WHAT ARE THE ADMINISTRATION PRIORITIES FOR CLIMATE CHANGE TECHNOLOGY?

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

COMMITTEE ON SCIENCE

HOUSE OF REPRESENTATIVES

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WHAT ARE THE ADMINISTRATION PRIORITIES FOR CLIMATE CHANGE TECHNOLOGY?

THURSDAY, NOVEMBER 6, 2003

House of Representatives,
Subcommittee on Energy,
Committee on Science,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:10 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Judy Biggert [Chairwoman of the Subcommittee] presiding.

COMMITTEE ON SCIENCE
SUBCOMMITTEE ON ENERGY
U.S. HOUSE OF REPRESENTATIVES

What are the Administration Priorities for Climate Change Technology?

Thursday, November 6, 2003
10:00 AM – 12:00 PM
2318 Rayburn House Office Building

Witness List

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HEARING CHARTER

SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

What Are the Administration Priorities for Climate Change Technology?

THURSDAY, NOVEMBER 6, 2003
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Thursday, November 6, 2003 at 10:00 a.m., the Energy Subcommittee of the House Science Committee will hold a hearing to examine the Administration's progress on its climate change technology programs.

The Administration is significantly behind its own schedule for developing a climate technology research and development (R&D) plan. Meanwhile, the Administration is emphasizing one particular R&D project related to carbon sequestration, which raises several fundamental policy and budget questions. (See below.)

Witnesses

The following witnesses will testify at the hearing:

Mr. David Conover is the Director of the interagency Climate Change Technology Program (CCTP) housed at the Department of Energy (DOE). Previously, he was Republican Staff Director & Chief Counsel of the Senate Environment and Public Works Committee. Mr. Conover holds a J.D. from the Georgetown University Law Center.

Mr. George Rudins is the Deputy Assistant Secretary for Coal and Power Systems at the U.S. Department of Energy.

Dr. Sally Benson is Deputy Director for Operations at Lawrence Berkeley National Laboratory (LBNL) and director of the Geological-Sequestration (GEO–SEQ) Project supported by the Office of Fossil Energy. She was the Division Director for Earth Sciences at LBNL from 1993 to 2001. She is a coordinating lead author on the geologic storage chapter of the Intergovernmental Panel on Climate Change (IPCC) study related to CO_2 Capture and Storage.

Dr. Marilyn Brown is the Director of Energy Efficiency and Renewable Energy at the Oak Ridge National Laboratory (ORNL). Dr. Brown recently co-led "Scenarios for a Clean Energy Future," a planning exercise that examined the potential role of hundreds of technologies in reducing carbon dioxide emissions over the next two decades. Dr. Brown serves on the Board of Directors of the Alliance to Save Energy and the National Commission on Energy Policy.

Overarching Questions

The hearing will address the following overarching questions:

1. What milestones has the Administration set for its climate change technology programs? How are the Administration's goals for its climate change technology development programs linked to its goal of achieving atmospheric stabilization of greenhouse gases, or to achieving its greenhouse gas intensity goal?
2. How does the Administration determine which energy technologies qualify as climate change technologies? How does the Administration set R&D investment priorities among these technologies? What weight should be given to non-climate benefits such as improved economic efficiency, reduced emissions of criteria pollutants, and enhanced energy security?

3. Why has the Department decided to place so much emphasis on geological sequestration of carbon, a technology that is less likely than other technologies to have benefits unrelated to climate change?

Overview

- On June 11, 2001, President Bush announced the creation of two initiatives to address climate change: the Climate Change Research Initiative (CCRI) to address areas of scientific uncertainty, and the National Climate Change Technology Initiative (NCCTI) to support applied research and demonstration projects.[1] At the working level, the CCRI was to be headed by the Department of Commerce, and the NCCTI was to be headed by the Department of Energy. The CCRI has since been renamed the Climate Change Science Program (CCSP), and NCCTI has since been renamed the Climate Change Technology Program (CCTP).
- The science initiative has made significant progress over the last two years. The CCRI released an interagency inventory of science activities in July 2002, and a draft strategic plan in the fall of 2002. After extensive public comment, it released its final strategic plan and program plan in July 2003.
- In contrast, the Climate Change Technology Program has not yet released a review of existing climate-related programs or a strategic plan for technology programs. In discussions with Science Committee, DOE Under Secretary Robert Card indicated that a draft plan for the CCTP would be released by July 2002. Under Secretary Card testified to the Committee in February 2003 that a review of climate change technology programs would be complete by the summer of 2003, but that deadline has passed as well.
- The Administration's criteria for selecting and prioritizing climate change technology projects have not been released for public comment.
- In February 2003, the Department announced a new ten-year, $1 billion project, FutureGen, which is to build a prototype plant that would combine the production of hydrogen and electricity from coal with geologic sequestration of carbon.
- On September 30, 2003, the White House Council on Environmental Quality (CEQ) released a fact sheet outlining the Administration's climate change initiatives. The fact sheet featured three major initiatives: the Hydrogen Initiative (the DOE program designed to develop hydrogen-based fuels and cars); the international fusion experimental reactor known as ITER; and FutureGen. All three of these initiatives involve technologies that are not expected to be available for widespread use for at least 10 or 20 years.

Current Issues

What criteria are being used by the Administration to determine which climate technology projects to undertake and are those the right criteria?

Most experts recommend that a climate technology R&D portfolio be balanced between shorter- and longer-term projects and among different types of technologies, and that it be able to accommodate a variety of energy price and regulatory scenarios. The projects that the Administration labels as climate change technology are all longer-term, but DOE does fund a wide variety of other R&D (e.g., energy efficiency) that could have an impact on greenhouse gas emissions.

How do the CCTP and other climate technology programs relate to the Administration's stated greenhouse gas emissions goals?

On February 14, 2002, President Bush announced the Administration's goal of reducing U.S. greenhouse gas emission intensity (the amount of emissions per unit of production) by 18 percent by the year 2012. According to Energy Information Administration (EIA) estimates, U.S. emissions intensity will decrease by 14 percent by the year 2012 in the absence of further action. Thus, the Administration goal requires a reduction in emissions intensity of four percent over ten years compared to the baseline case.

In the same speech, the President stated that the goal of U.S. climate policy was to stabilize greenhouse gas concentrations in the atmosphere, but did not say at what concentration level or by what date.

[1] "President Bush Discusses Global Climate Change," http://www.whitehouse.gov/news/releases/2001/06/20010611–2.html.

The Administration has given conflicting information about whether the objectives of its climate change technology initiatives will be linked to its broader climate goals. The Administration has also not identified the milestones it will use to evaluate the progress made under its climate change technology programs.

What were the criteria used to select carbon sequestration as a major climate change technology initiative?

Carbon sequestration technologies refer to mechanisms designed to capture carbon emissions and store the carbon to prevent it from entering the atmosphere. Possible carbon sequestration methods include piping carbon dioxide deep into the ocean or underground into geologic formations. The latter approach is referred to as "geologic sequestration."

Carbon sequestration is significantly less mature than many other technologies that could reduce greenhouse gas emissions, such as renewable energy and energy efficiency technologies, and there are fundamental questions that still require research on such matters as the safety and long-term stability of geologic sequestration.

Moreover, carbon sequestration is harder to characterize as part of a "no regrets" strategy—that is a climate change strategy that provides benefits to the environment and the economy regardless of whether human-induced climate change turns out to be a significant problem. For example, renewable energy and energy efficiency technologies can reduce emissions of pollutants and dependence on foreign oil, as well as reducing greenhouse gas emissions.

Background

What is the Department of Energy spending on climate change technologies?

It depends on what is considered a climate change technology—a question made more difficult by the lack of any plan for the CCTP. The Department of Energy spent $2.7 billion in fiscal year (FY) 2002 on applied energy research, development, and deployment programs. In a report to Congress, the Office of Management and Budget estimated that in FY 2002 the government spent more than $3.7 billion on climate change technologies, with $1.6 billion (43 percent of the total) spent at the Department of Energy.[2]

What is FutureGen?

In February 2003, Secretary of Energy Spencer Abraham announced the FutureGen initiative, a $1 billion, ten-year government-industry partnership. The goal of the initiative is to build a prototype coal-fired power plant that would combine electricity and hydrogen production with geologic sequestration of carbon dioxide (CO_2).

The FutureGen project would combine an Integrated Gasification Combined Cycle (IGCC) mid-sized coal plant (275 megawatts) with processes to separate, capture, and permanently store the CO_2 emitted by the plant. Separating out the carbon would leave a stream of hydrogen-rich gas that could then be combusted in a turbine, used in a fuel cell, or fed into a refinery to upgrade petroleum products. Once captured, the CO_2 would be injected deep underground into a geologic reservoir.

Experts in geologic sequestration emphasize that the selection of an appropriate site will be critical to the success of the FutureGen project. For a site to be considered appropriate it would have to provide a high degree of confidence that the CO_2 would be permanently isolated from the atmosphere. An exceedingly small (less than 0.1 percent per year) leak rate for the stored CO_2 would likely be needed to ensure the intended climate mitigation benefits. Other important siting considerations include public safety and the ability to build comparable plants elsewhere using similar geologic formations.

One concern with the FutureGen project is that it focuses on building an actual plant while much basic research may still need to be done to answer fundamental questions about the nature and feasibility of geologic sequestration.

What technological developments will geologic sequestration of CO_2 require?

The technology to inject CO_2 into geologic formations, developed for enhanced oil recovery is mature and directly applicable to carbon sequestration. However, far less is known about whether CO_2 can be stored successfully for long periods of time underground in petroleum-bearing rock formations. Moreover, still less is known about how to store CO_2 in other, more common types of geologic formations, such as saline aquifers (underground rock formations containing salt water).

[2] Fiscal Year 2004 Report to Congress on Federal Climate Change Expenditures, Office of Management and Budget.

Only one large-scale demonstration of carbon sequestration in a saline aquifer has been done worldwide. This project, owned and operated by Statoil, Norway's state oil company, has injected about a million tons of CO_2 into the Sleipner aquifer below the North Sea since 1996. The Sleipner aquifer is an uncommon formation, and it is unclear if the lessons learned on that project will be widely applicable.

Three types of reservoirs are candidates for geologic sequestration: depleted oil and gas fields, unmineable coal beds, and saline aquifers. Characterizing these reservoirs—their geologic stability, their capacity to absorb CO_2, and their rates of CO_2 leakage—will be one of the primary technical challenges to geologic sequestration.

Depleted oil and gas fields are known to be geologically stable to a high degree of certainty. Carbon storage in these fields builds on extensive experience with enhanced oil recovery using CO_2. But depleted oil and gas fields are relatively few in number, and at current rates of CO_2 generation from energy use, all such reservoirs would be filled in a matter of decades.

Injecting CO_2 into unmineable coal seams could provide carbon storage along with economic benefits through methane generation. Carbon dioxide injected into the seam dislodges methane that is adhered to the surface of the coal, leaving the methane free to flow out of the seam. A pilot project of CO_2-assisted coal bed methane production has been underway in the San Juan Basin, New Mexico, since 1996.

Saline aquifers are plentiful throughout North America, and in theory could provide enough storage for carbon generated over centuries. Carbon dioxide injected into the aquifers either slowly dissolves into the water within, or is converted to a mineral form over decades. Technical questions remain about the long-term stability of this type of carbon storage. Further work is needed to determine leakages rate into drinking water and the atmosphere.

Another crucial area for further technical work is the development of adequate, cost-effective monitoring systems. Monitoring of subsurface CO_2 flows will be essential to ensuring that the CO_2 contained in the reservoirs remains isolated from the atmosphere. Monitoring is also important for achieving public acceptance of geological sequestration. In large concentrations, CO_2 is an asphyxiant. Long-term carbon storage will require sophisticated monitoring devices to detect escaping CO_2 before dangerous concentrations accumulate.

How are hydrogen technologies related to climate change?

The FutureGen project will be designed to produce hydrogen, which would help accomplish the Administration goal of moving toward a "hydrogen economy." Hydrogen is not a greenhouse gas, and has no known detrimental effects on the environment. Hydrogen can be produced from many sources other than coal with far fewer environmental concerns. Some experts believe that the Administration may be placing too much emphasis on producing hydrogen from coal.

Questions for Witnesses

In the invitation to testify, the witnesses were asked to address the following questions:

Mr. Dave Conover

1. When will the Administration release for public comment its draft strategy for the Climate Change Technology Program (CCTP)? What milestones has the Administration set for its climate change technology programs?
2. What were the total federal expenditures on climate change technologies in fiscal year 2003? Please include a breakdown of these expenditures by agency, or by project. What are the proposed expenditures for fiscal year 2004?
3. How are the Administration's goals for climate change technology development linked to achieving its stated greenhouse gas intensity goal, or to its stated goal of achieving atmospheric stabilization of greenhouse gases? What is the timeline for the latter goal?
4. How does the Administration determine which energy technologies qualify as climate change technologies? How does the Administration set R&D investment priorities among these technologies? What weight should be given to non-climate benefits such as improved economic efficiency, reduced emissions of criteria pollutants, and enhanced energy security?
5. Why has the Department decided to place so much emphasis on geological sequestration of carbon, a technology that is poorly understood and is less likely than other technologies to have benefits unrelated to climate change?

Mr. George Rudins

1. What are the most important outstanding technical issues associated with geologic sequestration of carbon dioxide? What technical questions will the FutureGen project be designed to address? Is our state of knowledge sufficient to proceed with a full-scale carbon sequestration demonstration project?
2. How did the Department choose the scale and scope of FutureGen? How did the Department determine the cost of this project? What levels of funding will be provided by industry and international partners?
3. What factors will the Department consider in selecting geological sites for carbon sequestration projects and experiments? What work should be done prior to selection of the FutureGen site?

Dr. Sally Benson

1. What are the most important outstanding technical issues associated with geologic sequestration of carbon dioxide (CO_2)? Please describe the geologic, environmental, economic, and technical uncertainties. What portion of these uncertainties could be reduced through additional research?
2. Is our state of knowledge sufficient to proceed with a full-scale carbon sequestration demonstration project? By concentrating funding in one large project, do we run the risk of moving to large-scale sequestration before the technical uncertainties have been adequately addressed?
3. What factors should the Department consider in selecting geological sites for carbon sequestration projects and research? What work should be done prior to selection of the FutureGen site?
4. What are the costs of CO_2 injection? How directly do the injection technologies developed for secondary recovery of oil apply to the injection of CO_2 for sequestration?

Dr. Marilyn Brown

1. How would you define a well-balanced climate change technology portfolio for the U.S.? Are there climate change technologies that you feel the Administration should give greater emphasis? What evidence do we have that R&D investments in greenhouse gas mitigation technologies can deliver products that industry, businesses, and consumers will choose to use?
2. If we counted the non-climate benefits of federal climate change R&D investments, such as improved economic efficiency, reduced emissions of criteria pollutants, and enhanced energy security, would we be making the same investments we are now making?
3. The "no regrets" strategy pursued in the George Herbert Walker Bush Administration targeted cost-effective energy efficiency measures as the first priority in funding projects to reduce greenhouse gas (GHG) emissions. What are our best quantitative estimates of the benefits from a concerted investment in cost-effective energy efficiency technologies? Please include estimates of emissions reductions, improvements in GHG intensity, and reductions in criteria pollutants, and economic benefits.

Chairwoman BIGGERT. The hearing will come to order. I want to welcome everyone here today to this hearing of the Energy Subcommittee, the purpose of which is to review the Administration's progress on its climate change technology programs.

On June 11, 2001, President Bush announced the creation of two initiatives to address climate change, the Climate Change Research Initiative, CCRI, to address areas of scientific uncertainty, and the National Climate Change Technology Initiative, now known simply as the Climate Change Technology Program, or CCTP, to support applied research and technology demonstration project. The Administration has made significant progress over the last two years with respect to the science initiative releasing in July, 2002, an inventory of science activities across agencies that will fill the gaps in our understanding of climate change. After extensive public comment, it released a final strategic plan and program in July of 2003.

In contrast, the Climate Change Technology Program is still at the study line. The Administration charged the Department of Energy with leading the interaction CCTP effort back in July of 2001. Since then, we have asked the Department for a report on its Climate Change Technology Initiative, and today, we did receive the first down payment, or the first installment of the report, and I hope that this will be addressed in somewhat in the hearing today.

Since I have not had a chance to read it, it is hot off the press, nor have the other Members, so—but I would ask unanimous consent to include the report in the record at this time. So ordered.

[The information referred to appears in the Appendix.]

Chairwoman BIGGERT. The pieces that we have already had included, the President's Hydrogen Initiative, the subject of a hearing by the Full Science Committee earlier this year and one of the Administration's major actions relating to climate change, according to the White House Council on Environmental Quality. Another big piece that we are aware of is the FutureGen, a new 10 year, $1 billion project to generate hydrogen electricity from coal while sequestering the carbon and geological formations. This will enable DOE to demonstrate on a large scale that existing sequestration technologies and perhaps those still under development work on the ground, or perhaps I should say work in the ground and work well enough to convince investors to put their money into what hopefully becomes the next generation of coal power plants.

While we are talking about hydrogen, FutureGen, or sequestration, these initiatives could pay off substantially in the long-term, not only by reducing emissions, the greenhouse gases, but also by improving America's energy independence. In the short-term, there is much more R&D already underway at the DOE and other federal agencies that could result in technologies with immediate climate change benefits. Is this R&D and our resulting technologies a part of the DOE's Climate Change Technology Program? If so, how did the DOE decide which technologies made the final cut for inclusion in the CCTP.

But the questions don't stop here. How will FutureGen and carbon sequestration programs build off and complement DOE's existing energy efficiency and renewable energy programs. How will the technology milestones for these programs help us meet the President's goals of reducing the carbon intensity of our economy and stabilizing atmospheric concentration of greenhouse gases?

I am asking these questions because I want the DOE to succeed. I think my colleagues here today share the sentiment. We want FutureGen, carbon sequestration and all of DOE's other climate change technologies to work and to work well. I think we can all agree that our investments in such technologies serve as a kind of insurance policy against climate change, supporting a diverse portfolio of climate change technologies such as energy efficiency, carbon sequestration and carbon neutral energy technologies, including even nuclear energy, will provide us with the most insurance coverage for the best price.

I want to thank the witnesses for sharing their expertise with us today. I am confident that you can give us a first installment of DOE's plan and the promise of climate changes technologies like hydrogen, FutureGen and carbon sequestration. So I look forward to our discussion. The Chair now recognizes Mr. Lampson, the Ranking Minority Member on the Energy Subcommittee, for his opening statement.

[The prepared statement of Chairman Biggert follows:]

PREPARED STATEMENT OF CHAIRMAN JUDY BIGGERT

The hearing will come to order.

I want to welcome everyone to this hearing of the Energy Subcommittee, the purpose of which is to review the Administration's progress on its climate change technology programs.

On June 11, 2001, President Bush announced the creation of two initiatives to address climate change: the Climate Change Research Initiative (CCRI) to address areas of scientific uncertainty, and the National Climate Change Technology Initiative, now known simply as the Climate Change Technology Program or CCTP, to support applied research and technology demonstration projects.

The Administration has made significant progress over the last two years with respect to the science initiative, releasing in July 2002 an inventory of science activities across agencies that will fill the gaps in our understanding of climate change. After extensive public comment, it released a final strategic plan and program plan in July 2003.

In contrast, the Climate Change Technology Program is still at the starting line. All we know is that the Administration charged the Department of Energy with leading the interagency CCTP effort back in July 2001. Since then, we have asked the Department on numerous occasions for a report on its climate change technology initiative, and it has promised to provide one. At this point, the DOE is significantly behind its *own* schedule to provide that report. We hope today to hear something about what that report will look like, and when we can expect to see it.

Without this report, Congress is left to complete a puzzle for which we don't have the full picture, or all the pieces. The pieces we do have include the President's hydrogen initiative, the subject of a hearing by the Full Science Committee earlier this year, and one of the Administration's major actions relating to climate change according to the White House Council on Environmental Quality.

Another big piece we are aware of is FutureGen, a new ten-year, $1 billion project to generate hydrogen and electricity from coal while sequestering the carbon in geologic formations. This will enable DOE to demonstrate on a large scale that existing sequestration technologies, and those still under development, work "on the ground"—or perhaps I should say, work "*in* the ground"—and work well enough to convince investors to put their money into what hopefully becomes the next generation of coal power plant.

Whether we are talking about hydrogen, FutureGen, or sequestration, these initiatives could pay off substantially in the long-term, not only by reducing emissions of greenhouse gases, but also by improving America's energy independence.

In the short-term, there is much more R&D already underway at the DOE and other federal agencies that could result in technologies with immediate climate change benefits. Is this R&D, and are the resulting technologies, a part of the DOE's climate change technology program? If so, how did the DOE decide which technologies made the final cut for inclusion in the CCTP?

But the questions don't stop there. How will FutureGen and carbon sequestration programs build off and complement DOE's existing energy efficiency and renewable energy programs? How will the technology milestones for these programs help us meet the President's goals of reducing the carbon intensity of our economy and stabilizing atmospheric concentrations of greenhouse gases?

