renewable energy systems—notably solar photovoltaic and solar thermal systems, windmills, biomass energy systems, and fuel cells—are each technologies that meet these demands (1 & 2, above). It is particularly important for energy systems to be able to deliver energy at any scale, from less than a mega-watt (MW) to 10 MW or more

reliably, and at least cost. The tragic attacks on both the Pentagon and the World Trade Center among other things illustrate the need for energy security, and quality in a distributed, often stand-alone fashion. Each of the renewable energy systems listed above can meet these conditions, *and* provide modular energy services that fit the needs of emerging markets in both developing and developed nations. Further, these are precisely what emerging distributed generation systems in the U.S. will need to move towards a clean, low-cost energy system. At present the U. S is lagging nations such as Japan (PV), Denmark and Germany (Wind), and Canada (Fuel Cells) in developing and commercializing these technologies *each of which saw their initial development phase take place in the United States.* Added material on the decline of R&D support for this critical emerging clean energy market can be found in two recent papers I co-authored with my doctoral student Robert Margolis (Margolis and Kammen 1999, 2001).

Margolis, R. M. and Kammen, D. M. (2001) "Energy R&D and Innovation: Challenges and Opportunities" in Schneider, S, A Rosencranz, and J. Niles, editors *A Reader in Climate Change Policy* (Island Press: Washington, DC).

Margolis, R. and Kammen, D. M. (1999) "Underinvestment: The energy technology and R&D policy challenge," *Science,* **285,** 690–692. WWW: http://socrates.berkeley.edu/~rael/Margolis&Kammen-Science-R&D.pdf

Question 2. What role will an international agreement on emissions reduction play—will it hurt or help the US ability to take a lead role in these technologies.

Answer. Contrary to some of the claims about the Kyoto Protocol (and now the Bonn Compromise), recent analysis indicates that by taking a leadership position on the prevention of global warming, the U.S. will *benefit* financially. The lack of support for the global warming treaty that the current U.S. administration has shown is therefore particularly troubling.

A range of studies are all coming to the conclusion that simple but sustained standards and investments in a clean energy economy are not only possible but would be highly beneficial to our nation's future prosperity.[i] A recent analysis of the whole economy shows that we can easily meet Kyoto type targets with a net increase of 1 percent in the Nation's GDP 2020.[ii] The types of energy efficiency and renewable technologies and policies described here have already proven successful and cost-effective at the national and state level. I argue that this is even more reason to increase their support. Figure 14 in my testimony shows how a combination of readily available options can be used to meet the Kyoto Protocol targets. This type of strategy would cost-effectively enable us to meet goals of GHG emission reductions while providing a sustainable clean energy future.

Krause, F., DeCanio, S, and Baer, P. (2001) "Cutting Carbon Emissions at a Profit: Opportunities for the U.S.," (International Project for Sustainable Energy Paths: El Cerrito, CA), May.

Question 3. Should we be using programs in the Department of Commerce like the Commercial Service to start exporting our existing technologies overseas?

Answer. As discussed in my testimony, we have decades of experience that market support and expansion through a combination of 'technology push' (i.e. support for R&D) *and* 'demand pull' (i.e. domestic and overseas technology education and market support) provide the best recipe for economic expansion. Clean energy technologies are no exception, and, in fact, show far larger returns on the investment than do older technologies such as fossil-fuels. In a recent paper, I detail the benefits that the U.S. has achieved through this sort of integrated technology policy in the energy efficiency as well as the renewable energy sector (Duke and Kammen, 1999). The Department of Commerce, as well as US AID and the Department of Energy as well as the U.S. EPA all provide opportunities to support clean energy market expansion. In the past these efforts have been scattered, and often uncoordinated. I recommend that an Office of Clean Energy Commerce be established to utilize the changing technology base as well as the latest economic and policy measures to help the U.S. recapture its leadership role in this area.

Duke, R. D., and Kammen, D. M. (1999) "The economics of energy market transformation initiatives," *The Energy Journal,* **20 (4)**, 15–64. WWW: http://socrates.berkeley.edu/~dkammen/dukekammen.pdf

Question 4. What do we need to do to get our R&D investment out to the market?

Answer. Certainly a key part of making effective R&D investments is also supporting 'demand pull' policies, as indicated in the response the question above. The

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[i] Interlaboratory Working Group.

[ii] Krause, F., et al, *op cit.*

other key issue, however, is to demonstrate a sustained commitment and support for clean energy technologies. As detailed in Margolis and Kammen (1999) as well as in my written testimony, federal support for R&D has been episodic, consisting of 'boom and bust' cycles. Research, development and dissemination, however, requires time to bring new ideas to market, and to overcome barriers in both the initial technology and in market economics. This can best be accomplished by demonstrating to the investors in new areas—such as renewable energy—that R&D and market support will not evaporate in the next budget cycle.

Margolis, R. and Kammen, D. M. (1999) "Underinvestment: The energy technology and R&D policy challenge," *Science,* **285,** 690–692. WWW: http://socrates.berkeley.edu/~rael/Margolis&Kammen-Science-R&D.pdf

NIST Role in Efficiency Standards

Question 5. What can NIST do to help the renewables and energy efficiency sector.

Answer. The greatest barrier that renewable energy and energy efficiency technologies face is simply that of barriers to enter the commercial energy market in the form of subsidies for fossil fuels. Coal, oil, gas, and nuclear energy all have very large subsidies, either through direct support, or through implicit subsidies in U.S. infrastructure, military actions, or political support. These are not always unreasonable, but they prevent our energy economy from becoming diverse, secure, and innovative. The following table, from my written testimony, highlights the degree of support for the fossil fuel and nuclear industry at the expense of other technologies, such as renewables.

NIST could play a significant role in evening this economic 'playing field.' Currently, few standards exist that explicitly reward clean air, human and environmental health. Several studies, for example, have found that the *direct* health impacts of coal burning rival the traditional economic cost of coal (i.e. doubling the 3–5 cents/kilowatt hour cost of electricity from coal. NIST could examine the set of metrics it uses and make recommendations for energy generation technologies that meet these standards. Regional air quality, greenhouse gases, air and watershed protection, and energy security through efficient use of energy could all be measures that NIST recommends and measures. Instituting these measures would significantly level the playing field while providing direct economic and health benefits to the U.S.

FUEL SOURCE	PRIMARY ENERGY SUPPLY 1998 CONSUMPTION		DIRECT EXPENDITURES and TAX EXPENDITURES (1999)	
	VALUE (quads, quadrillion BTU)	PERCENT	VALUE (million $)	PERCENT
Oil	36.57	40%	263	16%
Natural Gas *Alternative Fuels Credit*	21.84	24%	1,048 *(1,030)*	64%
Coal	21.62	24%	85	5%
Oil, Gas, Coal Combined			205	12%
Nuclear	7.16	8%	0	—
Renewables	3.48	4%	19	1%
Electricity			40	2%
Total	**90.67**	**100%**	**1,660**	**100%**

Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy,* (Washington, DC: DOE, 1999).

Question 6. How can they (NIST) assist other agencies, whether state or federal in improving our energy efficiency and increasing the availability of renewable energy to consumers.

Answer. There is a great deal that can be done to work across agencies to expand the role of clean energy in our society. Energy efficiency and environmental standards, if written to challenge the industry and encourage innovation provide the best,

market based, means to clean-up our energy mix. The California 'Zero Emission Vehicle' (ZEV) Mandate both accelerated the development of hybrid, fuel-cell, and battery-powered vehicles, but also rapidly accelerated the automotive industry around the world to produce far cleaner internal combustion engines. Thus, a clear, aggressive standard provided better existing technology and accelerated the development of a new industry.

As discussed in my written testimony, a Renewable Portfolio Standard (RPS) provides one of the best means to use the market to spur a larger clean energy component in our energy mix. An RPS is legislation which places an "obligation" on all sellers of power to the retail market to demonstrate through ownership of "renewable energy credits" that they have supported the production of a certain amount of electricity from qualifying renewable sources. These credits can come from either their own renewable power generating facilities, buying renewable power from other sources, or simply buying renewable energy credits. A renewable energy credit represents the environmental value of the kilowatt-hours generated from renewables, with the market price set through the flexible trading of these credits. The purpose of the RPS is to open the markets to clean energy production by ensuring the swift penetration of renewable energy into competitive electricity markets so as to bring down the costs until such a purchase obligation is no longer necessary.

