CARBON CAPTURE AND SEQUESTRATION: AN OVERVIEW

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND AIR QUALITY

OF THE

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CARBON CAPTURE AND SEQUESTRATION: AN OVERVIEW

TUESDAY, MARCH 6, 2007

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND AIR QUALITY,
COMMITTEE ON ENERGY AND COMMERCE,
Washington, DC.

The subcommittee met, pursuant to call, at 10:06 a.m., in room 2322 of the Rayburn House Office Building, Hon. Rick Boucher (chairman) presiding.

Members present: Representatives Melcanon, Barrow, Markey, Wynn, Doyle, Harman, Gonzalez, Inslee, Dingell, Hastert, Hall, Upton, Whitfield, Shimkus, Walden, Sullivan, Burgess, Matheson, and Barton.

Staff present: Sue Sheridan, Laura Vaught, Lorie Schmidt, Bruce Harris, Chris Treanor, David McCarthy, Kurt Bilas, Tom Hassenboehler, and Peter Kielty

OPENING STATEMENT OF HON. RICK BOUCHER, A REPRESENTATIVE IN CONGRESS FROM THE COMMONWEALTH OF VIRGINIA

Mr. BOUCHER. This morning the subcommittee continues its series of climate change hearings with an overview of carbon capture and storage methods. Our witnesses will discuss the state of technology development, the costs that are associated with the use of the technology, the status of research efforts to improve the technologies, and time frames for expected commercialization of the technologies. These are key considerations for the subcommittee as we prepare to draft climate change legislation.

Coal is America's most abundant domestic fuel with reserves of 250 years within our borders. We have greater coal reserves than any other nation. Coal is also by a broad measure the Nation's least costly energy resource. Today coal accounts for 51 percent of the fuel that is used for electricity generation and the Energy Information Administration predicts that by 2030 coal's share of the electricity generation market will grow to 57 percent. Given our large coal reserves and its lower cost in comparison with other fuels that are used by electric utilities, preservation of the ability of electric utilities to continue coal's use in a carbon-constrained economy is desirable. The carbon capture and sequestration methods we are focusing on today are the means by which that result can be achieved.

In drafting climate change legislation, our goal will be to have a nation which makes a substantial contribution to resolution of the global problem while not dislocating any domestic economic sector. We should enable electric utilities that desire to use coal to have the continued ability to do so after the carbon control provisions that we will write become effective.

The technologies for carbon capture and sequestration we will discuss this morning will be essential to our ability to meet that test. If carbon controls take effect before the capture and storage technologies are available, there could be a rapid switch from coal to other fuels, and that rapid switch could prove unbearable for the Nation's economy. Fuel switching away from coal would significantly increase electricity prices to the detriment of both residential and industrial electricity consumers. Fuel switching from coal would probably result in far greater uses for natural gas by electricity generators, severely straining our already constrained natural gas supplies. At the present time, one-half of homes in the Nation are heated with natural gas. Industries, notably including the chemical sector, rely on natural gas for chemical feed stocks and some are already leaving the United States because of the high and volatile pricing for natural gas at the present time. That flight of jobs would certainly worsen if fuel switching from coal to natural gas occurs, and many other natural-gas-dependent industries would also suffer including farmers who use fertilizer manufactured in a natural-gas-intensive process. To avoid these problems, we must protect the ability of electric utilities to continue coal use. In a very real sense, therefore, the technologies that we are discussing today will be the enablers of a successful climate change program for the United States.

The average coal-fired utility emits approximately 3 to 4 million tons of carbon dioxide annually. While carbon storage projects are underway in research, demonstration and in limited commercial phases, none has attempted to store that much carbon dioxide. In addition, much of the work done to date is with the purpose of enhanced oil recovery. While that is a viable use for injected carbon, we also need to store large quantities of it underground indefinitely, and on that front, further research, development and demonstration is clearly called for.

We need to learn more about how the carbon behaves once it is injected underground in large quantities. Are there seepage issues or groundwater concerns? What kind of regulatory regime do we need to have in place to permit carbon injection? Are there liability issues that are associated with these projects? Most importantly, when will we have the capture and storage technologies available for both reliable and widespread use? Is the current flow of research dollars to these projects sufficient? Would larger allocations of research monies speed the availability of the technologies?

I want to welcome our witnesses this morning and thank them for sharing with us information regarding the status and expected future development of carbon capture and storage methods, and we very much look forward to their testimony.

I am pleased to recognize the ranking Republican member of the Energy and Air Quality Subcommittee, the gentleman from Illinois, Mr. Hastert.