I am asking these tough questions because I want the DOE to succeed. I think my colleagues here today share that sentiment. We want FutureGen, carbon sequestration, and all of DOE's other climate change technologies to work and work well.

I think we can all agree that our investments in such technologies serve as a kind of insurance policy against climate change. Supporting a diverse portfolio of climate change technologies such as energy efficiency, carbon sequestration, and carbon-neutral energy technologies—including even nuclear energy—will provide us with the most insurance coverage for the best price.

I want to thank the witnesses for sharing their expertise with us today. Despite the absence of a report or plan for the CCTP, I am confident that you can give us at least a sneak preview of the DOE's plan, and the promise of climate change technologies like hydrogen, FutureGen, and carbon sequestration. I look forward to our discussion.

Mr. LAMPSON. And I thank you, Chairwoman Biggert, for the time to speak this morning, and for your putting together this hearing, and I look forward to hearing the comments of all of our panelists.

I know that when President Bush announced the criterion for two climate change initiatives in June of 2001, it was hoped that the Administration was beginning to focus on the climate change problem. And while the Science Initiative at the Department of Commerce has made a significant amount of progress since President Bush's speech, the Climate Change Technology Program at the Department of Energy has yet to share a view of—a review of existing programs, or a strategic plan with this Committee, and I understand that, you know, we have missed some deadlines and certainly this report this morning is helpful and shows the good faith that we, indeed, want, are most interested in, in as far as reaching the completion and completing the review of climate change programs, and we also do not yet know DOE's criteria for selecting and prioritizing these projects.

In the meantime, the White House Council on Environmental Quality recently outlined the Administration's major climate change initiatives. These include the Hydrogen Fuels and Cars Initiative, the ITER Fusion Project and FutureGen, the billion dollar prototype plant that will combine the production of hydrogen and electricity from coal with geological sequestration of carbon, and I am hopeful that we can hear from our witnesses today about the criteria that this Administration is using to choose which climate technology projects should be pursued.

I have concerns about pursuing research and development projects that are not expected to be available for widespread use for at least 10 or 20 years from now. We need to put more emphasis on technologies and energy efficiency which could have real benefits today. I am also anxious to learn what technological benefits the geologic sequestration of carbon will provide to help us in the climate change arena.

Again, I thank our witnesses for joining us, and I look forward to learning more about the Administration's climate change—climate technology research and development plans, and I yield back my time.

[The prepared statement of Mr. Lampson follows:]

PREPARED STATEMENT OF REPRESENTATIVE NICK LAMPSON

Chairwoman Biggert, thank you for holding this hearing today on the Administration's progress on its climate change technology programs. I look forward to hearing from our outstanding panel of witnesses today.

When President Bush announced the creation of two climate change initiatives in June of 2001, it was hoped that the Administration was beginning to focus on the climate change problem.

While the science initiative at the Department of Commerce has made a significant amount of progress since President Bush's speech—the Climate Change Technology Program at the Department of Energy has yet to share a review of existing programs or a strategic plan with this committee.

It is my understanding that DOE has missed deadlines for releasing a draft plan for the program and completing the review of climate change programs.

We also do not yet know DOE's criteria for selecting and prioritizing these projects.

In the meantime, the White House Council on Environmental Quality recently outlined the Administration's major climate change initiatives.

These include the Hydrogen fuels and cars initiative, the ITER fusion project, and FutureGen, the $1 billion prototype plant that will combine the production of hydrogen and electricity from coal with geological sequestration of carbon.

I am hopeful that we can hear from our witnesses today about the criteria that this Administration is using to choose which climate technology projects should be pursued.

I have concerns about pursuing research and development projects that are not expected to be available for widespread use for at least 10 to 20 years.

I am also anxious to learn what technological benefits the geologic sequestration of carbon will provide to help us in the climate change arena.

Again I thank our witnesses for joining us today and I look forward to learning more about the Administration's climate technology research and development plans.

Chairwoman BIGGERT. I would like to ask at this time for unanimous consent that all Members who wish to do so have their opening statements entered into the record. Without objection, so ordered.

It is my pleasure to welcome our witnesses for today's hearing and to introduce them to you. They are Mr. David Conover, the Director of Interagency Climate Change Technology Program, CCTP, at the Department of Energy, welcome. And then, Mr. George Rudins, the Deputy Assistant Secretary for Coal and Power Systems at the Department of Energy, welcome to you. Dr. Sally Benson, Deputy Director for Operations at Lawrence Berkeley National Laboratory; and Dr. Marilyn Brown, the Director of Energy Efficiency and Renewable Energy at the Oak Ridge National Laboratory, welcome to you both.

As the witnesses know, spoken testimony will be limited to five minutes each, after which the Members will have five minutes each to ask questions, so we will begin with Mr. Conover.

STATEMENT OF DAVID CONOVER, DIRECTOR, CLIMATE CHANGE TECHNOLOGY PROGRAM, U.S. DEPARTMENT OF ENERGY

Mr. CONOVER. Madam Chairman, Members of the Subcommittee, thank you for this opportunity to testify today on the Bush Administration's climate change technology priorities.

The Climate Change Technology Program, or CCTP, is a multiagency research, development and deployment coordination activity, organized under the auspices of the Cabinet-level Committee on Climate Change, Science and Technology Integration. CCTP was established in 2002 to implement the President's National Climate Change Technology Initiative. By focusing federal RD&D programs on achieving the President's climate change goals, both near and long-term, our multi-agency organizational structure provides an opportunity across the Federal Government, to develop a coherent plan for climate change technology R&D.

Our draft plan should be available in the first calendar quarter of 2004. As an initial part of the plan, we are establishing an inventory of climate change technology activities using a set of defined criteria. To be included in the CCTP inventory, R&D activities must be aimed at one or more of the following: current and future reductions in, or avoidances of greenhouse gas (GHG) emissions; greenhouse gas capture and/or long-term storage; conversion of greenhouse gases to beneficial uses in ways that avoid emissions to the atmosphere; monitoring and/or measurement of emissions, inventories and fluxes in a variety of settings; technologies that improve or displace other GHG-emitting technologies, thereby reducing emissions compared to technologies they displace; technologies that could enable or facilitate the development, deployment and use of other greenhouse gas emission reduction technologies; technologies that alter, substitute for, or otherwise replace processes, materials and/or feed stocks, resulting in lower net emission of greenhouse gases; basic research activities undertaken explicitly to address a technical barrier to progress on one of the above climate change technologies; greenhouse gas emissions resulting from clear improvements in management practices.

Using the inventory as a baseline, we will then apply principles to guide our investments. These principles include diversification, the logical sequencing of R&D investments, systems integration and planning in the face of uncertainty. Let me highlight three of those. Diversification is important for several reasons. The potential magnitude of the technological challenge posed by climate change makes it extremely unlikely that a single technology could meet the challenge on its own. A diversified portfolio is a hedge against the possibility that some advanced technologies may not be as successful as hoped, while others in the portfolio could exceed expectations. A diversified portfolio maintains the flexibility to respond to new information, and a diversified portfolio is better able to balance short and long-term objectives.

The principle of sequencing R&D investments to quickly resolve critical uncertainties and to demonstrate early the feasibility of determinate technologies is also very important and helps explain our increased attention to carbon sequestration research. If large-scale geological sequestration is proved successful, then continued use of fossil fuels will be possible and future climate change strategies could be built on existing infrastructure, thus accelerating progress and avoiding the early, costly retirement of that infrastructure.

If large-scale geologic sequestration were to prove unsuccessful, the longer-term climate change technology portfolio will need to place even more emphasis on energy efficiency and zero emissions technologies such as renewable energy and nuclear power.

The principle of recognizing uncertainty and planning for the long-term requires a robust portfolio that can be successful under a number of economic and energy policy scenarios. While nearly all such scenarios rely heavily on further advances in energy efficiency, we will also need significant new sources of low carbon or zero carbon energy supply. Thus, some investments focus on development of low carbon fossil fuel technologies that employ sequestration. Others focus on building a new energy backbone, envisioning increased roles for renewable energy and advanced concepts for nuclear power.

Some activities are long-term, more risky, but potentially transforming technologies, such as fusion energy and advances in biotechnology. We also want to ensure that innovative, cross-cutting technology ideas with significant potential to reduce, avoid, or sequester greenhouse gas emissions are not overlooked.

Using these principles and the professional judgment of the interagency participants, the CCTP will assess the inventory of activities to clearly articulate priorities in the context of the President's FY 2005 budget. These will likely be consistent with the Administration's current priorities, such as the Hydrogen Fuel Initiative, FutureGen and fusion, which are well-aligned with our planning principles and are highlighted in my written testimony.

Madam Chairman and Members of the Subcommittee, these current priorities and other climate change technology efforts together constitute a diverse portfolio of energy technologies that has the potential to bring about dramatic improvements in our energy systems with significantly reduced greenhouse gas emissions.

I look forward to working with the Members of this Subcommittee as the Climate Change Technology Program moves forward in evaluating, making recommendations and reporting progress on our technology-based approaches to address the risk of climate change.

Thank you for the opportunity to testify, and I look forward to answering your questions.

[The prepared statement of Mr. Conover follows:]

PREPARED STATEMENT OF DAVID W. CONOVER

Madam Chairman, Members of the Subcommittee,

Thank you for this opportunity to testify today on the Bush Administration's activities for climate change technology. My testimony will cover the mission and activities of the Climate Change Technology Program; criteria and principles for climate change technology investments; and some highlights of our current climate change technology activities.

Climate Change Technology Program

As part of the President's National Climate Change Technology Initiative, launched on June 11, 2001, the President directed the Secretary of Energy, in coordination with the Secretary of Commerce and the Administrator of the Environmental Protection Agency, to lead a multi-agency review of the Federal R&D portfolio and make recommendations. The Climate Change Technology Program (CCTP) was established in 2002 to implement the President's Initiative. I am the Program's Director.

The CCTP is a multi-agency research and development (R&D) coordination activity, organized under the auspices of the Cabinet-level Committee on Climate Change Science and Technology Integration (CCCSTI). Participating federal agencies include the Departments of Energy, Agriculture, Commerce, Defense, Health and Human Services, Interior, State, and Transportation, as well as the Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Science Foundation.

The mission of the CCTP is to focus federal research and development activities and deployment programs more effectively to help achieve the President's climate change goals, both near- and long-term. The CCTP provides a forum for interagency exchange of information on on-going R&D activities. The CCTP's multi-agency organizational structure provides an opportunity to develop, across the Federal Government, a comprehensive, coherent, multi-agency, multi-year plan for the development of climate change technology. We expect a draft of such a plan to be available in the first calendar quarter of 2004.

As the Subcommittee is aware, the recent *Federal Climate Change Expenditures Report to Congress* reported that total federal expenditures for climate change technology research, development and deployment (RD&D) was $1.728 billion for FY 2003. The total amount requested in the President's budget for FY 2004 was $1.759 billion. In FY 2003, these expenditures were broken down by agency as follows: Department of Energy, $1.583 billion; Environmental Protection Agency, $106 million; and Department of Agriculture, $39 million. These amounts do not include substantial additional expenditures for climate change science ($1.722 billion) and international assistance ($276 million).

As part of our review of the federal RD&D portfolio, CCTP is developing an inventory of federal climate change technology activities using a set of defined criteria. This process is designed to get a more complete picture of climate change technology RD&D by ensuring that all CCTP member agencies analyze their portfolios using consistent criteria. RD&D activities classified as part of the Climate Change Technology Program (CCTP) are those activities that are relevant to providing opportunities for:

- Current and future reductions in or avoidances of emissions of greenhouse gases;
- Greenhouse gas capture and/or long-term storage, including biological uptake and storage;
- Conversion of greenhouse gases to beneficial use in ways that avoid emissions to the atmosphere;
- Monitoring and/or measurement of GHG emissions, inventories and fluxes in a variety of settings;
- Technologies that improve or displace other GHG emitting technologies, such that the result would be reduced GHG emissions compared to technologies they displace;
- Technologies that could enable or facilitate the development, deployment and use of other GHG-emissions reduction technologies;
- Technologies that alter, substitute for, or otherwise replace processes, materials, and/or feedstocks, resulting in lower net emission of GHGs;
- Basic research activities undertaken explicitly to address a technical barrier to progress of one of the above climate change technologies.
- Greenhouse gas emission reductions resulting from clear improvements in management practices.

The development of this inventory is a very important component of the CCTP's activities, and we look forward to sharing the results of this work with you and your colleagues when it is complete.

CCTP Goals and Objectives

CCTP seeks to address both the President's near- and long-term climate change goals. In the near-term, the President has committed to the goal of reducing the greenhouse gas intensity of the U.S. economy by 18 percent by 2012. Over the longer-term, the President has reaffirmed the U.S. commitment to the 1992 United Nations Framework Convention on Climate Change, which calls for long-term stabilization of concentrations of greenhouse gases in the Earth's atmosphere.

The CCTP intends to develop the technological capability that will enable both sustained economic growth and reduced risk of potential climate change and its impacts. Accordingly, the CCTP aims to accelerate the development and deployment of new technologies that can significantly contribute to the accomplishment of the President's goals.

CCTP participating agencies are pursuing research, development , and deployment activities, as appropriate to their specific agency missions, that are consistent with and supportive of the development of technology that can enable or advance the achievement of the following CCTP goals:

- Reduce or avoid emissions from energy end-use and infrastructure

- Reduce or avoid emissions from energy supply
- Capture and sequester carbon dioxide (CO_2)
- Reduce emission of non-CO_2 greenhouse gases

The achievement of these CCTP goals will be pursued, in general, by stimulating the science and technology enterprise of the United States, through coordinated federal leadership of its own R&D programs, and through partnership with others, at home and abroad. Specifically, the CCTP seeks to pursue the following strategic objectives:

- Strengthen Climate Change Technology RD&D
- Strengthen Supporting Basic Research at Universities and National Laboratories
- Enhance Opportunities for Partnerships with Businesses, States and Others
- Increase International Cooperation on Related Science and Technology
- Support Cutting-Edge Demonstrations
- Improve the Means for Measuring and Monitoring Greenhouse Gases
- Support Exploratory Research of Novel Concepts
- Ensure the Education and Training of an Adequate Technical Workforce

The CCTP function is interagency coordination and prioritization, not direct support of research, development and deployment. As such, CCTP will not advance these objectives directly, but will help agencies and programs that comprise the CCTP to advance them by making recommendations to reallocate and refocus resources consistent with agency and program missions.

Principles for Determining Priority Programs

Our investments in climate change technology will be guided by a few basic principles, which include diversification, a logical order of technological development, systems integration, and planning in the face of uncertainty.

Diversification of research and development activity is important for several reasons:

- The potential magnitude of the technological challenge posed by climate change makes it extremely unlikely that a single technology could meet such a challenge on its own;
- A diversified portfolio is a solid hedge against the possibility that some advanced technologies may not be as successful as hoped, while others in the portfolio could exceed expectations;
- A robust, diversified science and technology capability will maintain the flexibility to respond to, and assimilate, pertinent information from other countries, institutions, or areas of scientific inquiry; and,
- A diversified portfolio is better able to balance short- and long-term technology objectives.

Sequencing of R&D investments in a logical, developmental order requires that R&D investments should be evaluated upon:

- The expected times when different technologies need to be available and cost-effective;
- The need to quickly resolve critical uncertainties; and,
- The need to demonstrate early the feasibility of determinant technologies.

These last two points help explain our increased attention to carbon sequestration research. If large-scale geologic sequestration is proved successful, then continued use of fossil fuels will be possible, and future climate change strategies could be built on existing infrastructure for fossil fuels, thus accelerating progress and avoiding early and costly retirement of this infrastructure. If large-scale geologic sequestration were to prove unsuccessful, the longer-term climate change technology portfolio will need to be adjusted accordingly towards energy efficiency and zero-emissions technologies such as renewable energy and nuclear power.

Our R&D investments should also include attention to technology systems, including infrastructure, not just component technologies. The Hydrogen Fuel Initiative is an example of adherence to this principle, as it includes R&D activities on all aspects of the hydrogen system, including hydrogen production, storage, and delivery technologies, as well as fuel cells.

Finally, in setting R&D investment priorities, the CCTP recognizes uncertainty in planning for the long-term and seeks to build a robust portfolio of technical activities that can be successful under a number of economic and energy policy scenarios. While nearly all such scenarios rely heavily on further advances in energy efficiency, we will also need significant new sources of low-carbon or zero-carbon energy supply. Thus, some CCTP activities may focus on development of low-carbon fossil fuel technologies that employ carbon capture and sequestration. Other activities may focus on building a new energy backbone, envisioning increased roles for renewable energy, hydrogen, and advanced concepts for nuclear power. Some CCTP activities may be focused on the long-term, more risky, but potentially transforming technologies, such as fusion energy and advances in biotechnology. We also want to ensure that innovative, crosscutting technology ideas with significant potential to reduce, avoid, or sequester greenhouse gas emissions are not overlooked.

Priorities for the National Climate Change Technology Initiative

With these principles in mind and recognizing that not all climate change-related activities can be priorities, the CCTP will assess the inventory of CCTP activities and use professional judgment to clearly articulate its priorities in the context of the President's FY 2005 Budget. The priorities will likely be consistent with the Administration's current priorities, which are well aligned with our planning principles. Some of these priorities are highlighted below.

- *Hydrogen Energy.* President Bush launched his Hydrogen Fuel Initiative in this year's State of the Union address. The goal is to work closely with the private sector to accelerate our transition to a hydrogen economy, both on the technology of hydrogen fuel cells and a fueling infrastructure. The President's Hydrogen Fuel Initiative and the FreedomCAR Partnership launched last year will provide $1.7 billion over the next five years to develop hydrogen powered fuel cells, a hydrogen infrastructure, and advanced automobile technologies, allowing for commercialization by 2020. The United States will pursue international cooperation to affect a more rapid, coordinated advance for this technology that could lead to the elimination of air pollutants and a significant reduction of greenhouse gas emissions in the transportation sector worldwide.
- *"FutureGen"—Coal-Fired, Zero-Emissions Electricity Generation.* In February 2003, President Bush announced that the United States would sponsor, with international and private sector partners, a $1 billion, 10-year demonstration project to create the world's first coal-based, zero-emissions electricity and hydrogen power plant. This project is designed to dramatically reduce air pollution and capture and store greenhouse gas emissions. This initiative is part of an international Carbon Sequestration Leadership Forum, chaired by the Secretary of Energy, to work cooperatively with our global partners, including developing countries, on research, development and deployment of carbon sequestration technologies in the next decade.
- *Fusion Energy.* In January 2003, President Bush committed the United States to participate in the largest and most technologically sophisticated research project in the world to harness the promise of fusion energy, the same form of energy that powers the sun. If successful, this $5 billion, internationally-supported research project will advance progress toward producing clean, renewable, commercially-available fusion energy by the middle of the century. Participating countries include the United Kingdom, Russia, Japan, China, and Canada.

Conclusion

Madam Chairman and Members of the Subcommittee, these programs and others like them together constitute a diverse portfolio of energy technologies that has the potential to bring about dramatic improvements in our energy systems with significantly reduced greenhouse gas emissions. I look forward to working with the Members of this Subcommittee as the Climate Change Technology Program moves forward in evaluating, making recommendations, and reporting progress on our technology-based approaches to address the risk of climate change.

Thank you for the opportunity to testify, and I would be pleased to answer your questions.

BIOGRAPHY FOR DAVID W. CONOVER

Appointed Director of the Climate Change Technology Program in January 2003. The Climate Change Technology Program is a multi-agency research and development (R&D) coordination activity, organized under the auspices of the Cabinet-level Committee on Climate Change Science and Technology Integration (CCCSTI).

Previously served as Minority Staff Director & Chief Counsel (2001–2003), Majority Staff Director (1999–2001), and Subcommittee Counsel (1999) to the Senate Environment and Public Works Committee.

Prior to government service, was Federal Affairs Director for CH2M HILL, an international environmental engineering, management and construction company.

Received degrees from the Georgetown University Law Center and the University of Virginia. Licensed to practice law in the Commonwealth of Virginia.

Chairwoman BIGGERT. Thank you, Mr. Conover. Mr. Rudins, am I pronouncing that correctly?

Mr. RUDINS. That is correct. Thank you.

Chairwoman BIGGERT. Thank you.

STATEMENT OF GEORGE RUDINS, DEPUTY ASSISTANT SECRETARY FOR COAL AND POWER SYSTEMS, U.S. DEPARTMENT OF ENERGY

Mr. RUDINS. Thank you, Madam Chairman and Members of the Subcommittee.

In your letter of invitation, you requested I respond to specific questions recording FutureGen and carbon sequestration, which I attempted to do in my written statement, which I would like to submit for the record. And in that context, I would also like to make a short opening statement.