An RPS has now been signed into law by at least 10 states: Arizona, Connecticut, Maine, Massachusetts, Nevada, New Jersey, New Mexico, Pennsylvania, Texas, and Wisconsin. Minnesota and Iowa also have a minimum renewables requirement similar to an RPS. Bills that include an RPS are pending in several other states. Although 12 States is a good start it is difficult to determine how many will ultimately pass comprehensive and effective RPS laws. If the number of states remain small then the U.S. will ultimately miss or greatly delay the opportunity to build a sizable market for renewables. Only with a healthy and significant renewable energy market can this industry become commercially viable, so that we may all benefit from the energy security and environmental quality that renewable energy can provide.

A national market for clean energy will have a dramatic impact on driving down the costs of renewable energy technologies and moving these technologies fully into the marketplace. A patchwork of state policies would simply not be able to achieve this goal. In addition, state RPS policies have so far differed substantially from each other. This could cause significant market inefficiencies negating the cost savings that a more comprehensive, streamlined, market-based federal RPS package would give.

Second, not every state program is set up effectively. A successful RPS requires several critical components. These include:

- The obligation to buy renewables must apply equally to all sellers of electricity
- There must be a system of tradable renewable energy credits this will achieve the renewables goal at least cost
- Demand must outstrip supply by setting the obligation at either the level of existing renewables, increasing it from that point; or by excluding existing renewables; or by using separate tiers for existing and new renewables
- The obligation must rise gradually and predictably to ensure a stable market
- Stiff penalties must be imposed on market players that do not comply with the obligation to buy renewables; the penalty must significantly exceed the cost of compliance
- Requirements for new renewables should begin at least two years after all regulations are final to allow time for competition among all potential suppliers
- The RPS must be long term, continuing until renewable kWh prices drop to competitive market levels at which point the RPS will sunset
- Qualifying renewables must be limited to those that need market support (i.e., not large hydropower) and meet certain clean environmental criteria
- There must be flexibility for meeting the obligation, with a limited period for making up shortfalls, a system of credit banking, and an exemption provision for the case of extreme events.

If any of these above criteria are not properly detailed in RPS legislation then the program will likely be either ineffective or operate suboptimally. To date, except for Texas, each of the states mentioned above have left out some number of these critical elements and consequently their RPS programs are not proving as successful as they should be at encouraging renewables growth. Such a track record is worri-

some if an RPS is to promote the level of renewable energy growth that we need in this country to achieve a sustainable clean energy future.

It is for these reasons that I strongly recommend the implementation of a federal RPS that incorporates at a minimum all the elements listed above.

An RPS represents one of the best uses of true market forces, where policy sets the standard but economic competition is used to meet that target. The many economic, environmental, health, and social benefits of clean energy generation makes this a natural area for federal legislative action.

NIST, working with the Department of Energy and the U. S EPA and Department of Commerce could, as indicated above, set clear standards for a clean energy component, and work to certify and support the development of new renewable energy technologies.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO DR. DANIEL M. KAMMEN

Question 1. You mentioned in your written statement that some of the options for achieving energy supply and demand balance have not been given adequate attention. What are some of those options.

Answer. A number of policies are available to increase the supply of renewable energy. Among the most logical to support are: (1) a Renewable Energy Portfolio Standard, RPS, (as discussed above); (2) consistent cost accounting across technologies that *reflect the true social cost of energy, including the health, security, and environmental impacts.*

(1) As indicated in my testimony, an RPS (for example 10% in 2010, rising to 20% in 2020) takes advantage of market forces to open historically biased energy markets to competition, while at the same time putting a premium on clean energy. This makes economic, security, and environmental sense.

(2) Consistent accounting, involving the *life-cycle* costs of different energy options, has not been practiced in the past, yet provide the best mechanism for inter-technology comparisons between both fossil-fuel and alternative energy technologies.

Question 2. Does your industry use some standard evaluation metric such as kilowatt hour per dollar invested, whereby we can evaluate their different technologies on a common basis.

Answer. As indicated above (item 2) consistent comparisons between energy technologies has not been widely practiced, largely due to: (1) the hidden subsidies inherent in many fossil fuel as well as nuclear energy technologies; and (2) the lack of accounting for so-called 'externalities' of air and water quality, health, and energy security (import dependence). A national study—conducted by the National Academy or by an inter-agency team, could provide the basis to provide the sort of consistent measurement metric that you describe. I strongly support such an initiative.

Question 3. In your testimony, you state that the current focus on energy issues has, "fostered an ill-founded rush for 'quick fix' solutions that 'will ultimately do the country more harm than good'." Could you please explain how concerns about an energy crisis can end up actually hurting efforts to study renewable energy sources?

Answer. There are two aspects of the current 'energy crisis' that have ironically discouraged investment in clean energy options:

(1) In the rush to address the energy crisis, expansion of gas-fired electricity capacity has been pushed by a number of political figures. Over 90% of new power plants planned in the Western U.S., for example, are set to be gas fired. This represents a huge over-investment in a single energy source, both on economic and energy security grounds. This expansion of gas-fired generation *locks-in* one technology, possibly for decades, and crowds out renewable energy technologies, even those that are lower cost on a life-cycle basis. This is bad economics and bad policy. Energy diversity is the most critically needed change in the energy economy.

(2) The U.S. energy R&D budget is relatively small given the central role of energy to the U.S. economy. Over-emphasis on energy sector—such as gas—restricts the support available for R&D in other areas. We have seen this time and time again in U.S. energy policy (see, for example, Margolis and Kammen, 1999). A logical, and economically prudent, approach, would be to use the sort of market-based approach to diversity the energy mix that could be achieved with an aggressive Renewable Energy Portfolio Standard (RPS) that I describe in my written testimony, or through the sort of life-cycle cost accounting and comparisons discussed above.

Margolis, R. and Kammen, D. M. (1999) "Underinvestment: The energy technology and R&D policy challenge," Science, **285,** 690–692. WWW: http://socrates.berkeley.edu/~rael/Margolis&Kammen-Science-R&D.pdf.

Question 4. Your testimony highlights a recent revolution in the cost and technologies for renewable energy resources. Could you please explain the factors that created this revolution?

Answer. The last decade has seen dramatic decreases in cost, and increases in performance, of solar, wind, and biomass energy technologies, as well as in hybrid vehicles, energy efficient lighting and fuel cells. In each case, a mixture of *technology push* and *demand pull* policies has created the opportunity and facilitated market growth for a new, clean technology. In the U.S. and overseas, in fact, we have seen that a combination of 'technology push' (i.e. support for R&D) *and* 'demand pull' (i.e. domestic and overseas technology education and market support) provide the best recipe for economic expansion. Clean energy technologies are no exception, and, in fact, show far larger returns on the investment than do older technologies such as fossil-fuels. In a recent paper, I detail the benefits that the U.S. has achieved through this sort of integrated technology policy in the energy efficiency as well as the renewable energy sector (Duke and Kammen, 1999).

Duke, R. D., and Kammen, D. M. (1999) "The economics of energy market transformation initiatives," *The Energy Journal,* **20 (4)**, 15–64. WWW: http://socrates.berkeley.edu/~dkammen/dukekammen.pdf.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO MAUREEN KOETZ

Question 1. If a favorable decision is reached on the long-term storage of spent fuel at Yucca Mountain, what would that mean for the nuclear industry?

Answer. The Nuclear Energy Institute agrees with the views of Nuclear Regulatory Commission Chairman Richard Merserve that "purely from a technical perspective, . . . the establishment of a disposal site need not be a precondition for new construction." NEI also holds the view that establishment of a used fuel repository is not a precondition for increased output from existing facilities, completion of partially constructed facilities for future operation, or plant relicensing. Several facilities have already been issued 20-year extensions on their licenses, and during the 1990's, the increased output from existing nuclear facilities was the equivalent of building 22 new 1000-megawatt reactors and running them at 90 percent capacity. Neither enhancement of nuclear operations created an adverse effect on our ability to manage used fuel.

Ongoing nuclear fuel management practices represent one of the most successful solid waste management systems ever implemented for an industrial process involving hazardous material, and these successful efforts will continue through on-site pool and dry cask storage while a long-term geologic repository is made ready. However, the industry also believes that a centralized repository to hold used fuel and other by-product nuclear materials must proceed with all deliberate speed. Since 1983, American electricity consumers have committed almost $18 billion to the Nuclear Waste Fund specifically to finance the federal management of used fuel, including $458 million by the ratepayers of Arizona. The Fund has a balance of about $10 billion, which must be made available for facility construction and operation.