OPENING STATEMENT OF HON. J. DENNIS HASTERT, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ILLINOIS

Mr. HASTERT. Thank you, Chairman Boucher, for holding this hearing today. I want to recognize your work over the last few decades in trying to find environmentally friendly ways to use the huge coal reserves that we have under the surface of this Nation.

I remember in 1992 when we took on kind of an oversight, where are we going to go on energy, and the conclusion in 1992 was, well, we have enough natural gas; natural gas will be the end-all for all things. We found out that is not necessarily true. The supply isn't there. So we have to think of new ways, more inventive ways to use the resources we have in an environmentally friendly way.

This is the first of three hearings this week so we are going to be busy looking at these issues. Carbon capture and sequestration is probably a good way to start off this week's hearing. Whether or not you agree with the science behind the claims of human-caused global warming, at the end of the day we are going to have to deal with the proposed real-world solutions. We cannot legislate the science. We can only try to understand its uncertainties and nuances in order to inform our decisionmaking. We can, however, propose policies to deal with the emissions suspected of contributing to global warming.

Carbon capture and sequestration is put forward as one such solution. Carbon capture and sequestration is a new technology. It has never been attempted on the scale required to alter the climate-affecting emissions which accompany the generation of electricity. Initially it will be expensive. Although the price may drop as we gain experience, but in the short term, make no mistake, it will increase the price of electricity. That is why before we jump into anything, we need to know how much we are asking the American people to pay and what we will get in return. We cannot ask the American people to pay a heavy price in jobs and consumer costs in the name of solving global warming only to discover that there is almost no environmental benefit. This is exactly what the Europeans have done with the Kyoto Protocol, paying a high price and still not meeting their emissions targets and seeing almost no environmental benefit.

Carbon capture and sequestration is usually discussed in the context of the burning of coal. I am a strong supporter of coal. The United States has the greatest coal reserves of any nation on the planet. My State of Illinois has a lot of that coal. So does Virginia, so does Kentucky, so does a place like Gillette, Wyoming, where they claim they have enough coal to supply our energy needs for centuries into the future of this Nation.

Clean coal technology is good for the United States. It offers a secure source of domestic energy for our homes and our jobs. By increasing our use of coal through coal-to-liquids technology, for example, we can decrease our dependence on foreign sources of energy and no doubt, we need to expand its use in a way that increases the efficiency of these plants and decreases their environmental consequences. I also support the expanded use of renewables such as ethanol. These alternative fuels also increase our energy independence.

We have two very good panels today. I look forward to hearing from the Department of Energy and the Environmental Protection Agency about the work they are doing on the carbon capture and sequestration. I believe our Government must lead the way on the development and deployment of these new technologies. I am also looking forward to the discussion of the various coal combustion technologies needed for carbon capture and sequestration. I want to learn more about what is coming in the form of new combustion technologies and also what can be done to make our current fleet of coal-fired power plants cleaner and more efficient. I also want to hear about the legal and regulatory issues associated with long-term storage of carbon dioxide underground. While the technology is important, in today's society the legal and regulatory structure could be just as important in determining whether technology is ever going to be widely deployed.

Carbon capture and sequestration can get a lot of attention as an available solution to reduced carbon dioxide. However, there is still quite a bit of research and testing to do before these technologies are ready for large-scale commercial deployment. We should be mindful in any proposed legislation that we do not set up a system guaranteed to fail because we mandated technology that is not deployable. If we do, Americans will get all cost and no benefit.

I want to make sure that whatever we do, we do not overburden consumers, chase industry overseas, lose jobs and see no appreciable reduction in global emissions. That would be a lose-lose situation. I want to see a situation where new technology as it becomes available is deployed so that Americans reap the benefits of both a safer environment, a better future and affordable electricity. That is win-win.

Thank you, Mr. Chairman.

Mr. BOUCHER. Thank you very much, Mr. Hastert, for an excellent statement.

Pursuant to the rules of the committee, any Member who waives making an opening statement will have 3 minutes added to his time for asking questions of our witnesses.

The Chair is now pleased to recognize the gentleman from Texas, Mr. Gonzalez, for 3 minutes.

Mr. GONZALEZ. I waive.

Mr. BOUCHER. Mr. Gonzalez waives.

Mr. Inslee for 3 minutes.

Mr. INSLEE. I will waive.

Mr. BOUCHER. Mr. Inslee also waives.

Mr. Doyle for 3 minutes.

OPENING STATEMENT OF HON. MIKE DOYLE, A REPRESENTATIVE IN CONGRESS FROM THE COMMONWEALTH OF PENNSYLVANIA

Mr. DOYLE. Thank you, Mr. Chairman.