I am pleased to appear before you today, and in the context of the FutureGen initiative and carbon sequestration, with much of the Nation's attention again focused on the security of global energy supplies, it is important to remember that we remain an energy-rich country. Today, coal is an indispensable part of our nation's energy mix. Because of its domestic abundance and low cost, coal now accounts for more than half of the electricity generated in this country, and in the future, it can also be a source of clean hydrogen to fuel our future transportation fleet.

The challenge to keeping low coal—low cost coal available to fuel our economic growth is related to environmental concerns. Environmental issues can adversely impact coal use, especially in the long-term, if mandatory CO_2 controls are required. A solution to this problem is the development of technology options that would eliminate environmental concerns associated with its continued use.

Over the last 30 years or so, the investment that we, the U.S. Government and industry, have made in the development of coal and clean coal technologies, has resulted in advancing of the state of the art in this area to the point that it is now possible to develop the technological capability to generate electricity from coal, co-produce hydrogen and virtually eliminate emissions, including the CO_2 emissions from the process, and do so, potentially, in a cost-competitive manner.

This is what the FutureGen project is all about. FutureGen is one of the boldest steps toward a pollution-free energy future ever taken by our nation, and has the potential to be one of the most important advances in energy production in the first half of this century. FutureGen will pioneer carbon capture and sequestration technologies on a sufficient scale and an integrated fashion with power generation and hydrogen co-production that it will establish, if successful, the viability and affordability of this approach.

The ultimate goal for FutureGen is to show how new technology can eliminate environment concerns over future use of coal. Knowledge from FutureGen will help turn coal from a challenging energy resource into an environmentally sustainable energy solution.

In conclusion, coal is the workhorse of our domestic electric power sector, but it is also critical to the economic growth of key nations around the world. The International Energy Agency projects a 50 percent increase in worldwide coal use for the generation of electricity over the next quarter century. As a result, it would be prudent to include into any comprehensive climate strategy a technology option capable of reducing or eliminating CO_2 from the use of fossil fuels, such as carbon sequestration.

The fact that coal will be a significant world energy resource during the 21st Century cannot be ignored. Coal is abundant, it is comparatively inexpensive, and will be used widely, especially in the developing world. The global acceptance of the concept of coal-based systems, integrated with sequestration technology, is one of the key goals of FutureGen. In addition, FutureGen in its ultimate configuration could also push electric power generating efficiencies into the 60 percent range, nearly double the efficiency of today's conventional coal-burning plants.

Thus, the FutureGen prototype plant would be a stepping stone to commercial coal-fired power plants that not only would be emission-free, but also would operate at unprecedented fuel efficiencies and co-produce low-cost, clean hydrogen from coal.

With that brief statement, I would be pleased to answer any questions you may have. Thank you.

[The prepared statement of Mr. Rudins follows:]

PREPARED STATEMENT OF GEORGE RUDINS

Madam Chairman and Members of the Subcommittee:

I am pleased to appear before the Subcommittee today to discuss the great potential that new technology, especially carbon sequestration technology, will play in helping the Nation meet ever increasing demands for energy in the most efficient and environmentally responsible manner possible.

With much of the Nation's attention again focused on the security of global energy supplies, it is important to remember that we remain an energy-rich country.

Today, coal is an indispensable part of our nation's energy mix. Because of its abundance and low cost, coal now accounts for more than half of the electricity generated in this country.

Coal is our nation's most abundant domestic energy resource. One quarter of the entire world's known coal supplies are found within the United States. In terms of energy value (Btus), coal constitutes approximately 95 percent of U.S. fossil energy reserves. Our nation's recoverable coal has the energy equivalent of about one trillion barrels of crude oil—comparable in energy content to all the world's known oil reserves.

At present consumption rates, U.S. coal reserves are expected to last at least 275 years.

Coal has also been an energy bargain for the United States. Historically it has been the least expensive fossil fuel available to the country, and in contrast to other primary fuels, its costs are likely to decline as mine productivity continues to increase. The low cost of coal is a major reason why the United States enjoys some of the lowest electricity rates of any free market economy.

America produces over one billion tons of coal per year. Nearly all of it (965 million tons) goes to U.S. power plants for the generation of electricity.

According to the Energy Information Administration, annual domestic coal demand is projected to increase by 394 million tons from the 2001 level of 1.050 billion tons to 1.444 billion tons in 2025, because of projected growth in coal use for electricity generation.

Largely because of improving pollution control technologies, the Nation has been able to use more coal while improving air quality. While annual coal use for electric generation has increased from 320 million tons in 1970 to more than 900 million tons, sulfur dioxide emissions from coal-fired power plants have dropped from 15.8 million tons annually to 10.1 million tons in 2001, the most current year available. In addition, particulates from coal-fired plants declined some 60 percent over the same period, according to the Environmental Protection Agency.

Because coal is America's most plentiful and readily available energy resource, the Department of Energy (DOE) has directed significant R&D resources at finding ways to use coal in a more efficient, cost-effective, and environmentally benign manner.

New government-industry collaborative efforts are getting underway pursuant to the President's Coal Research Initiative. These programs will continue to find ways to limit emissions from power generation, at lower costs. The goal for FutureGen, discussed later in my testimony, is to remove environmental issues, including greenhouse gas emissions, from the fuel choice equation by developing a coal-based zero emission power plant.

The Next Generation of Power Plants

In the 1970's, the technology for coal-fired power plants was generally limited to the pulverized coal boiler—a large furnace-like unit that burns finely ground coal. As part of DOE's Clean Coal Technology Program, DOE and industry have demonstrated higher fuel efficiencies and superior environmental performance. For example, coal could be gasified—turned into a combustible gas. In gaseous form, pollutant-forming impurities can be more easily removed. Like natural gas, gasified coal could be burned in a gas turbine-generator, and the turbine exhaust used to power a steam turbine-generator. This "combined cycle" approach raised the prospects of unprecedented increases in fuel efficiency. Gasification combined cycle (IGCC) plants built near Tampa, Florida (TECO Project), and West Terre Haute, Indiana (Wabash River Project), are among the cleanest, most efficient coal plants in the world. The Wabash River Project, which is a repowering of an existing coal-fired unit, resulted in a 30-fold decrease in SO_2 and a five-fold decrease in NO_X emissions. These projects have recently completed their demonstration phases and are entering commercial operations.

The progress to date in developing these two IGCC demonstration projects—now in commercial service—has laid the foundation for broader application of IGCC.

FutureGen—Zero Emissions From Cutting Edge Technology

Earlier this year, President Bush and Secretary of Energy Abraham announced plans for the United States to build—with international and private sector partners—a cost-shared fossil fuel power plant of the future called FutureGen. It is one of the boldest steps toward a pollution-free energy future ever taken by our nation and has the potential to be one of the most important advances in energy production in the first half of this century.

This demonstration power plant will accommodate some cutting-edge technologies to the core demonstration facility. FutureGen will be a cost-shared $1 billion venture. While there has been no final decision on the appropriate cost-sharing, and 80/20 cost-share may be appropriate for those FutureGen activities that are prototype or basic research in nature and do not involve commercial demonstration. Demonstration activities would be cost-shared at 50/50. FutureGen will combine electricity and hydrogen production with the virtual elimination of emissions of such air pollutants as sulfur dioxide, nitrogen oxides and mercury, as well as carbon dioxide, a greenhouse gas.

The Department envisions that FutureGen would be sized to generate the equivalent of approximately 275 megawatts of electricity, roughly equal to an average midsize coal-fired power plant. It will turn coal into a hydrogen-rich gas, rather than burning it directly. The hydrogen could then be combusted in a turbine or used in a fuel cell to produce clean electricity, fed to a refinery to help upgrade petroleum products, or used as a fuel for a future hydrogen economy.

It will provide other benefits as well. FutureGen could provide a zero emissions technology option for the transportation sector—a sector that accounts for one-third of our nation's carbon dioxide emissions.

In the future, the plant could become a model for the production of coal-based hydrogen with zero emissions to power the new fleet of hydrogen-powered cars and trucks envisioned as part of President Bush's Hydrogen Fuel Initiative. Using our abundant, readily available, low-cost coal to produce hydrogen—an environmentally superior transportation fuel—would help ensure America's energy security.

Carbon sequestration will be one of the primary features that will set the FutureGen plant apart from other electric power projects. Engineers will design into the plant advanced capabilities to capture the carbon dioxide. No other electricity power plant in the world has been built with this capability.

Once captured, carbon dioxide will be injected deep underground, into brackish reservoirs that lay thousands of feet below the surface of much of the United States, or into oil or gas reservoirs, or into unmineable coal seams or volcanic basalt formations. Once entrapped in these formations, the greenhouse gas would be permanently isolated from the atmosphere.

The project will seek to sequester carbon dioxide emissions at an operating rate of one million metric tons or more of carbon dioxide sequestered per year. We will work with the appropriate domestic and international communities to establish standardized technologies and protocols for carbon dioxide measuring, monitoring, and verification.

The FutureGen plant will pioneer carbon sequestration technologies tied to power plants on a scale that will help determine whether this approach to 21st century carbon management is viable and affordable.

What are the Most Important Outstanding Technical Issues Associated With Geological Sequestration?

Integrated operation of energy production and sequestration in the FutureGen facility is required to establish that technical issues associated with sequestration are of no concern or can be readily managed during operation. Potential issues include downtime of CO_2 separation processes, and corrosion or plugging of the sequestration pipeline, wellbore, and formation, and leakage of sequestered CO_2.

Geologic Sequestration can be divided into four overarching categories: Transport; Storage; Measurement/ Monitoring/Verification (MM&V); and Infrastructure. For each of these areas, a brief description of R&D approaches being taken to overcome outstanding technical issues is provided. For Transport, R&D is developing an increased understanding and best practice strategies to minimize corrosion. For Storage, R&D is developing best practice strategies to identify optimal locations for candidate geologic reservoirs and reservoir management practices to maximize CO_2 storage. This R&D will provide FutureGen with site selection guidelines and reservoir management practices throughout the lifespan of FutureGen. MM&V is critical to ensure permanence and safety of CO_2 sequestration. R&D is developing technologies to minimize leakage and ensure permanent storage to below 0.01 percent leakage per year. Developments in sub-surface tracking relative to seismic, gravitational and logging technologies are evolving to where movement of very small amounts of CO_2 in reservoir can be tracked. Methods to track surface leakage are being developed to identify small surface leaks at nearly any point above the surface of a geologic formation. Lastly, for Infrastructure, the Carbon Sequestration Leadership Forum and Regional Carbon Sequestration Partnerships are developing the infrastructure, regulatory framework, and other sequestration protocols that are critical to both FutureGen deployment and, more importantly, subsequent widespread deployment of the integrated FutureGen power plant.

What Technical Questions Will the FutureGen Project Be Designed To Address?

FutureGen will focus on integrating and demonstrating the technology needed to economically remove the environmental constraints associated with producing energy from coal, especially those associated with the CO_2 emissions. The FutureGen project will demonstrate the technical and economic feasibility of zero-emission power plants by integrating the production of electricity and hydrogen from coal with the capture and permanent sequestration of CO_2 generated in the process. FutureGen will employ coal gasification technology, integrated with combined-cycle electricity generation, hydrogen production, and capture and sequestration of CO_2.

The goal of FutureGen is to conclusively show that using coal to produce electricity and hydrogen with zero or near-zero carbon emissions is a viable approach for carbon management. To prove viability, the sequestration technology needs to be demonstrated at a meaningful scale under real-world conditions. This requires the operation of a large scale, integrated system. FutureGen may also accommodate some cutting-edge technologies to produce electricity and hydrogen, which would need to be integrated with CO_2 sequestration technologies. Monitoring and verifying the permanence of CO_2 sequestration is a key part of the project. The geologic formations into which the CO_2 will be sequestered will be heavily instrumented to monitor and verify the permanence of CO_2 storage. Monitoring and verification of the amount of CO_2 sequestered are critical issues in public acceptance of sequestration. Other elements are to: maximize storage potential; track CO_2 movement in the geologic formation; monitor for and mitigate surface leakage, if it occurs; and integration of CO_2 capture and storage with the co-production of hydrogen and electricity.

Is Our Current State of Knowledge Sufficient To Proceed With A Large Scale Demonstration Project?

Our state of knowledge is sufficient to proceed with a large scale demonstration project. The use of sequestration to reduce CO_2 emissions is a relatively new idea. DOE's sequestration program is only six years old—a short time for a major technology development program. However, for more than 40 years the petroleum industry has injected CO_2 into depleted oil and gas fields for enhanced oil recovery and the disposal of acid gases that are produced from some gas and oil wells. The primary components of acid gas are CO_2 (typically up to 90 percent), hydrogen sulfide, and other trace contaminants. Hydrogen sulfide is lighter than CO_2 and has a strong smell even at concentrations of a few parts per million, making it easy to detect. No significant leaks of hydrogen sulfide have been reported over the years. Over 70 CO_2 enhanced oil recovery projects inject more than eight million tons of CO_2 per year into oil reservoirs throughout the United States and Canada. Many of these projects have been injecting at these levels for more than 20 years. The risk of catastrophic release of CO_2 is almost non-existent. No known hazardous CO_2 leaks have ever been associated with leakage from a geologic formation.

Two large-scale carbon sequestration projects exist today. The first project is the offshore Sleipner facility, owned and operated by Statoil, Norway's state oil company. Located beneath the North Sea, the Sleipner field is one of the world's largest natural-gas fields, and is characterized by a high concentration of CO_2, typically around nine percent. To produce pipeline-quality natural gas, Statoil strips the excess CO_2 from the recovered gas on its offshore production platform. The CO_2 is then injected into a saline reservoir 1,000 meters below the seabed. Since 1996, Statoil has injected one million metric tons of CO_2 per year. The project is partially driven by a Norwegian tax credit of up to $35 per metric ton of CO_2 sequestered.

The recently initiated Weyburn Project is the only other large-scale CO_2 sequestration effort in existence. This project, organized by the Department of Natural Resources of Canada, has the dual purpose of enhanced oil recovery and carbon sequestration. Carbon dioxide from the Great Plains Synfuels plant in Beulah, North Dakota is pumped 200 miles to the Weyburn oil field in southeastern Saskatchewan. Over the project's 20-year lifetime, 20 million metric tons of CO_2 will be injected into the Weyburn field. DOE's sequestration program is supporting extensive measurement, monitoring, and verification efforts for both the Sleipner and Weyburn large-scale projects.

How Did the Department Choose The Scale and Scope of FutureGen?

FutureGen will be designed to operate at a nominal 275 MW (net equivalent output), and may accommodate some cutting-edge technologies into the demonstration plant to produce electricity and hydrogen integrated with CO_2 sequestration technologies. This size is driven by the requirement for producing relevant data and by the requirement for producing one million metric tons per year of CO_2 to adequately validate the integrated operation of the gasification plant and the receiving geologic formation. Full scale demonstration is necessary to adequately address the integration issues including sequestration.

Since FutureGen is a first-of-a-kind project, the key cost risks include integration of advanced technologies for power and hydrogen generation with sequestration, and technologies at full-scale to capture and sequester large quantities of CO_2.

How Did the Department Determine the Cost of This Project?

Estimated project cost is based on cost experiences with other projects including ongoing large-scale sequestration projects as described earlier, and past coal gasification projects of similar size. DOE also accounted for the cost associated with using advanced technology, built-in flexibility features to accommodate possible testing of cutting edge subsystems and components, required instrumentation, the integration aspects between the power facility and the sequestration facility, and finally the operational costs for the demonstration period. On the basis of prior experience with first-of-a-kind power projects, DOE projects a total project cost of $1 billion.

Cost Element	Estimated Costs ($M)
Plant Definition, Baselining, and NEPA	77
Plant Procurement and Construction	423
Shakedown and Full-Scale Operation (plant only)	157
Sequestration (design, construction, operation)	224
Introduction of Advanced Technologies	61
Site Monitoring	58
Total	**1,000**

What Levels of Funding Will Be Provided by Industry and International Partners?

The funding required to accomplish FutureGen is expected to be $1 billion. A private-sector share of 20 percent will be required for those activities that are prototype or basic research in nature and do not include commercial demonstration while those activities that are commercial demonstration will be cost-shared at 50/50. DOE is also pursuing funding participation from domestic (e.g., states) and foreign government entities.

What Factors Will the Department Consider Regarding Site Selection For Geological Sequestration Projects and Experiments?

Site selection must consider many factors. Three considerations are the feedstock, use of the products (electric power, hydrogen, and other by-products), and sequestration options. The ideal location requires geologic formations that may be the best suited candidates for large-scale facilities. However, final site selection will be based on comprehensive criteria derived from detailed geologic assessment.

The reservoir(s) selected for sequestration will be representative of geologic sites commonly available throughout the United States. The candidate geologic formations include unmineable coal seams, depleted oil and natural gas reservoirs, deep saline reservoirs, or other formations. Geologic sequestration may be coupled with resource recovery in projects such as enhanced oil recovery or coalbed methane recovery.

What Work Should Be Done Prior to FutureGen Site Selection?

DOE plans to perform due diligence activities prior to site selection. The Sequestration R&D program, Regional Partnerships and Carbon Sequestration Leadership Forum will work to identify the most appropriate areas of the country for candidate sequestration formations. A Programmatic Environmental Impact Statement (PEIS) will be initiated in fiscal year 2004 which will identify environmental issues related to geologic site selection and provide guidelines for geologic site selection activities to support FutureGen.

Conclusion

The ultimate goal for the FutureGen project is to show how advanced coal-based generation using carbon sequestration technology can eliminate environmental concerns over the future use of coal and allow the Nation to realize the full potential of its abundant coal resources to meet our energy needs. FutureGen will show that coal, an environmentally challenging energy resource, can be an environmentally sustainable energy solution.

The fact that coal will be a significant world energy resource during the 21st century cannot be ignored. Coal is abundant, it is comparatively inexpensive, and it will be used widely, especially in the developing world. Global acceptance of the concept of coal-based systems integrated with sequestration technology is one of the key goals of FutureGen.

Thus, FutureGen will demonstrate the commercial viability of a coal-fired power plant that not only will be emission-free but also will operate at unprecedented fuel efficiencies and co-produce low/cost, clean hydrogen from coal.

This completes my prepared statement. I would be happy to answer any questions you may have.

BIOGRAPHY FOR GEORGE RUDINS

Mr. George Rudins has been with the Department of Energy (or ERDA - its predecessor agency) since 1975. Currently the Deputy Assistant Secretary for Coal and

Power Systems, within the agency's Office of Fossil Energy, Rudins has served in this position since 1998. Previous to that time, Rudins' assignments within the Office of Fossil Energy included: Assistant Deputy Assistant Secretary for Coal R&D; Director of the Office of Advanced Power Systems; Director of the Office of Advanced Energy Conversion Systems; and, Director of the Office of Magneto-Hydrodynamic (MHD) Systems. In conjunction with these assignments, Rudins' management responsibilities included oversight of the Clean Coal Technology Demonstration Program, the Coal Research and Development Program, the Power Plant Emissions Control Research Program, the Fuel Cell Research Program, the Gas Turbine Research Program, the MHD Research Program, the Coal Fuel/Diesel Engine Research Program, and others. Rudins' performance in his various assignments has been recognized through a number of awards, including a Presidential Rank Award. Before joining the Department of Energy, Rudins was with the Rand Corporation (1970–1975); prior to this he was with the National Academy of Sciences. Rudins received a B.A. from Rutgers University in 1966.

Chairwoman BIGGERT. Thank you very much, Mr. Rudins. Dr. Benson.

STATEMENT OF DR. SALLY M. BENSON, DEPUTY DIRECTOR FOR OPERATIONS, LAWRENCE BERKELEY NATIONAL LABORATORY

Dr. BENSON. Chairman Biggert and Members of the Subcommittee, thank you for the opportunity to provide testimony on this important and timely topic.

I am Dr. Sally Benson, a hydrogeologist at Lawrence Berkeley National Laboratory, and I have been working on this since 1999, with a team of geologists at my laboratory.

Today, nearly two million tons of CO_2 are sequestered annually in geologic formations at the Sleipner Project in the North Sea, and at the Weyburn oil field in Canada. More commercial projects are planned in Algeria, Australia and offshore Norway. In addition to these successful commercial projects, the existence of naturally-occurring CO_2 reservoirs proves that CO_2 can be sequestered for hundreds of thousands of years or more.

Depleted oil and gas reservoirs are especially promising for long-term sequestration, because they have seals that have stood the test of time. They are also attractive because CO_2 sequestration can be combined with enhanced oil recover, a mature technology that is applicable to 80 percent of oil reservoirs.

The availability of a low-cost and abundant supply of CO_2 could be a boon to the domestic oil industry. A similar idea can be applied to enhance the recovery of natural gas from deep coal beds. Now, to answer your question about the most important outstanding technical issues, sandstone reservoirs filled with salt water, such as the Mount Simon Formation in the Midwest, the Frio Formation along the Texas Gulf Coast and the Central Valley of California are estimated to have the capacity to store hundreds of years of CO_2 emissions at today's rates. That natural gas has been stored at over 50 aquifer storage sites in the U.S. alone demonstrates that appropriately-sited projects can safely and effectively sequester CO_2 underground.