Nuclear plant owners and operators are currently unfairly disadvantaged by the failure of the federal government to meet its obligations under the Nuclear Waste Policy Act to begin removal of used fuel from commercial facilities by 1998. These utilities and their customers have paid for a centralized facility, yet continue to have to pay for on-site storage as well. As competition develops in the electricity market, forcing double payments of this kind act as a hidden tax by the federal government on one of the cleanest forms of electricity available, distorting the market, and potentially undermining our future contribution to meeting environmental goals like managing the risk of climate change.

The Federal government's failure to meet its obligation could also expose a fundamental hypocrisy in our support for environmental protection goals and principles. All our waste management laws and programs are based on the premise that hazardous material should only remain on a production site long enough to be accumulated, packaged, and manifested—it should then be brought to a centralized facility where it can be best treated, stored or disposed of. For every other hazardous material handled in the United States, centralized facilities (usually designated as hazardous waste landfills) are open and operating in order to best protect the environment. In some cases, keeping hazardous material on a production site in excess of 90 days constitutes a violation of federal law. These other hazardous materials are routinely transported on public roads through populated areas in containers far less robust that those used to transport spent fuel. Our waste management programs

should not have two inconsistent systems for managing hazardous materials simply to satisfy political preferences at the expense of effective environmental protection.

The failure to complete and open a hazardous materials center for used radioactive fuel creates uncertainty in the future development of nuclear plants, threatens continued operation if states act politically to limit onsite storage, and undermines effective management of all hazardous materials nationwide. It also casts an unnecessary shadow on the single most effective technology available for eliminating greenhouse gas emissions that also supports economic growth. And although not a direct issue for commercial plant operation, the absence of a long-term disposal site can interfere with meeting cleanup deadlines at weapons complex facilities.

A favorable decision at Yucca Mountain would mean electricity consumers would finally get what they paid for, but more importantly, our nation would have a complete program that ensures environmental and health protection in the management of used fuel and other radioactive materials. It will also support the continued availability of a major tool to maintain our air quality.

Question 2. Can you comment on the status of standardized reactor designs? Is there a need for additional research?

Answer. The United States has always been the world leader in nuclear technologies. The industry has been working to set the stage for construction of new advanced design nuclear plants that will have more automatic safety systems and will be even more reliable and economical.

The NRC already has certified three such designs. Two units using a design by General Electric have been built and are setting world-class performance records in Japan, while others of this design are under construction in Japan and Taiwan. A variation of another certified design is being developed in Korea.

There are three additional reactor designs that are being studied for possible future use. The Pebble Bed Modular Reactor is currently undergoing feasibility studies in South Africa, and Westinghouse is determining whether to proceed with formal NRC review of its AP–1000 concept—a larger-scaled version of the already approved AP 600. In addition, General Atomics is considering commercialization of a gas-cooled reactor being developed that uses plutonium fuel from stockpiles of Russian weapons.

Beyond advanced reactor designs, industry executives have come together—contributing personnel, funding and guidance—to develop a plan that will mark a clear path for new nuclear plant orders. This plan for the future considers safety standards and objectives; NRC licensing requirements; policy and legislative implications; capital investment needs and changing business conditions. This effort is tied to the nuclear industry goal of building 50,000 megawatts of new capacity by the year 2020 in support of efforts to protect air quality and curb greenhouse gas emissions while maintaining a reliable electricity supply. Notably, developing 50,000 megawatts of new nuclear will only hold constant our current level of 30 percent emission-free electricity to support current and future emission control goals.

The ability to bring new nuclear plants to market in a timely manner must be demonstrated, however. The licensing process for future plants was laid out in the 1992 Energy Policy Act and has the potential to correct problems of the past. In particular, it allows for early resolution of safety and siting issues, and ample opportunities for public involvement, well in advance of large capital investments. There is a role for the Federal Government in assuring that the first-time implementation of this process does, in fact, meet the intent of Congress and the needs of the industry, regulators, and the public. Experience with certification of the three existing advanced reactor designs has shown the effectiveness of DOE-industry cost sharing. A similar effort to demonstrate the siting and plant licensing process would resolve many open questions and expedite business decisions to order new nuclear plants.

Research will remain key to achieving these goals. The United States Government has a right to be proud of its long history supporting scientific research and development. A key part of U.S. success in the world economy is the result of technical advancements that were translated into commercial applications to advance our knowledge, standards of living, longevity, protection of the environment, and support democratic and free market principles around the world. For these reasons, we should always support research to advance technology and the human condition. In the case of nuclear electricity, advanced reactors, improved fuel designs, and operational enhancements all stem from research and development. Continuing this effort is one of the recommendations on future R&D by the President's Committee of Advisors on Science and Technology (PCAST).

Our nation's research in nuclear energy has paid dividends in many categories for over four decades. Past research investment has improved safety, reliability, fuel and operational efficiency, and proliferation resistance at commercial electricity

plants. Nuclear research also supports our weapons programs to promote national security, reduce nuclear proliferation, and improve waste management practices at defense nuclear sites. Advanced designs are needed in international markets, creating trade and technology transfer benefits for both the United States and emerging economies in need of safe, environmentally sound electricity production.

But perhaps the largest dividend paid by nuclear research has been clean air. On an annual basis, generating electricity from nuclear reactors instead of alternative baseload sources prevents or avoids over 4 million tons of sulfur dioxide emissions, 2 million tons of nitrogen oxide emissions, 174 million tons of carbon (or 1 trillion pounds of carbon dioxide), particulate matter and mercury. This benefit cannot be duplicated or replaced. To maintain the contribution from this secure, emission-free source, developing advanced, standardized reactor designs for the immediate- and long-term must remain a key component of the energy/environmental policy of the United States over the next several decades. Research should not only continue, but expand.

Question 3. You have testified that U.S. policy originally envisioned recycling reactor fuel to separate out small volumes of waste, and that research continues on recycling fuel. Could you please describe the status of this research, when a program for recycling reactor fuel might be implemented, and how greatly a recycling program would reduce nuclear waste?

Answer. President Bush's National Energy Policy proposes to reconsider the option to recycle nuclear fuel. In 1977, President Jimmy Carter effectively banned civil reprocessing indefinitely in the United States to discourage other countries from similar programs, but this policy failed. President Ronald Reagan lifted the ban on commercial reprocessing in 1981, but by that time, abundant uranium resources had been found, the cost of recycled fuel far exceeded the cost of new fuel, and projections of uranium demand were falling due to plant cancellations. World uranium supplies are currently estimated to last 175 years without accounting for further exploration of anticipated reserves. However, growing electricity needs around the world, especially for cleaner fuel supplies, may lead to an increased rate of use for new fuel.

Ensuring sustainable development—coupled with the need to conserve fossil alternatives, such as gas, that supply other industrial and residential applications—may requiring more use of recycled as well as new uranium fuel in the long-term. According to British Nuclear Fuels, Ltd, a recycling company in Britain, 97% of fuel can be recycled and each ton reused saves about 100,000 barrels of oil. Recycling could increase the energy extracted from nuclear fuel by factors of 10–100, while at the same time reducing the volume of residual wastes that would eventually have to be stored in geologic repositories.

Two major areas of research are currently ongoing to improve the fuel recycling processes: electrometallurgical/pyroprocessing technology at Argonne National Laboratory, that would separate usable fuel material from wastes without producing weapons-usable plutonium; and transmutation of waste products to reduce residual radioactivity. Both are still in very preliminary stages of research.

However, the potential advantages of fuel recycling must be balanced against the overall economics of the fuel cycle, and the safety, radioactive emission, and proliferation potential inherent in fuel recycling technology. NEI strongly believes that the commercial nuclear fuel cycle should not create an unacceptable future proliferation risk. Advanced recycling technology may improve upon the proliferation resistance of the once-through commercial nuclear fuel cycle and further reduce the potential for diversion of nuclear materials for non-peaceful purposes. Innovations and improvements developed in the United States can improve recycling processes in countries where recycled fuel is used. However, in both once-through or recycled fuel systems, a geologic repository will be needed to provide a safe storage and disposal facility as part of the nuclear waste management system.

According to the Nuclear Energy Agency (NEA) in Paris, the concept of separation and transmutation of radioactive waste products should be explored and has the potential to contribute to the improved management of radioactive waste by reducing the proportion of long-lived isotopes it contains. Again, NEA is clear that it should not be considered as an alternative to deep geological disposal, and should not be presented as such. In addition, recycled materials will always create a certain amount of residue that can only be managed in a long-term repository. So irrespective of whether fuel recycling is pursued, geologic storage capability is always necessary.

Is the commercial industry prepared to deal with the security concerns surrounding the reprocessing of spent fuel?

Answer. Fuel recycling would only occur in the United States when economical to do so for electricity ratepayers. If recycled fuel were to be used, all the facilities used in the recycling process would be scrutinized and licensed by the Nuclear Regulatory Commission with all necessary safeguards in place. Experience with fuel recycling in France and Great Britain has demonstrated that a safe and proliferation-resistant system is both possible and successful.

Question 4. What levels of operations efficiency have been achieved by the nuclear industry to increase production at existing plants? How much more can be achieved?

Answer. The 103 nuclear plants in the United States produced 755 billion kilowatt hours in 2000, 20 percent of the nation's electricity. Since 1980, the capacity factor (or efficiency rate of plant utilization) has increased from 57 to 89.6 percent. Since 1990, the increased output at nuclear facilities has been the equivalent of building 22 additional 1000 megawatt plants with no significant adverse impacts to the environment (please see attached charts). This increase satisfied 22 percent of the growth in U.S. electricity demand over that time period.

It is expected that anywhere from 10–12,000 additional megawatts of output are still available from existing plants through additional operation efficiencies and capacity uprates.

Question 5. One of the public's major concerns about nuclear energy is safety, especially after Three-Mile Island, Chernobyl, and recent problems at Japanese nuclear facilities. Could you briefly describe what safety precautions are taken by American nuclear reactor operators to ensure safety in the United States?

Answer. Safety is ensured at nuclear power plants in the United States according to four interlocking steps:

1. extensive government regulations have been established to protect the public,

2. nuclear plants are built according to designs that meet the regulations,

3. owners are required to operate the plants according to approved specifications and abide by strict controls on changing the designs, and

4. regulators monitor operations and compliance with regulations through resident inspectors stationed at every site.

Multiple redundant safety systems. Nuclear plants are designed according to a "defense in depth" philosophy that requires redundant, diverse, reliable safety systems. Two or more safety systems perform key functions independently, such that, if one fails, there is always another to back it up, providing continuous protection.

Highly reliable automated safety systems. A nuclear plant has numerous built-in sensors to watch temperature, pressure, water level, and other indicators important to safety. The sensors are connected to control and protection systems that adjust or shut down the plant, immediately and automatically, when pre-set safety parameters are approached or breached.

Physical barriers safely contain radiation and provide emergency protection. Beginning with the nuclear fuel itself, fuel pellets are ceramic, locking inside the radioactive byproducts of the fission reaction. Three physical barriers are engineered to provide formidable defense-in-depth against the uncontrolled release of radiation. First, the fuel pellets are sealed inside rods made of special metal designed to contain fission products. Next, the fuel rod assemblies are contained within a large, thick steel reactor vessel. Lastly, the reactor vessel and extensive safety and steam generation equipment are enclosed, in turn, in a massive, reinforced steel and concrete structure, the "containment," whose walls are three to four feet thick. The containment ensures that the Chernobyl accident of 1986 a substantial radiation leak could not occur in the United States.

Multiple controls on the chain reaction. Control rods present in the reactor are adjusted to regulate the reaction by absorbing neutrons. In addition, the water level inside the reactor also moderates the reaction. Water ordinarily facilitates the reaction, but the greater the reaction and the greater the heat produced, the more water is turned to steam, leaving less to promote the reaction. In this way, the reaction is automatically moderated. Moreover, if the water were ever lost, multiple emergency cooling systems would activate to make up the water loss and keep the reactor from overheating.

Long-term maintenance for plant safety. Nuclear plant owners are continually implementing "life cycle management," a long-term plan for maintaining the plant's systems, structures, and components in good working order. *Preventive maintenance* consists of routine, scheduled activities to keep a plant's safety as well as non-safety equipment running or capable of functioning if needed. With more than

35 years of experience, plant operators have learned how systems wear and can refurbish or replace the vast majority before they fail. *Corrective maintenance* is performed on equipment that fails routine testing, breaks down during operation, or does not perform adequately. When the operation of an important component degrades or fails, plant operators conduct detailed, root-cause analyses, take corrective action, and share the lessons learned with all other plant operators throughout the industry and with regulators.

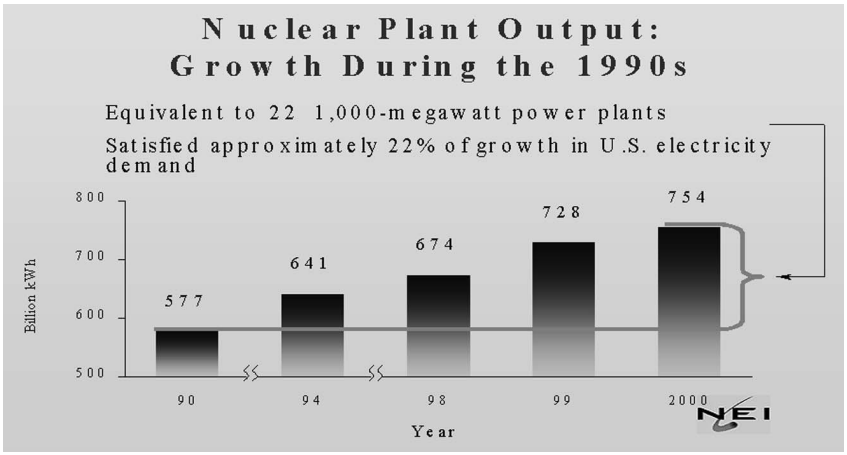
Plant fire protection receives special focus. Consistent with the "defense in depth" safety philosophy, there are multiple approaches to fire protection at a nuclear plant. *Prevention programs,* such as administrative procedures, inspections, and employee training, ensure the safe control of combustible materials and ignition sources. *Detection and suppression systems* and trained personnel are ready to control and extinguish quickly any fire that might occur. *Plant design,* intended to minimize the effect of fires on essential functions, specifies some combination of combustible-free separation, fire barrier, and fire detection and suppression systems between one set of systems and its back-up set.

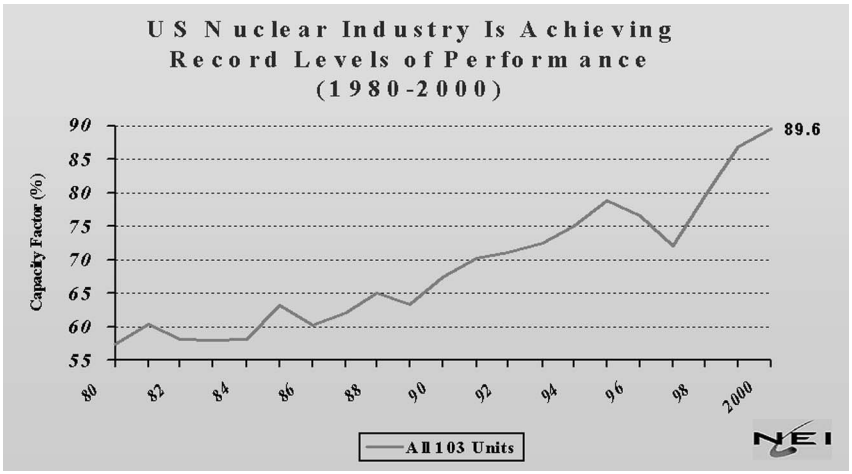
Industry-wide personnel training program for safe plant operation. Through the Institute of Nuclear Power Operations (INPO), the nuclear energy industry maintains a comprehensive system of training and qualification for all key positions at nuclear power plants. Workers involved in operations, maintenance, and other technical areas undergo periodic training and assessment. INPO developed industry-wide training and qualification guidelines and established procedures and criteria for training program accreditation. The National Academy for Nuclear Training integrates and standardizes the training efforts of INPO and all U.S. nuclear plant owners and operators. Each plant training program must renew its accreditation every four years. In addition, the NRC routinely monitors plant training programs and administers initial licensing examinations for plant operators.