The best sequestration sites will be at depths between three quarters and two miles deep, have a thick sequence of permeable and porous sands, and be overlain by at least one thick and continuous seal. However, site selection criteria have yet to be developed, and capacity estimates have not yet been validated by regional or site-specific experiments.

Monitoring to verify that CO_2 is safely and effectively sequestered, or to provide early warning in the event that a project is failing, is also needed. Methods developed by the oil and gas industry, such as 3–D seismic surveys, or injection well pressure monitoring, can be used, but more studies are needed to develop standard protocols for monitoring.

Computer models that predict the performance of sequestration projects are also needed. While reservoir simulation is a mature technology, the capability of today's models need to be extended to include accurate representation of the geochemical and geomechanical processes that are important for geologic sequestration. These need—models need to be validated by a number of site-specific studies that cover the range of geologic settings that could be used for CO_2 sequestration.

The potential environmental consequences of geologic sequestration are also well understood, based on analogous experience from the oil and gas industry, natural gas storage, EPA's Underground Injection Control Program and places such as Perrier in France, where CO_2 naturally seeps to the ground surface. The highest probability risks are associated with improper injection well completions, abandoned wells and inadequate characterization of the sequestration site. Over time, technologies and monitoring protocols have, however, been developed to manage and mitigate these concerns.

To summarize, geologic sequestration of CO_2 is in practice today and more is planned. However, to fully evaluate the potential for large-scale application, a research program that combines site-specific field studies with a directed research program must be pursued.

Now, to answer your question about what portion of these uncertainties could be reduced by additional research, well, all of them can be. However, because of the site-specific nature of the factors that provide secure storage, pilot tests should be located in each of the regions where there are large concentrations of stationary CO_2 sources. While many of these issues can be addressed by small-scale pilot tests, eventually, full-scale demonstration projects will be needed. So are we ready for full-scale demonstration projects? Well, clearly, the experience at Sleipner and Weyburn in Canada demonstrate that we are ready today. However, before we can embark on this, potential sites need to be screened, pilot tests need to be carried out, including demonstrating that our models and monitoring methods are adequate and risk assessment is needed.

So, in summary, geologic sequestration is an important component of a climate change technology portfolio. It offers the potential for deep reductions in CO_2 emissions, while allowing the continued use of fossil fuels. Efforts are underway to address these issues and success can be assured by a sustained commitment to an adequate program of directed research, pilot tests and full-scale demonstration.

Thank you for your attention.

[The prepared statement of Dr. Benson follows:]

PREPARED STATEMENT OF SALLY M. BENSON

Questions

1. What are the most important outstanding technical issues associated with geologic sequestration of carbon dioxide (CO_2)? Please describe the geologic, environmental, economic, and technical uncertainties. What portion of these uncertainties could be reduced through additional research?
2. Is our state of knowledge sufficient to proceed with a full-scale carbon sequestration demonstration project? By concentrating funding in one large project, do we run the risk of moving to large-scale sequestration before the technical uncertainties have been adequately addressed?
3. What factors should the Department consider in selecting geological sites for carbon sequestration projects and research? What work should be done prior to selection of the FutureGen site?
4. What are the costs of CO_2 injection? How directly do the injection technologies developed for secondary recovery of oil apply to the injection of CO_2 for sequestration?

Testimony

Chairman Biggert and Members of the Subcommittee, thank you for the opportunity to provide testimony on this important and timely topic. I am Dr. Sally Benson, a hydrogeologist. I work at the Lawrence Berkeley National Laboratory and since 1999 I have led a team of earth scientists working on geologic sequestration of carbon dioxide (CO_2).

Carbon dioxide capture and sequestration in deep geologic formations can provide greater than 90 percent reduction in CO_2 emissions from stationary sources such as power plants. The idea was first developed in the late 1970's but did not get much attention until the late 1980's when scientists began to look in earnest for solutions to the climate change problem. Since that time it has emerged as one of the most promising options for deeply reducing CO_2 emissions while continuing to use fossil fuels.

Before answering your specific questions, let me first provide some background information.

Today nearly two million tons of CO_2 are sequestered annually in geologic formations at the Sleipner Project in the North Sea and in the Weyburn oil field in Canada. More commercial projects are planned in Algeria, Australia and off-shore Norway. CO_2 can be sequestered in sedimentary basins made up of alternating layers of sandstones, carbonates, evaporites and shales. The sandstone layers typically provide the reservoir and the shale or evaporites provide seals to trap fluids or gases deep below the land surface. The existence of naturally occurring CO_2 reservoirs proves that CO_2 can be sequestered for hundreds of thousands of years or more. In addition many oil and gas reservoirs also contain large quantities of CO_2 confirming that oil and gas reservoirs can also contain CO_2.

Depleted oil and gas reservoirs are especially promising for long-term sequestration because they have seals that have stood the test of time. They are also attractive because CO_2 sequestration can be combined with enhanced oil and gas recovery. During the early stages of a sequestration project the remaining oil can be swept from the reservoir. Eventually, oil production will stop and the reservoir can be filled to capacity for long-term sequestration of CO_2. This is a mature technology and an estimated 80 percent of oil reservoirs are suitable for CO_2 enhanced oil recovery. The availability of an abundant low-cost supply of CO_2 could be a boon to the domestic oil industry. A similar idea can be applied to enhance the recovery of natural gas from deep coal beds. Tests of this concept are underway in the San Juan Basin in New Mexico.

Now, returning to your first question about the most important outstanding technical issues, most of them are about sequestering CO_2 in deep salt-water filled sandstones. Sandstone formations filled with salt-water, such as the Mount Simon Formation in the Midwest, the Frio Formation along the Texas Gulf Coast, and the Central Valley in California, are estimated to have the capacity to accommodate hundreds of years of CO_2 emissions at today's rates. That natural gas has been stored at over 50 aquifer storage sites in the U.S. alone, demonstrates that appropriately sited projects can safely and effectively sequester CO_2 underground. The best sequestration sites will be at depths between three-quarters and two miles deep, have several hundred feet of porous and permeable sands, and be overlain by at least one thick and continuous seal. However, site selection criteria have not been developed and capacity estimates have not yet been validated by regional or site-specific field experiments.

So far, I have only discussed the potential for physically trapping CO_2 in deep geologic formations. Sequestration can be even more secure if the CO_2 dissolves in water or is converted to minerals such as calcium carbonate. While we know that these geochemical reactions will occur slowly, we don't know exactly how slow or how much to expect. This is another important area for research.

Monitoring to verify that CO_2 is safely and effectively sequestered, or to provide early warning in the event that a project is failing, is also needed. Methods developed by the oil and gas industry such as injection well pressure monitoring and 3–D seismic surveys can be used. But more site-specific studies are needed to demonstrate their sensitivity and to develop standard protocols for monitoring. New remote-sensing techniques for directly verifying sequestration would also be valuable.

Computer models that predict the performance of a sequestration project also need to be verified. While reservoir simulation is a mature technology, the capability of today's models need to be extended to include accurate representation of geochemical and geomechanical processes that are important for geologic sequestration. These models need to be validated by a number of site specific studies that cover the range of geologic settings that could be used for CO_2 sequestration.

The potential environmental consequences of geologic sequestration are well understood based on analogous experience from the oil and gas industry, natural gas storage, EPA's Underground Injection Control Program and places such as Perrier in France where CO_2 naturally seeps out at the ground surface. The highest probability risks are associated with improper injection well completions, abandoned wells and inadequate characterization of the sequestration site. Over time, technologies and monitoring protocols have been developed to manage and mitigate these concerns. Implemented on a small scale, in a well characterized geologic setting, geologic sequestration poses no unique or poorly understood risks. However, after the best characterized and most secure sites are filled, a significant characterization and risk assessment effort will be needed to accommodate additional CO_2 sequestration.

To summarize about the most important outstanding technical issues, geologic sequestration of CO_2 is in practice today and more is planned. It builds upon a technology base developed over more than one-half a century by the oil and gas industry. However, to fully evaluate and realize the potential for large-scale application, site-specific field studies and a core directed-research program are needed. Specifically, the combined program must:

- Provide regionally validated estimates of sequestration capacity;
- Enhance our understanding of the geochemical reactions and geomechanical processes that enhance or compromise sequestration security;
- Provide validated approaches to modeling and monitoring; and
- Perform regional and site-specific risk assessments.

To answer your question about what portion of these uncertainties can be reduced by additional research, all of them can be with a research program that combines regionally-relevant pilot-tests with a core directed-research program. Because the regional and site-specific nature of the factors that provide secure geologic sequestration, pilot-tests should be located in each of the regions with a large concentration of stationary CO_2 sources. While many of these issues can be addressed by small scale pilot-tests, eventually, full scale demonstration projects will be needed.

With regard to the committee's second and third questions, are we ready for a full-scale demonstration and what work is needed before a site is selected? The full-scale geologic sequestration projects at Sleipner and Weyburn attest to this fact that a full-scale demonstration can be carried out today. However, first, potential sites need to be screened, pilot-tests must be carried out, including demonstrating that our models and monitoring methods are adequate, a risk assessment is needed and permits must be obtained.

To answer your fourth question, estimated costs for geologic sequestration of CO_2 range from about $3 to $10 per ton, depending on site specific considerations such as how many injection wells are needed, surface facilities, economy of scale and monitoring requirements. As the technology matures, uncertainties in costs will be reduced. These costs are small fraction of the cost of CO_2 capture and consequently have not been the focus of much attention.

In summary, geologic sequestration is an important component of a climate change technology portfolio. It offers the potential for deep reductions in CO_2 emissions while allowing continued use of fossil fuels. Efforts are underway to address the important technical issues and success can be assured by a sustained commitment to an adequate program of directed-research, pilot-tests at regionally relevant sites and full-scale demonstration.

BIOGRAPHY FOR SALLY M. BENSON

Dr. Sally M. Benson is the Deputy Director for Operations at Ernest Orlando Lawrence Berkeley National Laboratory. In addition to this administrative position, she is a staff scientist in the Earth Sciences Division of the Laboratory. A lead researcher in her field, Dr. Benson has addressed a range of issues related to energy and the environment, including environmental remediation, gas storage, and geothermal energy production. In many recent years she has focused her research on carbon sequestration, particularly on sequestration in deep geologic formations.

Dr. Benson is the Director of the GEO–SEQ Project, a National Energy Technology Laboratory (NETL) sponsored project. She continues to work on providing safe and cost-effective methods for geologic sequestration of CO_2. She has authored or co-authored an abundance of scientific publications on the subject. Currently, she is a coordinating lead author for the "Intergovernmental Panel on Climate Change (IPCC) Special Report on CO_2 Capture and Storage." Dr. Benson often travels, both throughout the United States and abroad, to lecture about her scientific research.

A graduate of Barnard College, Columbia University with a B.A. in Geology, she completed her education in 1988 at the University of California, Berkeley, receiving her M.S. and Ph.D. degrees in Materials Science and Mineral Engineering. Dr. Benson serves on numerous committees, such as the Carbon Mitigation Initiative (CMI) Advisory Board and the CO_2 Capture Project/British Petroleum (CCP/BP) Technology Advisory Board. In 1996, Dr. Benson was awarded the Department of Energy Certificate of Appreciation for her lead in the development of the Natural and Accelerated Bioremediation Research Program Plan.

BERKELEY LAB

SALLY BENSON
DEPUTY DIRECTOR FOR OPERATIONS

November 4, 2003

Congresswoman Judy Biggert
Chairwoman, Energy Subcommittee
House Committee on Science
Suite 2320, Rayburn House Office Building
Washington DC, 20515-6301

Dear Congresswoman Biggert:

This is to provide a record of financial disclosure according to the Rules of the House of Representatives for testimony at your Subcommittee's Hearing on "What are the Administration Priorities for Climate Change Technology?" on Thursday, November 6, 2003.

My current federal funding contracts and obligation are provided in the following list:

Federal Sponsor	Period	Amount	Remarks
DOE/FE	2001-2003	$2.890M	GEO-SEQ Project
DOE/FE	2001-2004	$0.70M	CO2 Capture Project

Please let me know if you require any further information regarding these federally funded contracts.

Sincerely,

Sally Benson
Deputy Director

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY | BERKELEY, CALIFORNIA 94720
MS 50A-4112 | TEL: 510.486.5875 | FAX: 510-486.6498

Chairwoman BIGGERT. Thank you, Doctor. And Dr. Brown.

STATEMENT OF DR. MARILYN A. BROWN, ENERGY EFFICIENCY AND RENEWABLE ENERGY PROGRAM, OAK RIDGE NATIONAL LABORATORY

Dr. BROWN. Good morning, Chairman Biggert and Members of the House Subcommittee. Thank you for inviting me to comment on the subject of climate change technologies.

Let us start with the issue of portfolio balance. One needs to consider all of the standard dimensions, such as the benefits, that is, the greenhouse gas emission reductions, the other benefits that might result, the ancillary, productivity and safety and security and health and pollution reductions that could occur. You have got to consider the costs, the R&D and other costs, equity concerns, who pays, who wins, as well as looking at the full spectrum of ways that carbon atmospheric concentrations can be reduced.

And in doing that, I like to divide those methods into three categories. One is ways of reducing the energy intensity of the Nation's economy, using less energy per GDP, and to do that, you can employ various energy efficiency technologies, or you can use system enhancements, such as locating power generation near to facilities that can take advantage of the heat, waste heat, that is produced at those facilities.

A second way is to reduce the carbon intensity of the energy system. Here, you turn to ways of producing energy using less carbon intensity, so renewable energy, nuclear energy, those are some of the approaches that would work there. And third is carbon sequestration, where you, as Dr. Benson and Mr. Rudins have focused on some of those technologies.

There was a study completed in the late 1990's by 11 national laboratories that used the typology I just mentioned, energy intensity, carbon intensity and carbon sequestration, and enumerated hundreds of specific approaches in each of those three categories, and concluded that there is a relationship between those categories, and the time horizon required to produce cost-effective solutions, and the most cost-effective solutions that exist today are in the energy intensity reduction category, that is, in the energy efficiency arena. It is going to take another decade or two, possibly three, for the other approaches to become cost-effective.

So, let us talk about the no regret strategy you asked me to address. Many studies have documented that the Nation has a significant reservoir of cost-effective energy efficiency opportunities. Focusing on these technologies has been called a no regrets approach, because it promotes the investments—it promotes investments that would be good for the consumer and good for the environment. It is also sometimes called the double dividends approach for that reason.

As an example, let us look at the experience of the Department of Energy's Best Practices Program, which has developed industrial plant assessment tools to try to reduce the consumption of energy at industrial plants in the areas of steam, air—compressed air, motors and drive systems. I like to use that as an example, because they have documented so carefully the powerful amount of opportunity that exists in these manufacturing facilities to save energy.

In the first five plant assessments that were done by this program, they documented $17 million worth of savings that, in fact, not only could be achieved, but were achieved following the completion of these assessments. And subsequently, they have done a total of 28 assessments, and have shown that there is an aggregate savings potential of $163 million in just 28 plants.

A study by five national laboratories that was completed in the year 2000 tried to itemize the opportunities one by one available to the Nation to reduce CO_2, and they concluded that over the next 20 years, we could reduce our energy consumption by 20 percent, and our carbon dioxide emissions by 31 percent, if we put in place an aggressive set of policies to try to deal with the market imperfections that are hindering these technologies from advancing into the marketplace.

The 31 percent of carbon reductions were driven by—two thirds of those reductions were the result of energy efficiency improvement, one third by low carbon technologies and it is assumed that following those technology advances, we would soon see carbon sequestration delivering that next decade of opportunities, allowing the Nation to consider—continue to use fossil fuels, and meet the need for even greater carbon reductions.

Well, what kind of evidence do we have that if you were to put in place an aggressive set of policies and programs, including much more R&D, that we would in fact deliver viable technology options that consumers would buy? Take a look at the National Academy's report that was published earlier this year that looked at several dozen energy efficiency projects completed by the Department of Energy. They concluded that these several dozen projects generated economic benefits of $30 billion, far exceeding the $7 billion which constituted the entire Department of Energy's efficiency budget over that time period.

Just to bring that home, consider one particular project, which dealt with the household refrigerator. In the year 1970, your household refrigerator consumed nearly 2,000 kilowatt-hours a year of electricity. Well, as a result of a very aggressive public/private research partnership, today, the average new refrigerator requires only one third of that electricity.

Well, what about the future? Where are we going to find these similar savings? What should we invest in, in terms of promising research? Earlier this year, the Department of Energy's Basic Energy Sciences Advisory Committee, called BSAC, published a report that documents the physical science, basic energy sciences, that could deliver the fundamental breakthroughs that we will need in order to continue to keep the pipeline of cost-effective technologies full. That is, they documented that energy efficiency and the no regrets approach is not a short-lived phenomenon, that through continued science and technology investments, we can provide even better technology solutions well into the next several decades.

Consider some of the materials breakthroughs that have occurred recently, nickel aluminide alloys, for instance, are being used in plants——

Chairwoman BIGGERT. Draw your——

Dr. BENSON. Oh, great.

Chairwoman BIGGERT [continuing]. Testimony to a conclusion. I know we will have questions for you, though.

Dr. BENSON. Okay. Some of the most exciting scientific advancements have been in the materials area.

In conclusion, energy conservation does not have the rugged, romantic appeal of oil drilling or coal mining. It doesn't wow us with massive dams or dramatic cooling towers, or a large power—solar power towers. It is somewhat invisible, and yet, it does make a tremendous amount of energy available, prevents pollution and avoids emissions of greenhouse gas reductions.

To secure such double dividends in the future, we need to move forward on three major fronts: on policies to address market barriers, market imperfections, R&D to accelerate technology advancements and programs to facilitate technology deployment.

Thank you very much.

[The prepared statement of Dr. Brown follows:]

PREPARED STATEMENT OF MARILYN A. BROWN

Chairman Biggert and Members of the Energy Subcommittee, thank you for inviting me to comment on the subject of climate change technologies. You have asked me to address three issues:

- the attributes of a balanced climate change technology portfolio,
- the "no regrets" strategy of targeting cost-effective, energy-efficient measures, and
- the non-climate benefits of federal climate change R&D investments.

Many of my comments on these issues are drawn from a study completed in November 2000, called the *Scenarios for a Clean Energy Future.* This study, which I co-led, examined the ability of energy-efficient and clean energy technologies to reduce U.S. greenhouse gas emissions. It was commissioned by the U.S. Department of Energy (DOE), was co-funded by the U.S. Environmental Protection Agency, and was completed by researchers from five DOE national laboratories.[1] My comments draw on other research, as well, including *Technology Opportunities to Reduce U.S. Greenhouse Gas Emission* (a.k.a. the "11-Lab Study")[2] and a recent workshop on *Basic Research Needs to Assure a Secure Energy Future.*[3]

Attributes of a Balanced Climate Change Technology Portfolio

The balance of a climate change technology portfolio can be evaluated along many dimensions. These include market and technical risk; time-to-market introduction (near-, medium-, and long-term); size of potential greenhouse gas emissions reductions; magnitude and nature of other benefits; R&D investment requirements and other costs; and distributional impacts (by region, income group, etc.). For carbon dioxide, the most important of the greenhouse gases, the RD&D portfolio for climate change should also consider the full spectrum of ways that carbon concentrations in the atmosphere can be reduced. These include:

- reducing the "energy intensity" of the economy (that is, total energy use divided by the gross domestic product),
- reducing the "carbon intensity" of the energy system (that is, carbon emissions per unit of energy consumed), and
- removing atmospheric carbon through "sequestration."

These three approaches embody distinct technology pathways to reduce greenhouse gas emissions. Energy intensity can be decreased through the more efficient use of fossil fuels in transportation, buildings and industry and through system designs such as co-locating facilities that produce both electrical power and heat with facilities that need them. Carbon intensity can be decreased by increasing the efficiency of energy production, or by using either fuels that emit less carbon or technologies that use lower carbon-emitting fuels such as nuclear power plants and re-

[1] The report can be found at http://www.ornl.gov/ORNL/Energy_Eff/CEF.html
[2] The report can be found at http://www.ornl.gov/climate_change
[3] The report can be found at http://www.sc.doe.gov/production/bes/BESAC/reports.html

newable energy sources such as hydroelectric, wind, and solar power plants. Ways to increase carbon sequestration include capturing and storing CO_2 after combustion but before it enters the atmosphere, and increasing the rate at which oceans, forests, and soils absorb CO_2 from the atmosphere.

To reduce carbon emissions significantly while sustaining economic growth, all three of these technology avenues may be needed. The 11-Lab Study concluded that these three approaches have different time dimensions. The report concluded that:

- In the first decade of this century significant advances in energy efficiency technologies could deliver substantial near-term carbon-reducing impacts by decreasing the energy intensity of the U.S. economy.
- Along with continued improvements in energy efficiency, research-based advances in clean energy technologies could reduce significantly the carbon intensity of the U.S. energy economy during the second decade. A wide range of improved renewable, fossil, and nuclear technologies could be introduced and widely deployed in this period.
- Complementing ongoing advances in efficiency and clean energy technologies well into the third decade, carbon sequestration technologies could add a third important dimension to the package of solutions. Success in this technology area could enable the Nation to continue its extensive use of fossil fuels without harming the global climate.