Plant security protects against sabotage. Plant security resources and procedures are designed to prevent a hypothetical intrusion involving a paramilitary force armed with automatic weapons and explosives. Security measures include physical barriers and illuminated isolation zones; well-trained and well-equipped guards; surveillance and patrols of the perimeter fence; search of all entering vehicles and persons; intrusion detection aids, such as closed-circuit television and alarm devices; bullet-resisting barriers to critical areas; a contingency reaction force; coordinated emergency plans with off-site police, fire, and emergency management organizations; and regular drills and periodic procedural reviews. Employees undergo a variety of tests and record checks before obtaining various levels of security clearance, which is controlled by electronic key cards. Employees with unescorted access are subject to continual behavioral observation programs.

Technical Specifications, which are part of the operating license, place limits on how long key portions of safety systems can be out of service before the plant must be shutdown. In addition, technical specifications also require extensive surveillance tests at specified intervals to ensure that key safety systems are capable of performing their intended safety functions.

Reactor Oversight Process is an extensive performance monitoring program conducted by the NRC to ensure that licensees are performing to high standards of safety in seven key areas: minimizing initiating events, ensuring safety systems are capable of performing their function; ensuring the barriers to radionuclide release are maintained; establishing an effective emergency plan capability; controlling public radiation exposures from routine operations are maintained well within Federal standards; ensuring occupational radiation exposure is minimized and ensuring strict security measures are maintained. The baseline program includes approximately 2500 NRC inspection hours at each facility per year. The process considers the safety significance of identified performance issues and precipitates increased inspection activity based on the safety significance until the performance issue is corrected.





RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ERNEST F. HOLLINGS TO WILLIAM T. MILLER

Question 1. What are the current limiting factors for producing hydrogen?

Answer. Hydrogen production from fossil fuels is not an issue. Hydrogen for International Fuel Cells' (IFC) installed base of 220 stationary 200 kW PC25™ fuel cell power plants is derived from hydrocarbon feedstocks such as natural gas, propane and methane by using proprietary fuel processing technology.

For mobile fuel cell applications, IFC is working with the Department of Energy to develop fuel-processing capability onboard the automobile. This will enable vehicles to use pump grade gasoline in combination with fuel cells as a transition strategy until the necessary hydrogen infrastructure is in place.

Ultimately, the most cost-effective and environmentally sound approach is to fuel the vehicle directly with hydrogen and avoid carrying fuel-processing capability onboard the vehicle. This would require introduction of on-site fuel processors with hydrogen storage and dispensing capability. IFC believes that transit buses and government and private fleet vehicles offer the strategic path for deployment of the nec-

essary hydrogen infrastructure since these vehicles return to a central location each day.

In the long term, to achieve the maximum environmental benefit of fuel cells, we need to develop technology that can produce hydrogen from renewable energy sources instead of fossil fuels for stationary and mobile fuel cell applications.

Question 2. Where could Congress direct our efforts to support increasing the supply of hydrogen?

Answer. In general, Congress can help increase the supply of hydrogen by providing funding for hydrogen research programs that reduce fuel cell manufacturing costs and improve performance and efficiency. Funding for small fleet demonstrations is also necessary to document the operability, durability and viability of fuel cell powered vehicles.

Hydrogen fleet vehicle demonstration and development programs in both the government (including the military) and private sector could also be used to stimulate the market for hydrogen through government procurement of fleet vehicles powered by hydrogen. In addition, there's an important role for Congress in helping to educate the public concerning the safe use of hydrogen and the development of necessary codes and technical standards.

Legislation currently pending before the Senate addresses these needed programs. The Energy Independence Act of 2001 (S. 883) includes provisions that would create hydrogen fuel cell demonstration programs for commercial, residential and transportation applications including buses. In addition, S. 883 provides grants for state and local governments to deploy fuel cell technology and directs the federal purchase of fuel cells for stationary use and development of plans for deployment of fuel cells in federal vehicle fleets.

The Hydrogen Future Act (S. 1053) also provides a roadmap for needed hydrogen research, development and demonstration initiatives. Section 9 of S. 1053 lays out a strategy for the establishment of hydrogen power parks that integrates the use of stationary and mobile fuel cells. Under this concept, hydrogen fueled fuel cell power plants would be installed and generate electricity until the market for hydrogen vehicles matures.

In addition, Congress can provide incentives to the hydrogen producers as fuel cell vehicle deployment becomes imminent to encourage the expansion of hydrogen production capacity and retail distribution outlets.

Question 3. Is using hydrogen as a fuel source such a high-cost option that it will never make sense on a large-scale? Alternately, are current fuel sources "good enough," especially when compared to other types of power production?

Answer. Hydrogen is not a high cost fuel option. In recent analyses, conducted by a study team at Directed Technologies Incorporated, it was shown that for fuel cell vehicles hydrogen is the least cost fuel option when compared with gasoline and methanol. The cost of hydrogen use was calculated to be "about 2.6 cents/mile." The study, sponsored by the U.S. Department of Energy and the Ford Motor Company, is reported in the "International Journal of Hydrogen Energy" 25 (2000) pages 551–567.

The study also concluded that hydrogen is the preferred fuel in terms of:

1) Least infrastructure cost per vehicle. Specifically the authors note: "Gasoline was projected to require the greatest infrastructure cost in the form of relatively expensive and complex onboard fuel processor systems that have a capacity factor of less than 1%."

2) Greatest greenhouse gas reduction;

3) Near elimination of oil consumption; and,

4) Achieving a sustainable energy future for the transportation sector since hydrogen can be produced from wind, photovoltaic, solar thermal, hydroelectric, biomass or municipal solid waste sources.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO WILLIAM T. MILLER

Question 1. You mentioned that fuel cell technology produces 60% more electricity per pound of carbon dioxide emitted than the average U.S. combustion based power-generating system. How does fuel cell technology compare to some of the other technologies discussed here today?

Answer. Attached is a chart (Attachment A) that shows the comparison of fuel cells versus various technologies including the average U.S. fossil fuel plant, microturbines and combined cycle gas turbines. Nuclear, solar and wind technologies produce no carbon dioxide emissions, but are not applicable to the diverse applica-

tions that fuel cells can serve including distributed generation capability for residential and commercial power requirements as well as powering cars, trucks and buses. In addition, fuel cells can operate regardless of time of day or weather conditions and have no significant hazardous disposal issues. In fact, fuel cells can compliment wind, solar and nuclear technologies through a hydrogen storage mechanism.

Question 2. What is the most limiting barrier to the widespread commercialization of fuel cells? Are there regulatory barriers which the government can address?

Answer. The cost of fuel cells has been one of the greatest impediments to their commercial use. However, the costs have been reduced dramatically in the past two decades. The space shuttle fuel cells, developed in the late 1970s by International Fuel Cells (IFC), cost roughly $600,000 per kW. IFC's PC25 commercial stationary unit, which was developed in the early 1990s, has an installed cost today of $4,500 per kilowatt.

IFC and other fuel cell companies are now developing new fuel cells that are smaller, lighter and cheaper to produce. This new technology, along with higher production volume, should help reduce the cost of fuel cell power plants by two-thirds by 2003, from $4,500 a kilowatt to $1,500. Legislation proposed in the 107th Congress (S. 828/H.R. 1275) to provide a $1,000 per kilowatt tax credit for stationary fuel cells is a critical strategy for helping to reduce costs and thereby increase volume which will accelerate the commercialization of fuel cell technology.

In addition there are a number of regulatory barriers faced by fuel cells as a distributed generation technology that need to be overcome. IFC recommends that the federal government:

- Adopt a common technical standard for interconnection of small power generation devices to the U.S. utility system based on the Institute for Electrical and Electronic Engineers' (IEEE) 1547 recommendation.
- Establish streamlined procedures and appropriate exemptions for smaller sized fuel cell units.
- Minimize the competitive impact of exit fees and stand-by charges.
- Standardize user fees for Independent Power Producers (IPPS) in the same geographic region.
- Require states to ensure that the "buy" and "sell" rates of power are the same for any given time of day or year.

Question 3. You have highlighted a number of examples of research to put fuel cell technology into cars, such as the IFC/Hyundai Santa Fe vehicle. When do you believe that fuel cell technology will be ready for widespread use in automobiles? What will be the added cost to consumers of buying cars with fuel cell technology?

Answer. We believe fuel cells will be widely available for personal automobiles by the end of the decade.

The ultimate goal is to ensure that consumers see no initial purchase price or operating characteristic differences between the cars they operate today and fuel cell powered vehicles. In order to achieve this goal, the fuel cell power plant must cost less than $50 per kilowatt. The achievement of this goal is the challenge we face.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. OLYMPIA J. SNOWE TO WILLIAM T. MILLER

Question 1. Other than cost, what barriers must fuel cells overcome to increase their usage?

Answer. In addition to the cost barriers, there are a number of regulatory challenges faced by fuel cells as a distributed generation technology that need to be overcome. IFC recommends that the federal government:

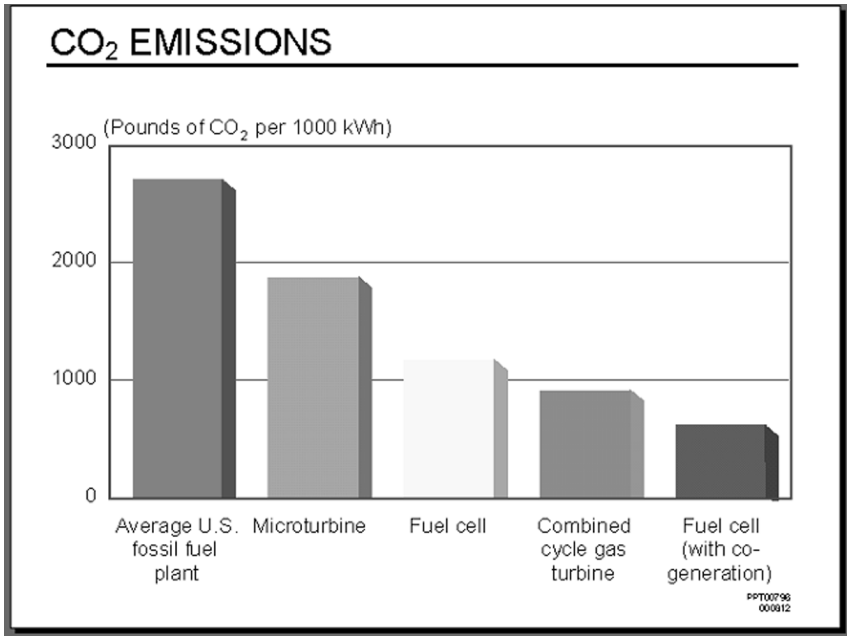
- Adopt a common technical standard for interconnection of small power generation devices to the U.S. utility system based on the Institute for Electrical and Electronic Engineers' (IEEE) 1547 recommendation.
- Establish streamlined procedures and appropriate exemptions for smaller sized fuel cell units.
- Minimize the competitive impact of exit fees and stand-by charges.
- Standardize user fees for Independent Power Producers (IPPS) in the same geographic region.

- Require states to ensure that the "buy" and "sell" rates of power are the same for any given time of day or year.

Question 2. Besides a tax credit, what other methods would you recommend to provide economic incentives for fuel cell use?

Answer. IFC supports enactment of a five-year $1,000 per kilowatt tax credit up to one third of the cost of the equipment for stationary fuel cells. (See Attachments B and C for details.) This will enable homeowners and business property owners to invest in the technology, increase volumes and bring costs down to accelerate the commercialization of fuel cell technology. In addition, financial incentives are needed for non-tax paying entities such as federal and municipal government facilities, schools and non-profit organizations. IFC supports continuation and expansion of the existing DOD/DOE fuel cell buydown grant program for public sector and non-profit organization investment in fuel cell technology as outlined in Attachment D. An $18 million FY 2002 DOD appropriation is being sought for this initiative as indicated in the attachment.

Attachment A



Attachment B

Why Should Congress and the Administration Support a Stationary Fuel Cell Tax Credit?

Overview

A fuel cell is a device that uses any hydrogen-rich fuel to generate electricity and thermal energy through an electrochemical process at high efficiency and near zero emissions. Fuel cell developers, component suppliers, utilities and other parties with an interest in clean distributed generation technology are working together to enact tax credit legislation that will accelerate commercialization of a wide range of fuel cell technologies.

Credit Description

The $1000 per kilowatt credit will be applicable for purchasers of all types and sizes of stationary fuel cell systems. It will be available for five years, January 1,

2002–December 31, 2006, at which point fuel cell manufacturers should be able to produce a product at market entry cost. The credit does not specify input fuels, applications or system sizes so a diverse group of customers can take short-term advantage of the credit to deploy a wide range of fuel cell equipment.

Why is a fuel cell tax credit necessary?

- A credit will allow access to fuel cells by more customers NOW when there is a grave need for reliable power in many parts of the country.
- A credit will speed market introduction of fuel cell systems.
- A credit will create an incentive for prospective customers, thus increasing volume and reducing manufacturing costs. As with any new technology, price per unit decreases as volume of production increases.
- A credit will speed the development of a manufacturing base of component and sub-system suppliers.

Benefits of Speeding Market Introduction through Tax Legislation

- Because fuel cell systems operate without combustion, they are one of the cleanest means of generating electricity.
- While energy efficiency varies among the different fuel cell technologies, fuel cells are one of the most energy efficient means of converting fossil and renewable fuels into electricity developed to date.
- Fuel cell systems can provide very reliable, uninterruptible power. For example, fuel cells in an integrated power supply system can deliver "six nines" or 99.9999% reliability. Thus fuel cells are very attractive for applications that are highly sensitive to power grid transmission problems such as distortions or power interruptions.
- As a distributed generation technology, fuel cells address the immediate need for secure and adequate energy supplies, while reducing grid demand and increasing grid flexibility.
- Installation of fuel cell systems provides consumer choice in fuel selection and permits siting in remote locations that are "off grid."
- Fuel cell systems can be used by electric utilities to fill load pockets when and where new large-scale power plants are impractical or cannot be sited.
- Fuel cell systems, as a distributed generation resource, avoid costly and environmentally problematic installation of transmission and distribution systems.

Cost

The five-year budgetary impact of the credit is less than $500 million.

Attachment C

Key Elements of a Fuel Cell Tax Credit for Stationary Applications

Overview

The goal of the stationary fuel cell tax credit is to create an incentive for the purchase of fuel cells for residential and commercial use. The prompt deployment of such equipment will generate environmental benefits, provide a reliable source of power for homeowners and businesses, reduce our nation's dependence on foreign oil supplies, help commercialize clean technology, enhance U.S. technology leadership and create economic benefits for the nation.

Fuel cell tax credit proposals should be designed to benefit a wide range of potential fuel cell customers and manufacturers. They should therefore be all-inclusive without discriminating between different kilowatt sized units, type of technology, application, fuel source or other criteria. Efforts should be made to keep the proposals as simple as possible to aid in effective implementation. In addition, the proposals should strike a balance between ensuring the level of tax credit provided represents a meaningful incentive that will stimulate purchase and deployment of the technology while minimizing the budgetary impact.

The following are specific elements suggested for consideration and inclusion:

Coverage

U.S. business and residential taxpayers that purchase fuel cell systems for stationary commercial and residential applications should be eligible for the credit.

Basis for credit

The credit should be based on a "per kilowatt" approach with no distinction made for the size of unit.

Access to credit

No allocation of credit should be made to specific categories of fuel cells on an annual or total basis.

Fuel Source

No premium or penalty should be imposed based on the fuel source.

Definition of stationary fuel cell power plant

The term 'fuel cell power plant' should be defined as "an integrated system comprised of a fuel cell stack assembly, and associated balance of plant components that converts a fuel into electricity using electrochemical means."

Co-generation

No co-generation requirement should be imposed since not all fuel cell technologies offer an effective option for co-generation.

Efficiency

No efficiency criteria should be imposed. Fuel cell systems in the early stages of development, such as residential sized units, cannot predict the efficiency level at this time. Establishing arbitrary efficiency criteria could exclude early models for this important application, which are exactly the units that require incentives. Efficiency levels will vary based on whether proton exchange membrane, phosphoric acid, solid oxide or molten carbonate fuel cell technology is used. Designing fuel cell systems to maximize efficiency may require tradeoffs resulting in more complicated, higher cost, less fuel flexible and less durable units.

Floor/ceiling

No minimum or maximum kilowatt size criteria should be imposed.

Amount of Credit

$1,000 per kW for all qualifying fuel cell power plants. A five-year program with a $500 million budgetary impact is proposed.

Duration

1/1/02–12/31/06.