The "No Regrets" Strategy of Targeting Cost-Effective, Energy-Efficient Measures

Like many other analyses, the *Scenarios for a Clean Energy Future* study described a large reservoir of highly cost-effective energy-efficient technologies that are available for deployment. Climate change strategies that focus on these technologies have been called "no regrets" approaches because they promote technologies that would be good for consumers and the economy irrespective of their climate change benefits. The fact that such technologies remain under exploited leads to two key questions. If energy-efficient technology is cost-effective, why isn't more of it being used? If individuals and businesses can make money from energy efficiency, why don't they just do it?

Although some like to assert that markets are perfect, practical experience tells us otherwise. Energy markets, like all markets, are plagued by imperfections that can impede the adoption of new products, even those that are beneficial and economical. These market failures include:

- Misplaced incentives (for instance, these often occur in apartment buildings where landlords pay the utility bills, giving tenants no incentive to conserve)
- Distorting fiscal and regulatory policies (for example, electricity rates that do not reflect the real-time cost of electricity production)
- Unpriced costs (such as the health problems associated with burning hydrocarbons)
- Unpriced benefits (such as the public benefits associated with energy R&D: because the benefits of private-sector investments in R&D extend beyond any individual firm, investments are insufficient from a public perspective).

The existence of market failures that inhibit investment in improved energy technologies is a primary driver for public policy intervention. In many cases, feasible, low-cost policies and programs can be put in place to eliminate or compensate for market imperfections, enabling markets to operate more efficiently for the benefit of society.

As one example, consider DOE's Best Practices Program, which has developed plant assessment and analysis tools and has conducted plant-wide assessments of energy-saving opportunities. The goal is to address key information barriers to the adoption of energy-efficient measures. Improvements to industrial utility systems (steam, compressed air, motors, and pumps, etc.) offer tremendous energy-saving opportunities. Industrial motor systems, for example, use 25 percent of all the electricity consumed in the United States. In just five of the program's initial industrial assessment projects, annual energy savings of $17 million were realized, with an average payback on investment of 1.2 years. Altogether, the 28 assessments conducted to date have identified aggregate savings of $163 million (390,000 MWh/yr of electricity and 10 trillion Btu/yr of natural gas). Full implementation of such energy-efficient technologies could save 10 to 20 percent of the power used in motor-driven industrial systems, saving billions of dollars annually.

The *Scenarios for a Clean Energy Future* study concludes that accelerating the development and deployment of energy-efficient technologies could significantly reduce air pollution and greenhouse gas emissions, oil dependence, and economic inefficiencies, at no net cost to the economy. The overall economic benefits of the technologies and policies that are modeled result in energy savings that equal or exceed the cost of implementing the policies and of investing in the technologies.

The results of two scenarios modeled in the *Scenarios for a Clean Energy Future* illustrate the magnitude of benefits that could arise from a “no regrets” approach:

- The business-as-usual (BAU) scenario assumes that current energy policies and programs continue, resulting in a steady but modest pace of technological progress and improved efficiencies.
- The advanced scenario is defined by an array of policies including a 50 percent increase in cost-shared federal energy R&D; expanded voluntary programs; tax credits for efficient appliances, vehicles, and non-hydro renewable electricity; voluntary agreements to promote energy efficiency in vehicles and industrial processes; appliance efficiency standards; renewable portfolio standards; and a domestic carbon cap and trading system.

The BAU scenario forecasts that U.S. energy consumption will increase from nearly 100 quadrillion Btu (quads) in 2000 to 119 quads in 2020. Carbon dioxide emissions are forecast to increase at a comparable rate, from 1,346 MtC in 1990 to 1,920 MtC in 2020 (see Figure 1).

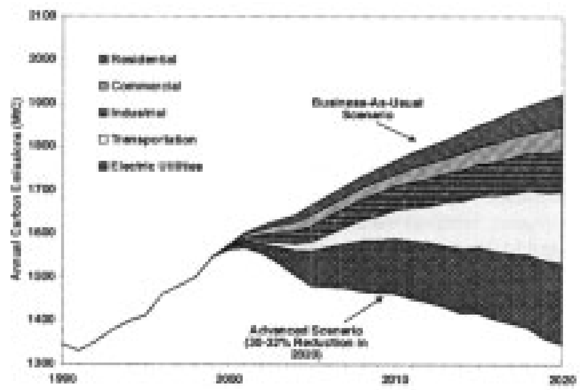

Figure 1. Carbon emission reductions, by end-use sector, in the advanced scenario.

Under the advanced scenario, the United States consumes 23 quads (20 percent) less energy in 2020 than is predicted under the BAU forecast. Under the advanced scenario, U.S. CO_2 emissions drop in 2020 to 1,330 MtC (31 percent), avoiding nearly 600 MtC compared with the BAU forecast. Two-thirds of these reductions are due to “no regrets” energy efficiency improvements—improvements that shave $120 billion off the U.S. energy bill in 2020. Consistent with the 11-Lab Study, energy intensity reductions occur quickly through energy efficiency investments. Carbon intensity reductions are also significant by 2020, and carbon sequestration technologies are assumed to take hold in subsequent decades.

Evidence that Climate Change R&D Investments Can Deliver Viable Technology Options

What evidence do we have that climate change technology R&D can deliver products that consumers, industry, and businesses will choose to use? Consider the results of a recent study completed in 2001 by the National Academies as reported in *Energy Research at DOE, Was It Worth It?* This study concluded that energy efficiency and fossil energy research at DOE has produced economic net benefits:

- Total net realized economic benefits associated with selected energy efficiency programs were approximately $30 billion, substantially exceeding the roughly $7 billion in total energy efficiency RD&D investment.
- The realized economic benefits of $7.4 billion resulting from fossil energy programs instituted from 1986 to 2000, exceeded the estimated $4.5 billion cost of the programs during that period.

The National Academies also noted that additional environmental and security benefits resulted, and there were significant options and knowledge benefits.

As one example of the many successes enumerated by the National Academies, consider the outcome of a major R&D effort that began in the late 1970s to improve the efficiency of household refrigerators.

Between 1977 and 1982, DOE invested approximately $1.6 million in R&D to make home refrigerators more energy efficient. Working in a public/private partnership with compressor and appliance manufacturers, DOE and two federal laboratories identified ways of improving the performance of refrigerator compressors, motors, insulation, and controls, and they provided test data for use in the setting of national standards. These technology investments, in conjunction with the issuance of appliance standards, cut the energy use of the average new refrigerator in half by the year 1990 and saved U.S. consumers $7 billion in energy costs from 1981 to 1990 (1999 dollars) (see Figure 2).

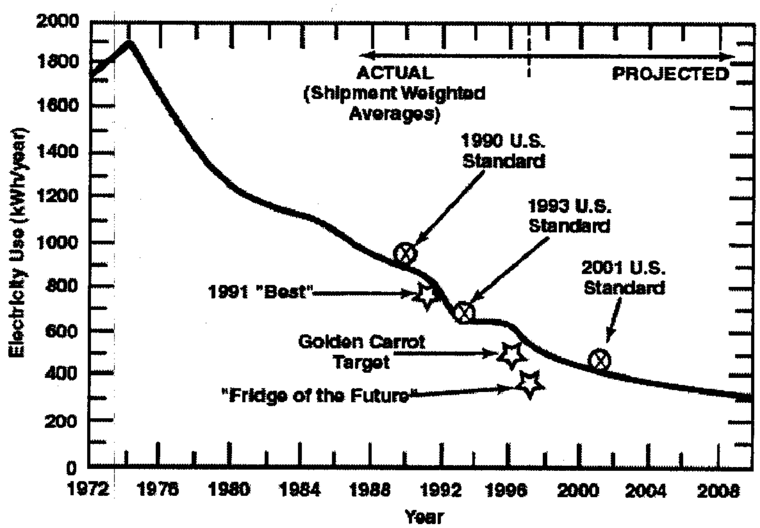

Figure 2. Average electricity use of household refrigerator/freezers by year of purchase.

In 1997, a DOE-industry cooperative R&D effort developed a prototype "fridge of the future" that, again, used nearly 50 percent less energy than refrigerators then on the market and surpassed the 2001 efficiency standard for refrigerators. These developments, in combination with the 2001 U.S. standard, will save consumers billions of dollars in the future.

The Non-Climate Benefits of Federal Climate Change R&D Investments

The National Academies also note in their 2001 study *(Energy Research at DOE, Was it Worth It?)* that environmental and security benefits have resulted from DOE's energy efficiency and fossil energy research. These include cleaner air and water, which can produce significant public health benefits, and the potential for greater fuel flexibility, which is important to national security. In addition, the National Academies cite the importance of options and knowledge benefits. Options benefits are derived from technologies that are fully developed but for which economic and policy conditions are not currently favorable for commercialization. Knowledge benefits refer to the contribution of R&D to the stock of engineering and scientific information and wisdom.

Productivity improvements, product quality gains, and job creation have been important additional collateral benefits of many energy efficiency investments. These have been particularly significant in the industrial sector, where energy efficiency investments have led to greater labor productivity, better products through improved process control, greater equipment longevity, and waste minimization. Such productivity benefits often exceed the value of the energy saved from the introduction of advanced efficiency technologies in industry. Consideration of non-climate costs and benefits is important in the design of a climate change technology portfolio, because they have a significant impact on the likelihood of market success and the ultimate delivery of climate benefits.

Promising Energy Efficiency Technology Opportunities

The Nation has at its disposal an underutilized reservoir of currently cost-effective, energy-efficient technologies that can deliver significant greenhouse gas reductions, if targeted, market-based policies are implemented. Other energy efficiency technologies are on the brink of cost-effectiveness, but need performance enhancements and cost reductions to become viable.. Still other technologies require significant science-based improvements to achieve major technical breakthroughs necessary for technical and market viability.

The *Scenarios for a Clean Energy Future Study* describes a range of policy options for accelerating the deployment of market-ready technologies. It also describes many of the near-term technology opportunities that could have a significant impact by 2020, if their performance and cost profiles can be improved. The 2003 report by DOE's Basic Energy Sciences Advisory Committee (BESAC), *Basic Research Needs to Assure a Secure Energy Future,* describes a set of research directions that could deliver the more fundamental and necessary breakthroughs. These directions underscore the importance of a strong physical sciences investment to enable the technologies that provide long-term solutions. A sampling of these research directions are listed below:

- **Residential, Commercial, and Industrial Energy Consumption**
  - Sensors
  - Solid state lighting
  - Innovative materials for new energy technologies
  - Multi-layer thin film materials and deposition processes
- **Transportation Energy Consumption**
  - Integrated quantitative knowledge base for joining of lightweight structural materials
  - Vehicular energy storage
  - Fundamental challenges in fuel cell stack materials
  - Integrated heterogeneous catalysis
  - Thermoelectric materials and energy conversion cycles for mobile applications
  - Complex systems science for sustainable transportation
- Distributed Energy, Fuel Cells, and Hydrogen
  - Advanced hydrogen synthesis
  - High-capacity hydrogen storage for distribute energy of the future
  - Novel membrane assemblies
  - Designed interfaces

Based on the BESAC report, it is clear that the technology "pipeline" for reducing the energy intensity of the economy can be kept full for several decades. The energy-efficiency "no regrets" approach is not a short-lived phenomenon. Rather, it can take the Nation well into the current century with climate-friendly solutions that will allow the economy to continue to grow.

Consider some of the materials breakthroughs that are already advancing the performance of energy technologies. Nickel aluminide alloys, developed through a DOE-industry R&D partnership, are extraordinarily strong, hard, and heat-resistant. Delphi Automotive Systems in Saginaw, Michigan, recently celebrated the installation of trays made from this new bimetallic alloy, in its steel carburizing heat-treating furnaces. These trays are cutting energy use by five to ten percent by making it feasible to operate furnaces at higher temperatures and with fewer shutdowns. New steels promise similar advantages in a wide range of other applications. Researchers at Oak Ridge National Laboratory and Caterpillar have developed a new stainless steel (CF8C–Plus) that is stronger and tougher at both high and low temperatures than standard steels without costing more. Not only the steel itself but also the method of producing it, termed "engineered microstructures," are being hailed as revolutionary. Immediate applications planned for CF8C–Plus include turbocharger housings for heavy-duty diesel engines and industrial gas turbines, which will allow higher temperature operations, producing significant energy savings. Nanoscience materials research promises to produce a stream of future breakthroughs that will offer continuing improvements to energy technologies.

The BESAC report also enumerates promising research directions that would reduce greenhouse gas emissions through advances in nuclear energy and renewable energy resources, by reducing the carbon intensity of the energy system. To meet the long-term goal of stabilizing atmospheric concentration of carbon, breakthroughs in sequestration technologies are also required. Finally, improved technologies are needed for measuring and monitoring the quantities and fluxes of greenhouse gases in the Earth's atmosphere.

Conclusion

Energy conservation does not have the rugged, romantic appeal of oil drilling or coal mining. It does not wow us with massive dams, dramatic cooling towers, or tall smokestacks. But energy conservation does make a tremendous amount of energy available, prevents pollution, and avoids the emission of greenhouse gases. In fact, over the past 25 years, energy efficiency has become the number one domestic source of energy available for use by U.S. consumers. Nearly a quarter of the energy we use today is energy that would have been lost to waste without the energy-efficiency technologies that have been developed and implemented since the Arab oil embargo of 1973–74. In the absence of these energy efficiency improvements, the Nation's greenhouse gas emissions would be significantly greater.

An expanded climate change technology portfolio could significantly accelerate the development and deployment of cost-effective, efficient, clean energy technologies—technologies that are good for business, good for consumers, good for the economy, and good for the environment. To secure these benefits, the Nation needs to move forward on three major fronts—on policies to address market imperfections, R&D to accelerate technology advancements, and programs to facilitate technology deployment.

Thank you for this opportunity to talk with you today. I would be happy to answer any questions.

BIOGRAPHY FOR MARILY A. BROWN

Marilyn Brown is the Director of Oak Ridge National Laboratory's Energy Efficiency and Renewable Energy Program, a $125 million/year program of research on advanced energy efficiency, electric reliability, and renewable energy technologies. During her 20 years at ORNL, she has researched the impacts of policies and programs aimed at accelerating the development and deployment of sustainable energy technologies. Prior to coming to Oak Ridge, she was a tenured Associate Professor in the Department of Geography at the University of Illinois, Urbana-Champaign. While on the faculty, she received two NSF grants and funding from other sources to support her research on the diffusion of energy innovations. She has a Ph.D. in geography from the Ohio State University, where she was a University Fellow; a Master's Degree in resource planning from the University of Massachusetts; and a BA in political science (with a minor in mathematics) from Rutgers University. She has authored more than 140 publications and has received awards for her research from the American Council for an Energy-Efficient Economy, the Association of American Geographers, the Technology Transfer Society, and the Association of Women in Science. A recent study that she co-led *(Scenarios for a Clean Energy Future)* is the most comprehensive assessment to date of the policy and technology opportunities available to the United States to meet its energy-related challenges. This study was the subject of a dedicated issue of Energy Policy and has played a significant role in international climate change debates. Dr. Brown serves on the boards of several energy, engineering, and environmental organizations and journals. She is also a member of the National Commission on Energy Policy.

DISCUSSION

Chairwoman BIGGERT. Thank you. All written testimony will be submitted for the record. We welcome here today the gentleman for Maryland, Mr. Gilchrest, who is not an official Member of this subcommittee, but serves on the Science Committee, and I would ask unanimous consent to have him participate in this hearing. Without objection, so ordered.

Welcome, Mr. Gilchrest, and now, at this point, we will open our first round of questions, and the Chair recognizes herself for five minutes.

My first question is to Mr. Conover. The programs that the Administration cites as key to its climate change technology strategy appear to be all long-term efforts. If we wait for the results from FutureGen, it will be at least 10 years before results can reassure private investors that this technology is viable, significant penetration of hydrogen will take at least 15 years or more, and the international fusion experiment, ITER, is unlikely to lead to changes in the energy market for at least 50 years, and how can we wait so long?

Mr. CONOVER. Thank you, Madam Chairman. We need to be clear that while the Administration has announced those priorities as part of the NCCTI process of focusing on long-term large payoff areas, where there is a key role for federal R&D, we are not giving up on the rest of the portfolio, which does have significant nearer-term impacts, particularly in the area of energy efficiency, deployment of best practices, advances in renewables, solar, wind and geothermal, which are much further along the commercialization path than hydrogen and FutureGen, so we are, in fact, pursuing a diverse portfolio that has both near and long-term impacts, and look forward to reaping the benefits of those as we move forward.

Chairwoman BIGGERT. Thank you. Not having seen the first installment of the letter from Mr. Card, is there a priority of some of these—of the energy efficiencies and the other short-term solutions?

Mr. CONOVER. When you look at the programs that we have in place now, the Climate VISION and Climate Leaders, in particular, where the Administration is working with trade associations and individual companies to achieve voluntary reductions in greenhouse gas emissions in the near-term, the best practices and the diffusion of commercially available technology is really the key to achieving those nearer-term goals.

Chairwoman BIGGERT. Okay. Thank you. Dr. Brown, you note that with an aggressive set of policy and technology initiatives, it is plausible for the country to have the same or greater level of economic output in 2020, i.e., no net cost, as would occur under business usual, and yet, use about the same amount of energy as we use today. They apparently would also produce fewer greenhouse gas emissions than we produce today. That is a pretty remarkable statement. How much of this improvement comes from your assumption of increased funding for energy efficiency and renewable energy?

Dr. BROWN. If the modeling assumed a doubling of the R&D budget for all energy research that deals with climate reduction, carbon reduction technologies, and also a variety of market-based policies, as well as a carbon cap and trade system, we assume would be put in place by the year 2005. The study was done in 2000, so now, we are behind on that timeline, and we, today, couldn't achieve that all by 2020. It is a 20-year timeframe, though.

I think within 20 years of starting an aggressive set of programs and policies such as that, those estimates would still hold.

Chairwoman BIGGERT. Are there particular areas of energy efficiency or renewable energy research that you would recommend receive greater emphasis?

Dr. BROWN. The opportunities to reduce energy consumption in buildings and industrial facilities, I think, are very promising, and deserve greater focus in terms of improving those technologies through science-based research. I think they are just more difficult to, without strong policies, translate the research benefits in the transportation sector into real fuel economy savings in the marketplace. The policies are really needed there, in combination with the research.

Chairwoman BIGGERT. And two thirds of the improvement comes from what you call the no regrets.

Dr. BROWN. Yes.

Chairwoman BIGGERT. Are there any particularly low-hanging fruit that the Government could target for harvest? Where do we go first?

Dr. BROWN. Well, you know, that is why it is so difficult to sell energy efficiency, because there is no silver bullet. It is everywhere. It is your lighting, it is the building envelope, it is the equipment that is—the space conditioning and throughout an industrial plant, likewise, it is all of the ways that energy is used. I do think that material science is a fundamental research foundation to deliver many of the advances, because if we can operate equipment at higher temperatures, for instance, we can gain greater efficiencies, as in microturbines, or in diesel engines, and that is an area, I think, with great promise.

Chairwoman BIGGERT. Thank you, and my time has expired. I recognize the gentleman from Texas for five minutes.

Mr. LAMPSON. Thank you, Madam Chairwoman. Mr. Rudins, in the absence of compelling air quality regulations, what makes you think that the famously risk and innovation-averse electric utility industry will adopt such revolutionary and expensive technology, and why are they interested in participated in FutureGen when coal plants are still being plant and CO_2 is still not considered to be a criterion pollutant?

Mr. RUDINS. In fact, that is a very good question. I would answer that question by saying that one of the concerns utilities also have is regulatory certainty, and both for traditional pollutants, but especially for carbon, there is considerable regulatory uncertainty in terms of what they will face in the future.

Over the last 30 years or so, the investment that we have made in coal technology, clean coal technology, has led to ever cleaner systems, but ever cleaner systems still are not sufficient to deal with what might be on the horizon in terms of regulatory requirements and others.

FutureGen, if it is successful in achieving its goals, is the ultimate manifestation of clean coal technology. Technology, from an environmental perspective, cannot go much further than zero or near zero emission technology. If one could successfully develop that class of technology, that, in essence, would convey regulatory certainty and you could deal with future environmental requirements, regulated and non-regulated. If you can do it in a cost-competitive manner, you in a sense have your cake and you can eat it as well.

Now, a few years ago, the utility and the coal industry may not have embraced FutureGen as aggressively as they actually have. You may be aware that a FutureGen alliance has formed with the over nine member companies representing over 20 percent of the U.S.-based coal-based power generation. Over 45 percent of the U.S.-based coal production, saying we need this. We are committed to it, and we will work with you to try and make it happen. The National Mining Association has stepped forward with a similar statement. So, in essence, the electricity generation industry is stepping forward offering to do missionary work to establish the technology base for a future fleet of power plants and technologies that could meet whatever environmental future we foresee.