Attachment D

The Stationary Fuel Cell Incentive Program

Background

The Departments of Defense (DoD) and Energy (DOE) have cooperatively supported the development and commercialization of domestic stationary fuel cell systems since 1996. In 1995 Congress appropriated funds for the DoD Office of the Assistant Secretary for Economic Security for a competitive, cost-shared, near-term Climate Change Fuel Cell Program (H.R. 103–747).

The Program grants funds to fuel cell power plant buyers to reduce the high initial cost of early production systems, providing up to $1,000 per kilowatt of power plant capacity not to exceed one-third of total program costs, inclusive of capital cost, installation and pre-commercial operation. For the program's six years, the grant program significantly aided commercialization of the first generation of fuel cell systems as intended by the Congress.

Benefits of the Program

The fuel cell grant program has expedited market introduction of early fuel cell systems. Production quantities are low and first time costs (e.g. engineering, manufacturing facilities, tooling) are high, yielding high early unit capital costs. The grant program has facilitated an increase in manufacturing quantities thereby reducing unit cost and enabling early adopters to participate in demonstrations and field trials. Lastly, federal participation in fuel cell demonstrations and field trials has encouraged, in some cases, supplemental support from state agencies or electric utilities, further reducing costs. In virtually all cases, fuel cell projects would not be possible without the grant program support.

Requested Action

$18 million in FY 2002 funding is being sought for the fuel cell grant program at $1,000 per kW capacity. This level of funding is needed to support the growing number of fuel cell technologies and manufacturers that are bringing new fuel cell products to market. The criteria used to select applications for a program grant should be identical to that used in the last year of the program's operation.

The key criteria include, but are not limited to: demonstration by applicant of a commitment to purchase and use fuel cell power plants with a rated capacity of at least 1 kW; power plants purchased before September, 2000 are not eligible; grants awarded consistent with the amount of funding available; applicants must comply with all National Environmental Policy Act and other applicable regulatory requirements; signed contract within 60 calendar days of being notified of award required; first payment to applicant (70%) made after applicant submits a signed factory or site acceptance test form; second payment (30%) dispersed after receipt of acceptable report covering a year of fuel cell operation; applicants cannot be fuel cell vendors, manufacturers or developers; priority given to projects using DoD installations; all fuel cell technologies are eligible; no restrictions on fuel type; applicant's fuel cell vendor must offer commercial warranty for one calendar year of operation; and, it is desirable to select for award a group of projects representing diverse sizes, applications, fuels and locations.

Anticipated Program Benefits

Presently there are several fuel cell technologies completing advanced development and nearing commercial readiness. Over a dozen U.S. fuel cell manufacturers will field products that qualify for program grants. The fuel cell grant program has enjoyed bipartisan Congressional support for many years. Continuation of this initiative will benefit the nation by accelerating deployment of environmentally benign, reliable, distributed generation technologies to provide needed new electricity capacity.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO DR. RICHARD L. SANDOR

Question 1. You mentioned that the Chicago Climate Exchange will focus on downstream sources of carbon dioxide emissions. How does this approach compare with other trading systems?

Answer. Various market architecture design options were considered in our research study. A market could include emission limits taken by fossil fuel producers and processors—the "upstream" entities in the carbon emissions cycle—or by major "downstream" sources that burn fossil fuels, such as electric power generators, factories, and transport firms. An "intermediary" level approach could focus on firms that produce energy consuming devices, such as automobiles, or other intermediaries such as fuel distributors. Based on responsiveness (the ability of participants to directly cut emissions), administrative costs and existence of successful precedents, the recommended approach is a predominantly "downstream" approach. Accordingly, the research findings suggest the CCX should aim to include participation by large emission sources at the downstream level (e.g. power plants, refineries, factories, vehicle fleets).

Question 2. Can you discuss some the non compliance penalties for the participants in your exchange?

Answer. We are discussing with this issue with the participating companies. While we believe it will be critically important to establish clear consequences if a participating company does meet its commitments, the nature of a pilot market allows us to consider a variety of options.

Question 3. How important are mandatory emissions reductions to the future of the Chicago Climate Exchange?

Answer. The effectiveness of the market, and realization of its environmental objectives, depends critically on the voluntary acceptance of specified emission reduction objectives. Action by a government authority to mandate reductions is not necessary for the Chicago Climate Exchange to realize its objectives.

Question 4. You have mentioned the need for a registry and best practices for measuring and calculating emissions. Can a government support registry and standardized methods for measuring and reporting emissions help both your trading exchange and others like it?

Answer. Yes, both these sorts of efforts can help.

Question 5. In order to join the Chicago Climate Exchange, a company must meet requirements to cut its 1999 levels. Have any members of the Chicago Climate Exchange expressed concerns that reductions in emissions might hurt the economic well-being of the companies, or lead to reduced profits and unemployed workers?

Answer. No, we have not heard these concerns voiced in discussions with industry.

Question 6. The Chicago Climate Exchange program will exist until 2005. What will your plans be after it has ended? Do you intend to extend or enlarge the program?

Answer. We expect to enlarge the program over time, and, at this time, we would expect to extend the program past the 2005 timeframe. Enlargement to allow participation throughout the NAFTA region (U.S., Canada and Mexico), and to allow offsets from mitigation projects in additional developing countries, is anticipated.

Question 7. One important aspect of the Chicago Climate Exchange is its emissions registry. Could you briefly explain how it will work, and how that you will ensure that companies comply with it?

Answer. The registry records holdings and transfers of emission allowances and offsets, and these data will be matched with emissions data that are reported by the participants. Like all aspects of the Chicago Climate Exchange, we intend for the program to govern itself in a manner analogous to the various existing self-regulatory organizations (SROs) such as commodity futures exchanges. This mechanism would provide procedures for addressing instances when members fail to meet the commitments taken upon becoming a member.

PREPARED STATEMENT OF WILLIAM C. COLEMAN, PRESIDENT AND CHIEF EXECUTIVE OFFICER, HANCOCK NATURAL RESOURCE GROUP

Key Principles for Carbon Sequestration Component of a U.S. National Climate Change Action Registry Design

A. General Points

1. The registry should create confidence in the business community that any legally registered credits will apply against any subsequent national regulation of carbon dioxide emissions
2. The registry should create a standardized definition and measures for ensuring that all tons of carbon dioxide whether from sequestration, certified reductions or other offsets are treating as equal and exchangeable.
3. The registry should be voluntary, but should create limits on what types offsets and credits will be included in the registry.
4. For carbon sequestration, the concepts of additionality, permanence and leakage should be addressed.

B. Specific Points

1. Modular design, with standards established for each module. For Sinks the modules could be:

   i. Reforestation
   ii. Agricultural soil sequestration
   iii. Extending carbon sequestration in existing forests
   iv. Conservation of forests with documented threats of deforestation

2. Each form of offset should have sufficient rigour in its definition, baseline, measurement accuracy, inventory control, and verification to be fungible. In other words a tonne of any form of sequestration must meet a threshold which makes it the same as any other tonne.
3. Addresses permanence by linkage of credits to pools or entities that can demonstrate the rights or ownership of carbon in the areas having been used as the basis for registration. This means that an entity who wishes to produce carbon credits from forests, must have some demonstration of unique ownership, and carries the ongoing responsibility for those credits. While the total stock of carbon can vary from place to place the sum of the carbon stocks, minus any baseline stocks, must be protected or offsets purchased.
4. Addresses sustainable development by having the endorsement of the government in the country where the project is located.
5. Addresses additionality as follows:

   i. For reforestation, must provide air photos to demonstrate that the area was cleared land, under non-forest land use before reforestation

ii. For agricultural soil sequestration, must demonstrate statistically the soil carbon content to a depth of 1 m. Credits are provided only for statistically demonstrated increases.

iii. For existing forests, must identify the land area concerned and present a statistically robust estimate of carbon stocks.

iv. For conserving forests threatened by deforestation, this must be substantially documented, independently reviewed on a case by case basis, endorsed by the national and/or sub-national government authorities and then protected. In these areas, the issue of leakage must be specifically addressed. If ever in the future the forests are cleared or otherwise impacted these credits must be fully bought out of the system. These forests are the most difficult to integrate into the system, as they are based on some intangible decisions. These forests must also address the issue of leakage, where protecting one area simply leads to accelerated deforestation elsewhere.