Mr. LAMPSON. Well, through that process, you will capture CO_2. The intention is to reinject it and store it some place, put it into unminable coal seams, so a question for you, Dr. Benson. How much of that is available in this country, but more importantly that that, let me ask this question, and I would like for you to comment on it, but let me ask this one. In the case of sequestration in deep saline aquifers, will there be significant amounts of displaced or produced water, and if so, how will be handle such large quantities of water?

Dr. BENSON. You really need to look site by site, whether or not there will be significant quantities of displaced water. The best sites, those that are very large, such as the Frio Formation in the Houston area, can accommodate such a tremendous quantity of CO_2 that it is unlikely there would be produced brines, and if they did, you would be pushing them out into the ocean, not onto the land, so it really wouldn't be an issue there. But it is an issue, and again, you know, geologic sequestration is not a panacea. It needs to be done carefully with all the appropriate site characterization and monitoring and so forth.

Mr. LAMPSON. These unminable coal seams, make—just one quick comment on it. How much of that is available, and where do you find them? Where are they?

Dr. BENSON. Well, I am not an expert on the quantity of unminable coal seams. There are, in the Rocky Mountain region, there are a number of significant deposits. There is also some new work by the U.S. Geological Survey showing significant deposits in the Southeast that may be amenable to this kind of technology as well. That is some of the work that needs to be done to characterize just how much and where this could be accomplished.

Mr. LAMPSON. Dr. Brown, in H.R. 238, this Committee authorized the construction of a network of regional advanced energy technology transfer centers to bridge the gap between development of energy-efficient technologies and full-scale commercialization, and this provision has been included in the draft Research and Development Title of the Energy Bill, H.R. 6. Are you aware of this provision, and if so, how do you think initiatives such as this would fit into a national climate change initiative?

Dr. BROWN. I have to confess I am not familiar with that initiative, but I want to learn more, because it sounds like it is very promising and would help to bridge that gap between science and marketplace improvement, so it sounds like an excellent way to proceed.

Mr. LAMPSON. Thank you very much. My time is up.

Chairwoman BIGGERT. Thank you. The gentleman from Georgia, Mr. Gingrey, is recognized for five minutes.

Mr. GINGREY. Thank you, Madam Chairman. Mr. Rudins, in her testimony, Dr. Benson indicated a cost range of $3 to $10 per ton for carbon disposal, not including the cost of carbon capture. This is certainly in the range of the Department of Energy goals. What are the costs of CO_2 capture, and how soon do you see DOE's goals being reached?

Mr. RUDINS. The greater cost component, in fact, is the capture component. Today's technology, if you were to employ it such as a means coverage with existing power plants, would be very costly indeed, much more so than just the disposal costs. But already, technologies that are coming out of the laboratory, like the clathrate process, to name one, offers the potential, when integrated with advanced systems, such as IGCC, to reduce that cost by perhaps an order of magnitude, as well as the energy costs associated with it.

The goal that we have for the Department sequestration program is to get the costs to $10 a ton carbon, and that is capture and disposal. The current price point in terms of laboratory technology, like the clathrate process, is still at the laboratory stage is in the $30 or so range.

Mr. GINGREY. Mr. Conover, this question is for you. Given the long time horizons of carbon sequestration and hydrogen technologies, what does the Administration plan to do to meet its near-term goal of reducing the carbon intensity of the economy by 18 percent by the year 2012?

Mr. CONOVER. Thank you, Congressman. Again, this goes back to the voluntary partnerships that the Administration is forging through Climate VISION and Climate Leaders, particularly focused in on areas of energy efficiency, the buildings and industrial technologies that Dr. Brown mentioned, further advances in solar, wind and geothermal, all of which are still robustly funded in the Administration's budget.

Mr. GINGREY. And the Administration has stated that it supports stabilization of greenhouse gas concentrations in the atmosphere. By what date will your technology efforts be able to achieve this goal at current rates of funding?

Mr. CONOVER. Well, the issue of timing on the stabilization goal is an important one. Our philosophy is moving forward aggressively on investments in technology with both long and near-term impacts, and as the scientific certainty advances with respect to both what the levels need to be and how quickly we need to achieve them, our mission is to provide a diverse portfolio of technology that allows policymakers to respond to that information as it becomes clearer.

Mr. GINGREY. And I would like to ask Mr. Rudins on this one. Several experts have told us that a full-scale single site sequestration experiment without a power plant would cost about $50 million over 10 years, including the purchase of CO_2. Your testimony includes a cost estimate sequestration that is over four times this number at $224 million. Can you explain how that your number was reached?

Mr. RUDINS. I can't comment comparatively, because I haven't seen the $50, $50 million estimate, but the cost that you see incorporated in FutureGen involves extensive instrumentation of the site, development of the site and extensive monitoring for at least 10 years and beyond, so I don't know if it's an apples to apples comparison. It also allows for innovation, new technology development. It allows, within that cost, enhanced modeling and research support activities, so it is not just go to the site, dig a hole, or drill a hole and pump CO_2 in there. It is essentially a full-scope research project in addition to that. But I couldn't comment specifically without seeing the estimates you are talking about.

Mr. GINGREY. I yield back my time at this point, Madam Chairman.

Chairwoman BIGGERT. Thank you. The Chair now recognizes the gentlewoman from California, Ms. Woolsey.

Ms. WOOLSEY. Thank you, Madam Chairman—Chairwoman. I would like to each of you, from your vantage point in what you know so much about—you are great input for all of us, you are just a great resource. But you come from different places, each one of you. What do you, from your vantage point, consider to be the one most serious threat to our climate, and will voluntary compliance meet the needs and come up with the right solutions soon enough? So why don't we start with you, Mr. Conover.

Mr. CONOVER. Thank you, Congresswoman.

Ms. WOOLSEY. And I know there is no one, but you tell me your one that you think is the most important.

Mr. CONOVER. Well, the issue is that—the real issue is achieving the goal of long-term stabilization at levels below which dangerous interference with the climate will not occur. That is the goal. The question is how does that translate into atmospheric concentrations and over what timeframe? So the most important thing we can be doing here is ensuring that we have a sufficient array of technologies, both in the near and the longer-term, that as our investment portfolio moves forward, technologies succeed and fail based on a variety of conditions, we are able to be flexible and respond appropriately as time moves forward. It is not just a voluntary approach. It is a voluntary approach coupled with significant federal R&D investment, and we believe that is the best way to address this challenge.

Ms. WOOLSEY. Mr. Rudins.

Mr. RUDINS. Let me respond to you in the context of the FutureGen technology and the project, and your thought on voluntary compliance. The logic behind the FutureGen project is if one can develop the technology that not only deals with carbon emissions and traditional emissions and boosts the performance of that technology, but does so in a cost-competitive fashion, meaning the costs of electricity we are projecting is no more than a 10 percent growth in the cost of electricity, and if we are successful, perhaps at no growth in the cost of electricity.

If that kind of technology is developed, it would be rational that the industry would opt for deploying a cleaner technology that is at or close to the same price point than a less clean technology. So FutureGen does have the potential for being a highly desirable technology with—and without any mandatory controls as a requirement.

Ms. WOOLSEY. Dr. Benson.

Dr. BENSON. So, first to address your questions bout the biggest concerns regarding climate change. A number of studies have been done recently which suggest that sea level rise would be amongst the first things to be concerned about, and second, a broad issue than climate change alone, but some recent studies suggest that acidification of the surface ocean is already taking place today, and that can potentially impact the ocean food chain, starting with the most productive area of the region, so those are the kinds of concerns.

With regard to voluntary compliance, I am no expert on this, but in the circles that I spent my time, largely with the oil and gas industry, there is certainly the feeling that voluntary compliance, at least in the short-term, will not be enough to motivate them in most cases.

Ms. WOOLSEY. Dr. Brown.

Dr. BROWN. Yes, I guess that in terms of the impacts of climate change, in addition to the global warming impact, sea rise level, et cetera, I would be concerned about the increase in extreme weather events, more droughts and more floods, not the net impact, but the extremity of the impacts. And I guess I think you asked what might be a high priority for action. I would like to offer that I believe the Federal Government needs to lead by example in a stronger way. We do do some of that, of course, but—and not just the Federal Government, but State and local government as well, so show the steps that can be taken to address, reduce greenhouse gas emissions cost-effectively.

Ms. WOOLSEY. Thank you. Mr. Conover, when you talk about the goal of the Federal Government, long-term stabilization, I never hear anything about when and at what levels, so what stabilization levels for CO_2 parts per million would be the aim for the Federal Government and when?

Mr. CONOVER. Well, thank you for that. That is the issue of a flexible portfolio that employs a diverse set of technologies, because we don't have a specific target. We don't know exactly when we need to hit that target, but we need to be taking action now. As the scientific uncertainty decreases and we get better information moving forward, making these investments today positions us better for the future to address those problems as they become more clear.

Ms. WOOLSEY. Well, thank you very much. I have to say I think the future is here, and that doesn't make me feel very confident. I think we are behind the gun on all of this, and we had better be boogying, or we are going to be in big trouble. So, thank you, my time is up.

Chairwoman BIGGERT. The gentlelady's time has expired. The gentleman from Michigan, Mr. Ehlers, is recognized for five minutes.

Mr. EHLERS. Thank you, Madam Chair. I have a host of questions, far more than I can do in five minutes, so I hope there is a second round while I am still here. The first question, to Conover or Rudins, I am not sure which one would be best. What sort of energy penalty are you looking at for separating, compressing and injecting the CO_2, and Mr. Rudins, you just mentioned 10 percent increase. Where do you get that figure? It seems to me that it is going to be a lot more than that, unless you are going to locate your power plants right on top of the coal field and inject right back in.

Mr. RUDINS. My 10 percent figure was in terms of cost of electricity. You asked about the energy penalty.

Mr. EHLERS. Right.

Mr. RUDINS. If you were to take an amine scrubber and add it to an existing coal plant, the energy penalty is probably on the order of 30 percent of the gross power output of the plant. If you were to take a technology like the clathrate technology that I described, that works effectively, most effectively with a high CO_2 concentration stream of the type that you would get, say, from oxygen blown gasification, which would have about a 90 percent CO_2 component, there the energy penalty by the developer is estimated to be in the five to eight percentage point range, as opposed to the 30 or more percent point for a traditional amine scrubber, and the developers are continuing to try to bring that energy penalty further down. But in terms of the costs of electricity differential, when we are talking about FutureGen, it is the power plant plus sequestration costs, so there are opportunities for driving down the cost of the power plant, the cost of the electricity generation.

Recognize that we are also talking about co-producing hydrogen, so there are a number of revenue streams that are part of that equation when I make that estimate of a 10 percent at most cost of electricity penalty.

Mr. EHLERS. And how do you propose to produce hydrogen?

Mr. RUDINS. In this particular concept, we would gasify gas through an oxygen blown-gasifier, or gasify coal, I should say, then go through a shift reactor to maximize the hydrogen content, then take the hydrogen plus CO_2 gas stream and separate it out, separate out the CO_2 through processes like the clathrate process or membrane technology, and then use the hydrogen to power a fuel cell or hydrogen turbine, and then sequester the CO_2 stream.

Mr. EHLERS. So would this be a combined generation plant, then?

Mr. RUDINS. It would be.

Mr. EHLERS. So you can electrical energy from the combustion of the carbon, and you subtract—and you generate electrical energy through the fuel cell, using the hydrogen.

Mr. RUDINS. There are two possible configurations, one using the carbon, the other is just going all the way to hydrogen and using the hydrogen in the turbine, rather than combusting the carbon, so there are several possible configurations there.

Mr. EHLERS. But the expense of operating a plant like that is much greater than the normal coal-fired plant, isn't it?

Mr. RUDINS. That is mainly because of the—new technology always costs more than mature, established technology. Today, gasification based systems have an initial capital cost about 20 percent higher than a traditional coal plant, but that price point differential is coming up, and future plants will be more efficient, so while there may be—while higher capital costs may remain, the cost of electricity, through efficiency improvements, would come down.

Mr. EHLERS. Let me just say I am skeptical about the processes you have described. I find difficult to believe that you would be able to get the price down that much. I would guess it is probably a 30 percent penalty in either one. But let me pose the next question, then. If that is true, what happens to the competitiveness between nuclear power and coal power?

Mr. RUDINS. I am not sure how to answer that question, because you essentially have to postulate a future scenario, and——

Mr. EHLERS. That is what you have just been doing.

Mr. RUDINS. Well, but a future scenario, in terms of is there valuation for the carbon or not. If you were to look at today's coal-based prices and add 10 percent to it, I am not sure where the price point is for nuclear. You may have that knowledge. I don't off the top of my head.

Mr. EHLERS. I don't. Does anyone here have that knowledge? Most of you are from the Department of Energy. Well, I am just curious. Obviously, France and India have decided it is cheaper to produce electricity using nuclear power instead of fossil fuel, so the price differential can't be that much at this point.

Mr. CONOVER. Right, and that is the thrust of several of the Administration's programs on the nuclear power side. Our belief is that you are going to need, looking out over the next century, in order to provide clean energy, you are going to need all of these options, nuclear and sequestered fossil fuel.

Mr. EHLERS. And in terms of transportation-produced CO_2, are you assuming that is all going to be hydrogen fuel cell driven?

Mr. RUDINS. I am—did you say transportation-produced CO_2? In that particular scenario, with FutureGen, the first line of attack is to deal with the CO_2 emissions with power plants. The co-production of hydrogen would in fact allow hydrogen to also be available for the transportation fleet, yes, in that particular scenario.

Mr. EHLERS. Yeah. The question again is, at what cost compared to alternative methods of production?

Mr. RUDINS. Well, currently, the projection for FutureGen, or I should say, the goal, is to produce hydrogen at approximately $4 a million BTU or less. The present commercial price point for hydrogen is the price of natural gas plus about $2, give or take.

Mr. EHLERS. I believe my time has expired. Thank you.

Chairwoman BIGGERT. The gentleman is correct. The gentleman from Illinois, Mr. Costello, is recognized for five minutes.

Mr. COSTELLO. Madam Chair, thank you very much, and I thank you and Mr. Lampson for calling this hearing today. Mr. Rudins, as you know, we have a very deep interest in the state of Illinois in FutureGen. We met earlier this year with the Assistant Secretary, Mr. Smith, talked about it and Dr. Miller traveled to Southern Illinois University in Carbondale back in July, where myself and my colleague, Congressman Shimkus, as well as our Senators and the Governor, sponsored a forum where we brought industry and government together to talk about FutureGen, and as you know, we believe that we have all of the natural resources to make FutureGen a success in the state of Illinois. Since I have limited time and I have several questions, let me get directly into questions.

One is I wonder if you might lay out for the Subcommittee where we are as far as the process is concerned. As far as criteria, site selection, naming the consortium, preliminary environmental studies and all of those types of things.

Mr. RUDINS. We are presently at very early stages. We are now going through an internal departmental process called the CD0 process, to in fact enable us to then formally move forward. You may recall there was an RFI, request for information, that was issued that laid out an approach the Department proposed, including negotiating with a qualifying industry consortium to move forward.

Before we can get to that point, we have to go through our internal process, which I anticipate probably will take us through this calendar year, maybe into the next calendar year, at which point, then, we need to make a decision as to whether we are going to go forward in an—initially, a noncompetitive approach in terms of negotiating with the industry consortium, as the RFI laid out, or whether we would do that competitively.

In all cases, ultimately, the procurement of the components for FutureGen and the site will all be done competitively, and will be part of a formal, transparent, competitive process. But once we complete that step, then we would enter into either negotiations with a qualifying consortium or we would initiate a competitive procurement that would lead to selection of a qualifying consortium. That is about a one-year differential there, whether we do it noncompetitively or competitively.

After we initiate negotiations with a qualifying consortium, that would likely be a very complex cooperative agreement to negotiate in dealing with the various facets of such a project. It could take four to six months to negotiate such a cooperative agreement, after which the first priority would be to develop the key criteria, technical criteria for site selection that would then be the basis of a competitive procurement, but as I laid out that approximate timeline, you can see it is—we have got quite a bit of work to do before we are to the point of initiating site selection. I don't know if that fully answers your question.

Mr. COSTELLO. Well, if you—do you have a timeline chart, in other words, do you have a goal in mind as to when the negotiations will take place, and hopefully, a consortium will be named?

Mr. RUDINS. We basically have two timelines, one is if we go the noncompetitive route, and the other adds a year if one goes competitively.

Mr. COSTELLO. And when will you make that decision, when will the Department make the decision if it is going to be competitive or if it is going to be noncompetitive?

Mr. RUDINS. Hopefully before the end of this calendar year.

Mr. COSTELLO. But at the end of this year, we will know if you are going competitive or noncompetitive.

Mr. RUDINS. That is correct.

Mr. COSTELLO. How long do you expect that it will take to—assuming that you go noncompetitive, how long will it take to negotiate? What would you anticipate?

Mr. RUDINS. Well, recognize that at this point in time, it is simply my best estimate, but I would say four to six months.

Mr. COSTELLO. So sometime in the summer or fall, let us say the summer of 2004, you will have a consortium in place and you will then be able to proceed to evaluating sites?

Mr. RUDINS. Well, the first step will be—and we are doing all of this in parallel, developing the key technical criteria that would be needed for doing that. We expect to have it as a very open and transparent process and—much like we have done in former competitive stations, we could very well have one or more public meetings to talk about the criteria that have been developed and the process that we are proposing to pursue for that competitive selection.

Mr. COSTELLO. And the last question, and I know that the Administration and the Department of Energy has estimated that it will cost about $1.1 billion, this FutureGen prototype plant, and I understand that the goal is about 50 percent private investment, 50 percent federal. I don't know if that has been determined yet, but let me just ask you where are we in the funding process? Has the Department of Energy, the Administration, requested funds? I know that there is $9 million provided in the Interior Appropriations Bill for FutureGen, but are there other appropriations that you have requested?

Mr. RUDINS. Yes, a couple of questions. First, we have not yet made a final determination on funding. You are aware we just received some funding guidance in the '04 Appropriation Bill that we are now reviewing. That guidance indicated the appropriateness of less than 50 percent cost-sharing, 80/20 for research, prototype kind of components, and 50 percent cost-sharing for demonstration components, so we are still working through that in terms of making a final determination with regard to that.

With, and I forgot the other part of your question, sir.

Mr. COSTELLO. Have you requested additional funds other than the $9 million in the Interior Appropriations Bill?

Mr. RUDINS. No, just the $9 million. We did request authorization to use prior year Clean Coal funds, prior—Clean Coal funds appropriated in prior years, and in the '04 Appropriation Bill, we received authorization, or in effect, appropriation of $9 billion in response to that request, which is the sum of money that we need for the first year.

Mr. COSTELLO. And how much is that the first year?

Mr. RUDINS. $9 million, the DOE share, for the first year.

Mr. COSTELLO. Madam Chair, thank you. I thank you, Mr. Rudins.

Chairwoman BIGGERT. Thank you, Mr. Costello. The gentleman from Maryland is recognized for five minutes.

Mr. GILCHREST. Thank you, Madam Chairman. I have a few questions, so I apologize for asking you for a quick response, so you can answer yes, no, or maybe to most of these questions. I just want to get a sense of how you feel. Based on the evidence that our climate is changing, I guess people have some evidence that the climate is changing. There is not too many people who still think that we are okay.

Do you feel that our policies are sufficient to mitigate the full range of the potential consequences of climate change, if we look at weather patterns, more rain, less rain, the potential significant biological consequences, the disease consequences, sea level rise, acidification of sea level surface, et cetera, et cetera. Do you think our policies right now, and you probably already looked at this, and I was just showing it to Vern, but this week's *Science Times* and *New York Times* is mostly about climate change, and they have some really—and I know you can't learn everything you need to know in one article, but there has been articles like this and books written over the past decades about the potential consequences.

One of the things I read in this article was that the Amazon jungle might be an exporter of CO_2, not a sink, as a result of a number of different variables that are going on down there, so have we taken the full range of consequences into consideration? Do we have, the Administration in particular, a sense of urgency about what is going on with the fragile biosphere as a result of human activity? Do we need, you might want to answer more than just yes, no, maybe on this, because I am going to—do we need a Manhattan Project? We are going to unload, this afternoon, $87 billion on Iraq. I voted for it. I am in support of what we are trying to do there, that is $87 billion. Are our policies right now sufficient enough to meet the consequences of the climate change? Do we need a Manhattan Project? Is there a sense of urgency about this, and is there a need for a sense of urgency?

Mr. CONOVER. Well, I am not sure, Congressman, what the—what a Manhattan Project in today's dollars would equate to, but this Administration is very proud of $1.6 billion investment in climate change related technologies. The really groundbreaking and leapfrog technologies, initiatives like the Hydrogen Fuel Initiative, ITER, FutureGen, we are putting the pieces on the table and making the investments to——

Mr. GILCHREST. Right. I apologize because I may not be around for the next round of questions, and I know everything that you are doing, and I have heard Vern discuss the hydrogen, coal sequestration, those kinds of things, and I have had meetings with the Department of Energy about this issues, and the particulars and the details of them. I think the overall riding sense that I would like to leave here with is we are okay, we are on the right track.