6. Baseline year: This should be 1990, or point of project commencement. Where land use change is occurring, the year 1990 should be used to prevent clearing and reforesting of forest being eligible for crediting

7. Definition of product. A standard based on an Environmental Management System or Total Quality Management System can be used for each form of sequestration credit. These systems require documentation of policies, planning, inventory, modelling, continuous improvement systems, etc. They can be the basis of verification and auditing of carbon stocks.

8. The product is a tonne of sequestration, vintaged by the year in which it is activated, and serialized. The tonnes are certified by the registry based on independent verification of the estimates by accredited third parties.

9. The registry must list serial numbers of tonnes, by vintage years, and additionally indicate the land base associated with those tonnes. It should encourage pooling, by also ensure that the linkage between which tonnes link to which land pool is clear. It should also provide for extinguishment of the tonnes in emissions trading, 'green product' promotions, or other purposes.

10. The governance of the system should be based on a steering committee of government, business, academics and conservation movement specialists in this area. The steering committee would endorse the standards for each module, would accredit verifiers, would accredit carbon pool managers, would oversee registry operations, would resolve disputes, and would approve policies for ongoing auditing of the carbon stocks in the registry. The steering committee could be appointed by the Secretary of Commerce or another government figure.

11. Ultimately the register should include both emissions and all forms of offsets in a fully fungible system that would underpin regulation and/or trading.

12. Entities placing offsets into the registry, must also be accredited by the steering committee. The key criteria would be expertise, systems, financial solvency, and good character.

13. In the event that a carbon pool manager became bankrupt, the registry would immediately take control of the carbon rights associated with the pool.

14. The ultimate accountability for the carbon stocks and the credits is with the carbon pool manager. Any decision by the steering committee, subject to appeal, can require the carbon pool manager to make good on carbon stock shortfalls, or provide additional documentation or reverification of the carbon stocks at any time.

15. The steering committee, subject to government approval, may also enter into bi-lateral arrangements with carbon pools in other countries or with international carbon pools, assuming accounting, verification, documentation and third party government endorsement.

16. In the event that the government changes rules or standards in a way that impacts negatively on the carbon pool managers, compensation will be payable.

17. The operation of the registry will be funded by government for a five year trial period, and then the registry will fund its own operations by a fee for registration of new credits.

PREPARED STATEMENT OF THE PACIFIC FOREST TRUST

The Pacific Forest Trust (PFT) commends Chairman Hollings and the members of the Commerce, Science and Transportation Committee for addressing the extremely important topic of climate change and policy options to address this growing problem. A variety of actions may be taken to ameliorate global warming, and PFT believes that U.S. forests can and should play a role in this process, as their man-

agement and loss contribute to the problem. An effective way that forests may contribute to the solution is in the context of a carbon market.

PFT is a problem-solving nonprofit organization dedicated to the nationwide preservation of privately owned productive forestlands through, among other things, the use of market-based conservation incentives. We collaborate with forest landowners, forest managers, policymakers and the public to ensure that private, working [1] forests are preserved and sustained for all the values that they provide. We support and recommend the establishment of a carbon trading market that includes the forestry sector. Such a market would reward forest landowners for the climate service that their forests provide and encourage owners to keep their forests as forests.

Background

Between 1982 and 1997, the United States lost over 21.5 million acres of private forestlands to other uses. In California alone, over 60,000 acres of forestland were lost annually to non-forest uses between 1992 and 1997. During the same timeframe, Georgia lost almost 60,000 acres of private forestland annually. Similar statistics are reflected among privately owned forestland in the most productive timber areas of the United States. While approximately 22 million acres of forestland have been replanted, these forests are much younger than the forestland being lost, and have negative or lower carbon stocks than the forests which were lost.

Over the years, the average age of working forestlands has also become increasingly younger. In large part, this decline in age is due to the increasing need to generate economic returns on shorter and shorter harvest and regeneration cycles. For example, in the Pacific Northwest, the average age of harvest of commercial species has declined from 80 to 40 years and less.

These trends of permanent forest loss and declining forest age signify that the forestlands of the U.S. are a declining carbon sink and contribute significantly to the release of carbon dioxide into the atmosphere. Therefore, they are also contributing to global warming, as carbon dioxide is a greenhouse gas. Forests absorb carbon dioxide from the atmosphere and store it as carbon in their biomass. When forests are converted to other uses, the carbon stored in the forest biomass, is released into the atmosphere both immediately and over time. Thus, the growing loss of private forestland means that declining amounts of carbon are being stored on the ground and significant amounts of carbon are being released into the atmosphere. Even carbon stores in wood products are released over time through decay at an average rate of 2% annually. Likewise, the declining average age of harvest rotations means that less carbon is being stored in forests than in the past, as older forests store more carbon than younger forests. While younger forests may, on average, grow at faster rates than older forests, older forests have greater stocks, storing more carbon per acre than younger ones.

The Benefits of a Forest Carbon Market in the United States

The establishment of a forest carbon market would create the private financial incentive to conserve forests and prevent carbon loss. A carbon market, whether voluntary or established through regulation, would monetize the carbon stored in forest biomass, as other carbon dioxide emission sectors would seek to meet their emission reduction goals through the purchase of emission offsets or carbon "credits" from entities that are able to provide these credits. Private forest landowners can accommodate buyers by selling their forest carbon stores as credits to buyers and maintaining these forest carbon stores over time. This will ensure forest conservation and stewardship. The added carbon value to forestland thus creates a new forest economy.

The inclusion of the forestry sector in a carbon trading market must be done with the right rules, so that real positive impacts are achieved in the atmosphere and on the ground. To ensure the quality of "credits" derived from such actions, a standardized carbon accounting system must be adopted. Such "generally accepted accounting principles," similar to GAAP used by American business, should use annual debits and credits and adjust appropriately for risk. The establishment of broadly accepted rules governing the accounting system will also help ensure that credits developed in the U.S. will be accepted in other carbon markets. Such rules should include the following:

- **Additionality:** Carbon sequestration gains must be *additional* to those that would have accrued from conventional, or "business-as-usual" forest management. This assures net gains in forest carbon stores.

[1] Working forests are those that undergo harvest and regeneration.

- **Permanence:** To earn credits in the carbon accounting system, forests must be managed for the *permanent* sequestration of carbon. This ensures that tons stored today are not released again and that forest loss is not simply delayed for a time.
- **Verifiability:** The forest carbon accounting system must be accurate and must ensure timely third-party *verification* of forest carbon gains and losses. Without this, carbon credits will lack credibility.
- **Co-benefits:** Forest carbon projects must avoid environmental harm and result in environmental and social co-benefits, such as habitat restoration, biodiversity enhancement, watershed protection and sustainable timber economies. Natural forest management achieves these co-benefits and should be credited, as should reforestation of previously cleared forest areas. On the other hand, since the conversion of non-forest native ecosystems, i.e., wetlands or grasslands, to forest plantations results in loss of other critical environmental values, this activity should not be eligible for credit.

While there has been a growing awareness of the role that forests in the tropics may play in forest carbon transactions, it should be emphasized that such transactions are very feasible in the United States. In fact domestic transactions offer greater security as there is generally more scientific and legal certainty in the United States than there is abroad.

PFT's recent sale of forest carbon credits to the Green Mountain Energy Company is an illustration of a cost-effective and scientifically credible forest carbon transaction in the U.S. Last fall, Green Mountain purchased carbon credits secured by PFT's forestland conservation easements so that they could offset half of their annual operational carbon dioxide emissions. These credits are the result of forest management practices that exceed business as usual practices (i.e. federal state and local land use laws and regulations) and thus, achieve real results in the atmosphere and on the ground. These credits are also permanent, as they represent the permanent storage of additional forest carbon, secured legally by a perpetual conservation easement.

PFT acts as a third party verifier, as we monitor the forestland easements to ensure that landowners comply with the easement terms and forest carbon stores are additional and permanent. Our monitoring of the easement is based on sound science and reassures Green Mountain of the credibility of their emissions reductions.

A forest carbon market would not only create a new forest economy, but it would also achieve multiple conservation co-benefits. As more forest is preserved and grows older, forest biodiversity is enhanced—making forests more resilient. In addition, older preserved forests provide habitat for endangered species and enhance water quality. Forest landowners would be encouraged to provide these additional conservation benefits if they received an economic benefit in return, and a carbon market can provide such dividends.

Thank you for the opportunity to submit this testimony, and we hope to continue informing this process so that the benefits of a forest carbon market may be realized.

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