Mr. CONOVER. We believe we are on the right track and making the investments we need to make today to be prepared to respond to the science as it answers these questions about the consequences. I think it is important to note that one area where there is great scientific uncertainty are the consequences of climate change in the long-term, but our focus is on mitigation technologies, not adapting to those consequences, but mitigating greenhouse gas emissions into the atmosphere.

Mr. GILCHREST. Thank you.

Mr. RUDINS. I have to respond to you in the context of my responsibility in the FutureGen. I can't imagine a more aggressive goal than the development of coal-based power generation technology with zero emissions. To me, it is the ultimate manifestation of clean coal technology, and if we are successful in achieving that, it will be a remarkable achievement in that you can continue to use fossil fuels with zero emission, and more so if we are successful with our economic targets, to do so at competitive electricity prices.

Mr. GILCHREST. Thank you. Can you sequester CO_2 without it leaking? That would be for Dr. Benson.

Dr. BENSON. Yes, you can.

Mr. GILCHREST. Okay. Can we sequester more CO_2 than we are producing so we have a net reduction in CO_2?

Dr. BENSON. Yes, we can.

Mr. GILCHREST. Okay. Good. But for how long, Vern says. Probably for our lifetime, anyway. Now, we want it for thousands of years.

Dr. BENSON. Yes.

Mr. GILCHREST. Good.

Dr. BENSON. Thousands of years.

Mr. GILCHREST. Okay. Dr. Brown.

Dr. BROWN. Yes, I guess I would like to draw to your attention that I do not believe we have an adequate program in the area of climate adaptation. In some instances, it may be more cost-effective for us to figure out how we can protect ourselves against the consequences of climate change, in combination with, of course, trying to invest in carbon mitigation efforts. So I would just offer——

Mr. GILCHREST. Do we need a two-track policy?

Dr. BROWN. We do.

Mr. GILCHREST. Mitigation and adaptation.

Dr. BROWN. Adaptation.

Mr. GILCHREST. Because we may have crossed the line as far as——

Dr. BROWN. We may need both.

Mr. GILCHREST. Yeah.

Dr. BROWN. In the end. Both offer solutions. And also, I believe we need to invest more in assisting the developing world, help them to develop along a pathway which is less carbon intensive, and we could use more resources to do that, and the benefits to the Nation would include export opportunities for our clean technologies.

Mr. GILCHREST. Maybe we should eliminate the space program for a decade. What do you think about that?

Dr. BROWN. No, I wouldn't. No.

Mr. GILCHREST. Just kidding. Thank you, Madam Chairman.

Chairwoman BIGGERT. Thank you. The gentleman from Oregon, Mr. Wu.

Mr. WU. Thank you, Madam Chair. I would like to take a step back. I realize that you all are implementing policy, developing policy, but I would like to ask you the same question that I have been asking meteorologists and atmospheric scientists for 10 or 15 years, and that is just first of all to go down the row, one way or the other, just take a step back and—what's—what probability, 0.30, 0.50, 0.80, higher or lower, would you assign, based on the evidence that we currently have available, I guess, there are some Members of the Full Committee who continue to have serious doubts about whether there is a real phenomena of atmospheric or climate change because of greenhouse gases, so I would just like to go down the row, and I have to say that over a period of time, I have been getting, it seems, like a steady change in probabilistic assessments from meteorologists and so on, and I would like to hear from you all, first your assignment of probabilities that there is an effect currently occurring. Either direction.

Mr. CONOVER. Well, I will start by saying the beauty of being the Director of the Climate Change Technology Program and not the Climate Change Science Program is I don't have to answer that question. I know——

Mr. WU. I would like to know what the implementer things about—whether the implementer believes there is a real problem or not. I think that is highly relevant.

Mr. CONOVER. We have our eye on the goal, sir, yes, and we are charged with facilitating the development and deployment of these technologies.

Mr. WU. But what I asked for is a number.

Mr. CONOVER. I am not qualified to give you that number, sir.

Mr. RUDINS. Unfortunately, I have to give you a similar answer. I am not really qualified to give you that number, but to respond to you in the fashion that again, with the development of the—of FutureGen, that question perhaps doesn't even need to be answered in the context of fossil fuels. If that technology is, again, developed and available for deployment, a zero emission technology, then whatever the predicted future is, that will be one possible solution path for dealing with it.

Dr. BENSON. Unfortunately, I am not a meteorologist and an expert in that topic, so I can't give you a probability. I will, however, say I think that we should work as aggressively and as quickly as possible to develop a suite of mitigation options, so that we are prepared to implement them both in the short, medium and long-term.

Mr. WU. Dr. Brown.

Dr. BROWN. Yes, I would refer to the conclusion of the Intergovernmental Panel on Climate Change, which said something like the body of the evidence is overwhelming, my probability would be very high.

Mr. WU. So, Dr. Brown, you have a very high probability, and as for Dr. Benson and Mr. Rudin's and Mr. Conover, would it be fair to say that whatever probability you all might assign to it, that you view this as—you are completely motivated to work on mitigation or solutions?

Mr. CONOVER. Absolutely, sir.

Mr. WU. And perhaps, Dr. Brown, since you are the only person who was willing to take a stab at the number, I read an article a long time ago, I can't remember whether it was in Nature or Science, but it said that climate change may be paradoxical, that is, we get these greenhouse gases, we get some temperature rise, but instead of steady creep in temperature, we may flip right into an Ice Age instead. I haven't been able to track that. If you know anything about that, I am dying to know whether it is going to get warmer or colder.

Dr. BROWN. I will get back with you. That is the best answer.

Mr. WU. Thank you.

Mr. GILCHREST. Would the gentleman yield?

Mr. WU. Yes, I would.

Mr. GILCHREST. Mr. Wu, there is some fascinating evidence about the global warming causing the slowdown or the stop of the ocean currents, the conveyor belt which drives that, and if that happens, that could trigger an Ice Age, because you don't have the dispersal of warm air from the equator getting up to the more northern regions around the Arctic Circle, and it is a little bit complicated, but there is a potential to trigger an Ice Age within less than 20 years, so——

Mr. WU. I thank the gentleman from Maryland, and I have also read about how precipitation could cause reflectivity to change, and that could be another effect, but the gentleman has me at a disadvantage. He has the Tuesday Science section from the *New York Times,* and I am afraid that that is probably as technical as I can get these days, so if the gentleman wouldn't mind loaning it to me at some point, I surely will appreciate it, and with that, Madam Chair, I am pleased to yield back the balance of my time.

Chairwoman BIGGERT. The gentleman from——

Mr. LAMPSON. I want to butt in——

Chairwoman BIGGERT [continuing]. Texas.

Mr. LAMPSON [continuing]. For a second, and ask Mr. Gilchrest also. Remember when we were in—at the South Pole, we were told something about those huge icebergs——

Mr. GILCHREST. Yes.

Mr. LAMPSON [continuing]. That were blocking, I forgot what it was.

Mr. GILCHREST. The Ross Sea.

Mr. LAMPSON. The Ross Sea, that actually could potentially change the climate of the Earth, or the temperature of those flows of water through the oceans.

Mr. GILCHREST. We saw a regional climate change right down there in the Antarctic, in that region around McMurdo Sound, when this—two huge icebergs closed off the outlet of the Ross Sea——

Mr. LAMPSON. Right.

Mr. GILCHREST [continuing]. To that southern part of the Pacific Ocean. When it did that, the frozen Ross Sea could not get out any more, so even though global warming caused those icebergs to break off, the region around McMurdo Sound became much colder, because the ice couldn't be pushed out by the wind, and therefore, that precipitated another mini regional climate change, but made it colder. There is a great trend——

Chairwoman BIGGERT. Maybe at our next hearing, we will have to include icebergs. I have a couple of more questions, so maybe all of our Members don't, but I would like to proceed. Mr. Conover, in the report that was delivered this morning, the Department notes that there—well, less than 10 technologies, 10 or less, I don't know what that means, submitted that were rated high in technical merit, responsive to the criteria. These were reports that were in response to the request for information, so they came from various places, and yet, were either novel or created but kind of fell through the current DOE programs, so were ineligible for funding. Do you know what some of these technologies are, and how DOE might help to ensure that these ideas perhaps will become commercialized.

Mr. CONOVER. Thank you, Chairwoman Biggert, and let me put that in context. The RFI that you are discussing and the report that we are providing today, was sent out in November of 2002, and closed in January of this year. It was asking for innovative approaches to climate change technology, and the intent was to try to determine whether there were concepts out there that were not being addressed by the existing procurement programs or would be unable to be addressed by the existing procurement programs, that RFI garnered about 180 different concepts proposed by 79 different entities.

All of those entities, in proposing those concepts, have an expectation of privacy with respect to their specific ideas, but I can say that because we are—we were able to move forward on one of the areas that is an extremely important, novel, sort of applied strategic research idea, and that is microbes that could potentially both produce hydrogen and sequester carbon dioxide. The outcome of the analysis that is discussed in that report was that the DOE Office of Science is able to modify its procurement programs and begin to incorporate that kind of program into its efforts, so while we were looking for gaps, what we were able to do as well was help the programs fine-tune their procurements so that they can gather in concepts such as that in the future.

Chairwoman BIGGERT. So, the Department will continue to monitor those programs and perhaps at some point, more of them will fit into something that can be used.

Mr. CONOVER. Yes, we have requested funding for a competitive solicitation program that would have followed on to the request for information. Haven't received funding from Congress on that yet. If we remain unsuccessful in getting funding for an actual procurement program along those lines, we may continue the request for information process to continue to survey the community and ensure that these concepts are brought forward and incorporated into the existing programs.

Chairwoman BIGGERT. Well, it makes it easier for Congress to fund something that they know what it is, I suppose. Dr. Benson, are candidate sites for geologic sequestration located throughout North America? Are there areas of North America that don't have any candidate sites?

Dr. BENSON. The majority of areas with large concentrations of CO_2 sources are located within close proximity to potential storage sites. If you look at the Northwest, the rocks that underlay that area may or may not be suitable. There are some studies that are being done by Batel to look at whether those kind of formations would be acceptable, too, but at this point, we don't know. But by and large, yes, there are reasonably close storage sites.

Chairwoman BIGGERT. Okay. What is the minimum number of sites that need to be tested to convince the scientific community that carbon sequestration is a viable technology?

Dr. BENSON. I think that demonstration projects, or you know, large scale pilots in about five different regions, I think something in the Gulf Coast area, something in the Southeast, something in the Midwest with the Mount Simon Formation and something in the West with the Central Valley of California would go a long, long way toward persuading scientists that this was a good strategy to pursue.

Chairwoman BIGGERT. And how long do you think this will take?

Dr. BENSON. I think a program, aggressively implemented now, I think that within 10 years or so, we could have a very good idea of whether there would be good sites and what the capacity would be in those regions.

Chairwoman BIGGERT. Would you agree with that, Mr. Rudins?

Mr. RUDINS. Yes, I would.

Chairwoman BIGGERT. Mr. Lampson, would you?

Mr. LAMPSON. No more questions, but just a wrap-up comment, it is hard to consider all of these things and fit it into context with what we are living. Mr. Gilchrest made the comment that we are providing $87 billion in Iraq right now, and I, too, voted for that. Yet we put that in the context of spending a billion dollars on research on something that has in its hands, the future of this whole Earth, and it gets a little frightening, where we are placing our priorities, where we puts tens or hundreds of billions of dollars into defense-related matters, yet we are more or less turning our backs on something that could consume each human being on this planet. We, perhaps, need to give that consideration, and perhaps coin the phrase that Ms. Woolsey used a while ago, maybe it is time for us to boogey.

Chairwoman BIGGERT. Thank you for your comments. The gentleman from Georgia, Mr. Gingrey.

Mr. GINGREY. Well, first of all, in response, maybe to follow up to what Mr. Lampson said, in comparing the cost and the priorities, I think those terrorists could kill us dead a whole lot quicker than some of these greenhouse gas effects, so maybe that is a part of it.

Mr. LAMPSON. But not the whole Earth.

Mr. GINGREY. My question, is guess, is to Dr. Benson. In regard to the CO_2 sequestration, I guess that seems to be the main focus of the hearing, and, you know, I realize that, you know, CO_2, you put it down deep, and it is soluble in water, and a lot of the CO_2 would dissolve, but I wanted to ask you in regard to sites of sequestration where you are putting literally tons and tons of CO_2, however deep it might be, under the Earth's surface, there is a certain amount of pressure that would develop even with the solubility of CO_2 in water, and would you have to worry a long-term about a site where there is a fault, a significant fault, as an example, in California, is there some potential at some point in time that we will push, we will make an island out of California if we were sequestering CO_2 in an area like that?

Dr. BENSON. Well, it turns out that faults often provide seals to oil and gas reservoirs, so just by virtue of existence of the presence of a fault does not mean that a site would not be a good storage site. In fact, you know, many of the best traps are located where you have a fracture and the sand get butted up against shale on the other side. So, you know, certainly, if you have a site that there is a fault there, you would want to characterize that that fault seals, rather than is open and leaks, and there are tests available today that are very applicable and useful for testing, those kind of things. So, you know, certainly, if there were an open fault, you know, that would need to be considered very carefully before you would store CO_2 there, but just because there is a fault doesn't mean you shouldn't do it.

Mr. GINGREY. Anybody else wish to comment on that? Dr. Brown? No? Thank you, Madam Chairman.

Chairwoman BIGGERT. The gentleman from Oregon, Mr. Wu. All right. Thank you. Just one last question, which is always tricky, because it usually is the one that is the hardest. Dr. Brown, how can the Federal Government act to eliminate the market failures that impede deployment of energy efficiency technologies?

Dr. BROWN. Well, first, I guess, the—we have got to get the prices. There are a number of externalities that are not incorporated into the price that we currently pay for energy, and that includes, of course, the criteria pollutants, but also, if you wanted a price for CO_2, a price for national security, all of those, if included, would result in a price of energy which would far exceed what we currently pay. That is a market failure. There are other market failures. One that I use as an example often is the principal agent failure. That is the case where decisions are being made by one individual that affect the energy technologies that are going to be used by another individual. An example is the landlord and the tenant, or the individual who purchases the fleet of automobiles for a state agency, for those users to utilize, so you have principal agents, and the failures are numerous, but those are just two of them.

Chairwoman BIGGERT. Do you have any idea which changes would make the greatest contribution to energy saving?

Dr. BROWN. I think getting the price right. A lot of——

Chairwoman BIGGERT. The price is right, isn't that——

Dr. BROWN. Yeah. Right. There are many ways that that can be done, but I would put that at the top of my list.

Chairwoman BIGGERT. Thank you. All right, again for Dr. Brown. What portion of your report's recommendations have been implemented?

Dr. BROWN. Now, what is the status of the Energy Bill today?

Chairwoman BIGGERT. Very close, it is very close.

Dr. BROWN. Not many yet, but we are hopeful that some will have some sticking power and maybe be implemented.

Chairwoman BIGGERT. Thank you. Before we bring this—the hearing to a close, I want to thank our panelists for testifying before the Subcommittee today. If there is no objection, the record will remain open for additional statements from the Members and for answers to any followup questions the Subcommittee may ask the panelists. Without objection, so ordered. The hearing is now adjourned.

[Whereupon, at 11:40 a.m., the Subcommittee was adjourned.]

Appendix 1:

ADDITIONAL MATERIAL FOR THE RECORD

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE

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October 17, 2003

The Honorable Robert Card
Under Secretary of Energy, Science and the Environment
Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Mr. Card:

This Committee has been anxiously awaiting your Department's report on the Administration's climate change technology programs. Because of conflicting information from the Administration, we are confused about what these programs encompass. We would like for you to deliver the report by the end of October, or explain to us in writing why you cannot do so.

As you know, on June 11, 2001, President Bush announced an agenda to advance climate change science, promote the development of climate technologies to monitor and reduce greenhouse gas emissions, and implement clean energy technologies. As part of his statement, he announced a National Climate Change Technology Initiative (NCCTI). The President directed the Secretary of Energy and Secretary of Commerce to recommend improvements in the existing climate research and technology programs across the Federal government.

In February 2002, in response to Committee inquiries, you defined NCCTI as "The President's FY '03 Budget [request for] $40 million within the Department of Energy." The President's budget request, however, was short on specifics. In an elaboration on our question, you noted that, "Specific research areas are being identified through an interagency review process. The NCCTI will build on an existing base of research and development in climate change technologies, primarily at the Department of Energy, the Environmental Protection Agency, and the Department of Agriculture. A complete report on the findings and recommendations of the NCCTI will be issued soon."

In April of 2002, this Committee asked for the results of that review. On July 10, 2002, you responded to a question from the Committee that "NCCTI is ***not*** a $40 million initiative. NCCTI is a comprehensive review and ongoing process, coordinated across all agencies, aimed at focusing Federal technology R&D on the President's climate change goals, both near- and long-term... At DOE, the amount of R&D funding falling under the advisory purview of interagency NCCTI process and directly related to climate change technology development included in the President's FY 2003 Budget Request amounts to $1.6 billion."(emphasis added.)

On February 13, 2003, you testified before the Committee that the Department of Energy funds more than 90 percent of the technology research. Despite this, for over two years, the Department has not been able to release a report outlining the Administration's climate change technology program or the criteria for selection of competing technologies for inclusion in the program, much less recommendations for improvement or a strategic plan. The Department has also failed to provide details about the proposed climate change technology solicitation, and details of how the funds will be awarded.

At the February hearing you indicated that, after repeated delays, the report on the Administration's climate change technology portfolio would be available "by summertime" of this year, but summer has come and gone.

It is unclear why it has taken more than two years to define this Presidential priority. If the report will not be available by the end of October, please respond immediately with an explanation for the further delay. Additionally, please provide the committee with a strategic plan for the climate technology program – or at least a timeline for its development – and a description of the selection criteria for the climate technology solicitation.

Sincerely,

SHERWOOD BOEHLERT
Chairman, Committee on Science

JUDY BIGGERT
Chairman, Subcommittee on Energy

SB/jb

Cc: David W. Conover
Director of the National Climate Change Technology Initiative
Renewable Energy

The Honorable Rick Dearborn
Assistant Secretary for Congressional
and Intergovernmental Affairs

The Under Secretary of Energy
Washington, DC 20585

November 6, 2003

The Honorable Sherwood Boehlert
Chairman, Committee on Science
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Thank you for your October 17, 2003, letter requesting a report on the Administration's climate change technology programs, a description of the selection criteria for the climate technology solicitation, and the climate change technology program strategic plan or a timeline for development of the plan.

As I testified before your Committee in February of this year, President George W. Bush's National Climate Change Technology Initiative (NCCTI) is inventorying and prioritizing all climate change activities within the $1.6 billion technology R&D portfolio that is included in the scope of the Climate Change Technology Program (CCTP). The CCTP is a multi-agency research and development coordination activity, organized under the auspices of the Cabinet-level Committee on Climate Change Science and Technology Integration (CCCSTI).

The CCTP is producing several reports that together will constitute the findings and recommendations of the NCCTI thus far. For example, enclosed you will find a recently-completed report analyzing responses to a November 2002 *Request for Information and Statement of Interest* (RFI) issued by the Department. The RFI analysis is a key component of the NCCTI report in that it helps us understand whether there are important climate change technology concepts that are not being addressed through current research and development activities.

While the analysis identifies some new areas for research that can be pursued either through modifications or improvements to existing Department of Energy (DOE) and other agency procurement strategies or through a future competitive solicitation, it also indicates that existing DOE programs do encompass the vast majority of proposals to research and develop technologies that can help avoid, reduce, or sequester greenhouse gases emissions.

Regarding the selection criteria for the NCCTI competitive solicitation, formal selection criteria have not been developed because Congress has not provided funding for the President's request. The RFI did contain criteria for submittals that would be the basis for those contained in a future solicitation. Those criteria were: (a) future reductions in or avoidances of greenhouse gas emissions; (b) greenhouse gas capture and sequestration (permanent storage); (c) capture and conversion of greenhouse gases to beneficial use; or (d) enhanced monitoring and measurement of greenhouse gas emissions, inventories, and fluxes in a variety of settings. In the event Congress does provide funding for the NCCTI competitive solicitation, the CCTP will formulate formal criteria based on the findings of the RFI analysis.

In addition to the enclosed RFI analysis, the CCTP will publish in December two reports on the Administration's climate change technology portfolio. The first, *U.S. Climate Change Technology Program – Research and Current Activities*, highlights technology initiatives and other important research, development, and deployment activities offering significant potential to contribute to the President's near- and long-term climate change goals. The second, *U.S. Climate Change Technology Program — Technology Options for the Near and Long Term*, is a more comprehensive compendium of baseline climate change technology research, development, demonstration, and deployment activities. Finally, the climate change technology strategic plan will be released as a draft for public comment during the first calendar quarter of 2004.

While I regret the delay in producing these documents, it is important to note that the underlying research and development activities they discuss have been and are moving forward to address the climate change challenge.

Thank you for your continued interest in these vital programs. If you have any questions, please feel free to contact me or Mr. Rick A. Dearborn, Assistant Secretary for Congressional and Intergovernmental Affairs, at (202) 586-4967.

Sincerely,

Robert G. Card

Enclosure

REPORT ON RESPONSES TO THE REQUEST FOR INFORMATION REGARDING THE NATIONAL CLIMATE CHANGE TECHNOLOGY INITIATIVE

U.S. DEPARTMENT OF ENERGY

On November 19, 2002, a "Request for Information and Statement of Interest" (RFI) was issued by the U.S. Department of Energy (DOE) to explore the depth and breadth of interest in a potential future competitive solicitation for research on innovative climate change technologies. This RFI was issued in support of the President's National Climate Change Technology Initiative (NCCTI). The RFI closed on January 31, 2003.

In brief, the RFI analysis revealed two benefits. First, the RFI process provided a valuable tool in evaluating and possibly expanding current agency R&D programs. It is possible that future RFIs can provide further ideas for improvements to existing programs. Second, the analysis revealed significant interest in participating in a NCCTI competitive solicitation program. At the same time, the RFI submittals raised a number procedural issues that will need to be addressed and resolved if an RFP is pursued. Better awareness of these issues can be expected to clarify and strengthen a future NCCTI competitive solicitation program.

Request for Information

As announced in the RFI, as in reference to the NCCTI, the DOE requested information on and expressions of potential interest in a possible, future DOE competitive solicitation on research. If pursued, the research would explore concepts, technologies and technical approaches that could, if successful, contribute in significant ways to: (a) future reductions in or avoidances of greenhouse gas emissions; (b) greenhouse gas capture and sequestration (permanent storage); (c) capture and conversion of greenhouse gases to beneficial use; or (d) enhanced monitoring and measurement of greenhouse gas emissions, inventories and fluxes in a variety of settings.

The RFI mentioned that, if pursued, the NCCTI competitive solicitation could involve the award of tens of millions of dollars in research grants or other forms of financial assistance for research over multiple years. The RFI said that, if pursued, the competitive solicitation would be open to all proposers in order to encourage the broadest possible participation.

As a first step in considering this program, the DOE invited interested parties to submit a Statement of Interest, which would include identification of a point of contact and other information about the party. Parties were also encouraged to submit a brief outline of an idea, concept, technology or technical approach, that would be the subject of research and focus on the above-stated NCCTI objectives.

Summary of Responses

DOE received 180 responses containing at least one proposed idea, concept, technology or technical approach, from a total of 79 different individuals, organizations or other entities. DOE received an additional 16 statements of interest, but with no submitted ideas. A summary of the RFI responses with ideas is provided below.

- 180 responses (technology ideas) were received, representing the interests or submissions of 79 different organizations or responding entities;
- 45 of the 79 entities were private sector;
- 10 of the 79 entities were non-governmental organizations (NGOs);
- 11 of the 79 entities were universities;
- A number of entities were States or municipal governments;
- Numerous additional entities (different from the 79 submitting) were mentioned in various responses as potential partners, contributors or collaborators.
- An additional 16 entities, beyond the 79 noted above, expressed interest in a future NCCTI competitive solicitation, but did not submit a concept or technology.

Technical Review of the RFI Responses

All 180 RFI responses with ideas were assigned for review to six working groups operating under the auspices of the multi-agency U.S. Climate Change Technology Program (CCTP). The six working groups broadly represented six technical areas: (1) energy production; (2) energy efficiency; (3) CO_2 capture and sequestration; (4) greenhouse gases other than CO_2; (5) measuring and monitoring of greenhouse gases; and (6) supporting basic or strategic research. If concepts or technologies were cross-cutting in nature, or did not fit uniquely in one area or another, such concepts were assigned to multiple working groups, as appropriate.

The resulting RFI reviews, in general, were limited to screening and initial assessments, intended to identify ideas that were relevant to the RFI criteria, innovative, and having overall technical merit. The evaluations were thorough, but not as rigorous as would be expected in a more formal review of responses to a Request for Proposals (RFP) where awards would be made under peer review.

Summary of Technical Review Findings

The overall response (79 entities submitting a total of 180 concepts) was considered reasonable, given that: (i) no funding was offered in the RFI; (ii) the announcement's 42-day open period spanned the Thanksgiving and winter holiday periods; and (iii) no advantage was conferred upon the respondent, vis-á-vis a future solicitation, from developing ideas and sending then in. Even so, the response should be considered light, compared to what might be expected if substantial funding were offered. Thus the findings summarized below should not be considered definitive or exhaustive. The technical review findings may be characterized as follows:

- 25 of 180 RFI responses focused on program management or decision support tools that might help focus R&D on climate change technologies or related concepts.
- More than 120 of the RFI responses were integrative in nature, or otherwise cut across two or more existing research and development program areas.
- More than 120 of the RFI responses were rated "high in overall technical merit," vis-á-vis the goals or criteria as stated in the RFI announcement.
- More than 90 of the RFI responses were assessed as either falling within the scope of currently funded State or federal R&D programs, or were consistent with such programs.
- More than 90 of the RFI responses were assessed as either falling within the scope of currently funded private sector R&D programs, or as consistent with such programs.
- More than 30 of the RFI responses were assessed as representing ideas or technical areas that would not fall within the scope of currently funded federal, State, or privately funded R&D programs, if broadly considered.
- Less than 10 of the RFI responses were simultaneously assessed as high in technical merit, responsive to the RFI criteria, and unique or novel, that is, not easily fitting into the scope of any existing R&D funding program, if broadly considered.

Although most of the 180 concepts submitted were assessed as both having "high technical merit" and being responsive to the RFI goals, few were found to fall outside the competitive purview of one or more of the known existing federal or privately funded R&D programs. The working groups concluded that most RFI responses would be appropriate for consideration for competition within the scope of existing R&D programs. The working groups were not able to determine from the information provide whether the submitted concepts would be sufficiently competitive to be awarded funding, compared to the universe of other concepts that would be competing for such funding.

RFI responses that seemed appropriate for consideration within the scope of existing R&D programs were forwarded to the appropriate R&D programs for such consideration. The existence of some RFI responses that were evaluated high in technical merit, responsive to the RFI criteria, and sufficiently innovative, novel, cross-cutting or integrative in nature that they did not seem to fit easily into existing R&D funding programs, suggested that there may be some gaps in the existing R&D program structure, where a future NCCTI competitive solicitation might complement others in the larger scheme of a multi-agency U.S. climate change technology R&D program.

Procedural Issues Identified

Beyond the findings of the RFI response technical review, a number of procedural issues, or points of potential confusion, were identified. In the event that a future Request for Proposals (RFP) should go forward for a future NCCTI competitive solicitation, these issues would need to be clarified or resolved. The reviewers suggested a few potential solutions to some of these issues:

- Apparently, one of the greatest sources of confusion, given the RFI's broad scope, was duplication with ongoing R&D programs, and the reviewer's desire to avoid duplicate or conflicting awards. As long as both sources of funding exist (current programs and the NCCTI solicitation), and as long as both are competing head-to-head with each other, extensive coordination will be required among the NCCTI reviewers and the existing R&D programs in order to avoid conflict or overlap.

- One solution might be to focus NCCTI research, instead, on selected areas that differentiate themselves from ongoing R&D, cut across multiple federal program mission areas, or score high on innovativeness or novelty of approach, thereby exploring new or novel areas of technology R&D not covered by existing R&D programs.
- Another approach would be to encourage proposals with integrated approaches for a more efficient use of research dollars, for example, power production with sequestering CO_2, rather than separate proposals.
- Many of the RFI submittals identified an idea or an R&D project that is already being accomplished by other efforts. Truly innovative proposals are likely to be rare, given that current R&D programs already have many and highly interactive mechanisms for inviting, unearthing and pursuing promising new research directions. At the same time, it is possible that enhanced R&D along existing lines for some technologies could have some accelerating effects, with resulting beneficial impacts on reducing greenhouse gas emissions. Thus, questions about the relationship between a future RFP and an existing R&D program will need to be spelled out clearly. Some sample issues follow:
  - How will the RFP deal with the varying degrees of overlap of new ideas with existing federal R&D activities?
  - Should a proposer be required to document how a new proposal fits with current federal R&D efforts?
  - How should innovation be defined and/or rewarded?
  - How should an idea be scored that suggests R&D that is already funded under an existing program, or that is closely related to or an extension of an existing program, or that is a specific project that could be funded under an existing program like the Federal Energy Management Program or Building America?
- Many RFI responses proposed projects that would demonstrate or deploy (extend the use of) existing technology (i.e., develop green building designs, demonstrate energy efficient buildings, or demonstrate use of CNG or H_2 in fleet vehicles). So, another area of confusion arose from questions about differences between R&D and demonstration projects, and how each should be evaluated. A future RFP would need to address this concern and, for example, clearly state that the funding is for "R&D" for climate change technology development, and not for demonstration projects, or alternatively, if demonstration projects are desired, then criteria would need to address how they will be treated, versus R&D.
- Many RFI responses sought funding support for commercialization of existing technologies, which is generally regarded as a private sector responsibility, and not consistent with the federal research mission. A future RFP would need to state a clear position on this point stating, for example, that commercialization of existing technologies are not within its scope.
- Request information on state of development for the technology. It may be helpful to apply the well defined research categories of "6.1—Basic Research, 6.2—Applied Research, 6.3—Advanced Technology Development," as employed in DOD research and development programs.
- Clarify the kinds of activities that would be most appropriate and likely to gain federal support. If it is likely that industry has sufficient motivation to pursue the research for its own benefit, then additional support by the government would not seem warranted.

Other issues arose with respect to who is eligible or not eligible to respond to the RFP and be awarded a federal grant or contract. Would there be restrictions on non-U.S. firms, or other forms of governments? Some suggestions from the review include the following:

- Encourage participation and collaboration across sectors (industry, university, and national laboratory), and discourage individual investigations, as a means of enhancing robustness.
- For truly novel, innovative (i.e., risky and far from commercialization) basic or strategic research, a requirement for industry cost-sharing or co-funding may be counterproductive, as private investment may draw research to more

tangible or nearer-term focus, and discourage longer-term, higher risk, but potentially higher payoff, ventures.

- Encourage collaboration with foreign investigators (possibly patterned after the DOE–NE NERI or I–NERI), so that the best ideas and best teaming arrangements, are available.

A number of other suggestions emerged, provided below, for consideration as a means to clarify responder requirements or otherwise improve the structure and facilitate the review of a future RFP.

- Provide links to relevant R&D programs and published technology roadmaps at all the agencies participating in the CCTP, in order to assist investigators in accessing information on related programs and technologies and improving their proposals.
- Require the responder to identify the source of all research funds being used on the proposed initiative. This will help the reviewer with coordination among multi-agency participants.
- Specifically require information as to whether or not the proposed technology has been submitted elsewhere to other U.S. Government funding programs.
- Request information on whether the technology is envisioned to be available in the near-term or longer-term. The NCCTI RFP should support a mix of innovative technologies and technology-based solutions—some of which could be brought to market quickly and others which require more sustained R&D over years to decades.
- Require information on project size and the required investment to achieve its objective.
- Request information on the applicability and GHG benefits of the technology. It would be useful to have information on the emission sources to which the technology is to be applied, and the magnitude of the impact on greenhouse gas stabilization that the proposed technologies are projected to enable. Impact analysis and assessment would contribute to the prioritization process within NCCTI.
- Provide guidelines to standardize basic information provided regarding the principal and co-investigators, and their affiliations, and the capabilities of the research team and facilities.

Finally, other issues arose about projects that might better fall under the scope or purview of the Climate Change Science Program (CCSP), rather than the CCTP. This also identified a need to clarify how cross-cutting (CCSP/CCTP) research should be addressed.

Technical Findings Identified

Several responses focused on program management or decision support tools that might help focus R&D on climate change technologies or related concepts. While the majority of the abstracts met the criteria associated with the RFI and rated well with respect to the criteria, decision support tools may be needed to help prioritize and integrate the diverse technology R&D and aid in achieving the long- and short-term missions of CCTP.

With respect to longer-term technologies, technologies and practices that rely on scientific advances, including geo-engineering, precision use of advanced information technologies, and advanced bio-products development, are still at points in their development where basic research and “proof of concept” demonstrations are priorities. Basic research questions also relate to the development and application of advanced technologies. For example, there are many opportunities for research in biotechnology (genomics, genetics, proteomics) that may aid in managing carbon. In addition, basic research is needed in establishing the interactions between efforts to improve carbon storage and nutrient cycling and potential positive and negative impacts on other environmental services.

Most current and proposed R&D explore individual technologies. However, there are possible commonalities and synergisms among the technologies that lend themselves to cross-cutting research activities in some areas. Such possibilities need to be identified and pursued early. For example, many materials issues are similar across a number of technologies, particularly as we look toward advanced technologies that employ higher temperatures, and pressures. It would be highly desirable for some of the early NCCTI initiatives to focus on such cross-cutting R&D areas.

Likewise, a number of technologies may be amenable to integrated implementation strategies. While implementation is largely not an R&D activity, there are some analytical issues that need to be addressed to determine compatibility of alternative energy production technologies, optimal configurations, and systems integration issues. These analytical activities are also appropriate to the NCCTI.

Enabling technologies also need to be identified and analyzed. In particular, issues like land use and long-term availability of resources or feedstocks critical to a technology need to be examined. For example, resources and reserves of natural gas, supplies of bismuth for potential lead-bismuth nuclear technology, catalysts for chemical processes associated with energy production technologies, etc., are all critical to the long-term feasibility of some of the technologies. This is an area that has had only fragmentary attention to date and is worthy of analysis under the NCCTI.

In some cases, infrastructure issues may also need to be addressed. This is particularly the case where an accelerated introduction of a technology may be desirable. Infrastructure issues which may be relevant include mining, fabrication, and construction facilities and capabilities. Little work has been done in these areas, particularly for advanced technologies, and NCCTI should initiate some studies, particularly to address accelerated introduction plans.

In this increasingly global economy, energy production resource and infrastructure issues need to be examined on both a national and international basis. In some cases, sufficient national resources and infrastructure will be necessary to ensure national security. However, significant elements of our energy production infrastructure are likely to be imported. In those cases, we need to assure the adequacy of supply globally, considering also the competing global demands for the supply. Given the important of an adequate energy supply to national security and economic health, this is an important area for the NCCTI to consider.

The NCCTI competitive solicitation may also wish to encourage proposals to assess how much the potential benefits of using different energy technology options, such as wind, solar, or sequestration might be affected by changes to a future climate, should they occur.

Finally, the solicitation should clearly state that the scope of the RFP includes R&D on all greenhouse gases (GHGs), not just CO_2 or methane. Other gases include nitrous oxide, sulfur hexaflouride, and other chemicals with high global warming potential (GWP).

Complementarity Issues for a Future NCCTI Competitive Solicitation

A number of RFI responses were evaluated as sufficiently innovative, novel, cross-cutting or integrative in concept to warrant further interest, yet did not seem to fit easily into existing R&D funding programs or the established federal R&D organizational hierarchies, or if they did, they seemed to fit only on the margins, and not likely to gain mainstream support. These responses were not necessarily the best developed RFI responses, but were among some of the more interesting, novel or unique concepts or applications. Although relatively small in number, these RFI responses suggest a number of gaps or potentially fruitful areas of R&D, as characterized below, where a future competitive solicitation might add value uniquely by complementing an otherwise robust federal program of ongoing R&D in climate change-related technology development.

The following is a generalized list of areas for further consideration, if a NCCTI competitive solicitation program were redirected at complementing, rather than competing with, existing R&D programs. Currently, these areas are not as well represented in the existing R&D portfolio.

- *Decision-support tools.* Numerous RFI responses proposed various analytical, assessment, software, modeling or other quantitative methods for better understanding and assessing the role of technology in long-term approaches to achieving stabilization of concentrations in the atmosphere. While individual R&D programs sponsor the development of such tools, these are applicable mainly to their respective areas of responsibility or technologies. There is no place where broad-based tools may be applied or integrated across all technologies.
- *Strategic research.* Strategic research is basic research applied to a particular problem or technological focus area. Many existing agency research programs are either basic or applied in their missions, and so restricted by their appropriations. As a result, strategic research often finds no specific program able or willing to explore novel concepts along unconventional lines.
- *Applied bio-engineering.* As an example of strategic research, one RFI proposed to search for or engineer unique microorganisms both to produce hydrogen and sequester carbon dioxide. Ideas such as this have not neatly fit into the basic energy research programs of DOE's Office of Science (SC), as they may be too applied, nor do they fit in the energy supply, energy conservation,

fossil energy or sequestration R&D programs of DOE's applied R&D programs in FE, EE or NE, as they are too basic and exploratory. The RFI analysis process enabled DOE's Office of Science to examine this concept for inclusion in its procurement strategy.

- *Integrative concepts.* Integrative concepts cut across R&D program lines and attempt to combine technologies and/or disciplines, and may promise some of the highest results, yet often experience difficulty in finding funding support from any of the areas. Integrative concepts present unique challenges for program lines and are difficult to coordinate across agencies or across traditional R&D program or mission areas.
- *Novel concepts.* Novel concepts, almost by definition, do not have logical funding homes within the boundaries of traditional R&D organizations. They may build on scientific disciplines outside the routine or expected, may be unfamiliar, or perhaps threatening to other approaches, can suffer poor reviews by tradition-bound peers, or simply present too high of a risk for regular, metric-monitored investments. Yet, novel concepts can promise potentially valuable ways to reduce GHG emissions, reduce GHG concentrations, or otherwise address the effects of climate change, if pursued and explored. Somewhere within the overall program support for climate change technology R&D there needs to be means provided for funding and exploring novel concepts not fitting within regular appropriated R&D programs.
- *Greenhouse gases other than CO_2.* Beyond CO_2, there are anthropogenic emissions of a number of other greenhouse gases, including methane, nitrous oxide, and several high-global warming potential (GWP) gases. In the near-term, emissions of such gases may be more amenable to capture and control than some of the major sources of CO_2. For some of these gases, near-term technological advances could result in rapidly attainable and cost-effective GHG emission reduction strategies. Although other agencies, such as USDA or EPA, have the agency-leads on inventorying or mitigating emissions of various sources or these other GHGs, technology R&D programs to address opportunities in these areas are needed.
- *Measuring and monitoring systems.* Accurate measurements underlie many climate related actions and strategies for reducing GHG emissions. Improving the ability to measure and monitor all important greenhouse gases (GHGs), including their emissions, inventories and fluxes, across a variety of media (soil, water, air) and spatial (local, regional) boundaries, is a top priority. RFI responses included innovative new systems for remote and continuous monitoring of GHGs (not just CO_2). These included detection and location of GHG leaks.
- *Feedstocks and materials.* Often neglected in the usual emphasis of R&D on energy are the more routine economic activities of heavy industry, mining, manufacturing, agriculture and construction; which require resources, materials, feedstocks and other material inputs to their production processes, all of which have associated GHG emissions in their resource cycles. One RFI concept suggested systematic analytical methods to identify, review and select promising areas for new technologies to be applied to reduce such emissions, capture carbon, or otherwise substitute processes that result in little or no net GHG emissions.
- *Enabling Technologies.* Enabling technologies contribute indirectly to the reduction of GHG emissions, by enabling the development, deployment and use of other important technologies that reduce GHG emissions. A modernized electricity grid, for example, is seen as an essential step enabling the deployment of more advanced end-use and distributed energy resources needed for reducing GHG emissions.
- *Exploratory Concepts Augmenting Existing Programs.* Although DOE has well established R&D programs in almost all areas of energy, from end-use energy efficiency, to energy supply, a number of RFI concepts suggest that there may be worthy areas found outside the mainstream focus of current R&D emphasis. Reasons for this may be because the field is broad and the programs need to be more narrowly focused to be productive. The industry cost-sharing requirements may discourage risk taking and long-term ventures. The extensive degree of collaborated processes may result in consensus building around central ideas, rather than on outliers. In DOD, extensive R&D funding is applied, yet one of the most intriguing elements of DOD's overall research program is DARPA, designed to augment and explore novel, but potentially high-payoff technology concepts.

Conclusion

In conclusion, the RFI responses indicated that there is broad interest in participating in a NCCTI competitive solicitation program, should one go forward. The RFI process also provided a valuable tool in evaluating and possibly expanding current agency R&D programs. A wealth of information was provided among the submitted RFIs, and many of these can serve well as test cases for a future RFP or RFI process. At the same time, the RFI submittals raised a number procedural issues that will need to be addressed and resolved if an RFP is pursued. Better awareness of these issues can be expected to clarify and strengthen the focus and intents of a future NCCTI competitive solicitation program undertaken in support of the President's National Climate Change Technology Initiative.