I want to start my remarks with a review of a few things that I believe are absolute fact. One, global warming is real; two, man's actions have contributed to it; three, that it can be slowed and reversed; and finally, that it will take a real determined and comprehensive strategy through which American innovation is provided the tools and the environment necessary to succeed if we are ever going to fully address this threat.

It is clear that carbon dioxide is one of the many contributors to global warming. As more continues to be pumped into our atmosphere, global warming grows worse. It is important that this committee and the American industry work together to craft a solution that is clearly defined, obtainable and allows our spirit of innovation to flourish. We have seen this begin with the Energy Policy Act and now it is time to redouble our efforts.

There is no doubt that carbon sequestration is a very real and near-term technology that we can encourage here on this committee. By capturing the carbon dioxide that otherwise would have blown out of the smokestacks, we can today take one step towards our shared goal of eliminating the threat posed by global warming. The questions before us are: what are the technologies that are out there, what are the risks, what are their costs and how soon can they be deployed. We are beyond the point of asking if carbon dioxide has an impact. We must look at how we are going to manage, reduce and eventually eliminate that impact. This doesn't mean that we should simply pick winners and losers from the various methods of sequestration that are being deployed or currently being demonstrated. Instead, we should look at each for what they are and what they can deliver while also looking at the environment in which they will be deployed to ensure that obstacles to success are not already standing in their way. This is one piece of the greater puzzle and it is critical that we get this piece in place.

I look forward to hearing from each of our panelists explain what successes they have had and what results they can clearly demonstrate. I am also interested in hearing what obstacles in current law may impede their progress as well as what incentives government should champion to encourage continued advancement in the field of carbon sequestration. This is clearly one place where government and industry can work hand and hand.

Mr. Chairman, I yield back.

Mr. BOUCHER. The Chair thanks the gentleman and recognizes the gentleman from Michigan, Mr. Upton, for 3 minutes.

Mr. UPTON. I am going to waive. Thank you.

Mr. BOUCHER. The gentleman waives.

Mr. Walden from Oregon for 3 minutes.

Mr. WALDEN. I waive as well.

Mr. BOUCHER. Mr. Walden waives.

I am pleased now to recognize the chairman of the full committee, the gentleman from Michigan, Mr. Dingell.

OPENING STATEMENT OF HON. JOHN D. DINGELL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MICHIGAN

Mr. DINGELL. Mr. Chairman, thank you, and I want to commend you and thank you for calling this hearing and for the remarkable vigor with which you have been addressing the very serious questions which are the subject of today's hearing and related matters.

Today, as we all know, we are continuing our series of hearings on climate change with an overview on the topic of carbon capture and sequestration, commonly referred to as CCS. CCS refers to the system of separating CO^2 from either the fuel source, usually coal, or the flue gas that results from combustion and then storing that CO^2 in an underground geologic formation. CCS will be a critical component of any policy that restricts and reduces carbon dioxide emissions due to the simple fact that coal is and will continue to be a major part of America's energy resource base. It is also extremely important to us for many reasons, not the least of which is the impact it will have on communities where this is a major part of the industrial base and the industrial activity.

The United States has an estimated 250 years' worth of coal. According to the Energy Information Administration, coal provides fuel for 50 percent of our electrical generation needs today. We must, however, also recognize that coal-fired generation is a major source of CO^2 emissions. The challenge we face then is how to continue to use this country's abundant coal supplies to meet our energy needs while at the same time limiting the amount of CO^2 that we add to the atmosphere. I look forward to hearing from our experts today about how CCS can help us meet that challenge.

Capturing CO^2, transporting it and storing it to some same place in the ground or elsewhere is one of the basic components of CCS policy. The subcommittee's work today will focus on the challenge of capturing and storing CO^2 because these areas present the greatest difficulty. But I must note that the transportation is not without challenges. The U.S. currently has some 1,500 miles of pipeline devoted to CO^2 transport, mainly in Texas, where it is used for enhanced oil recovery. The amount of CO^2 that would be needed to be sequestered under mandatory CO^2-reduction policy would likely dwarf that capacity. We hope that we can explore this aspect of CCS at a later date.

With regard to the capture of CO^2, we have several excellent witnesses here today who can speak on the specific technology options, their state of readiness for commercial deployment and their costs, and I thank them for their presence and their assistance. I hope our witnesses will be able to inform us how a climate policy could take technology readiness into account. Can we achieve significant reduction in greenhouse gas emissions before carbon capture technologies are fully mature? Will we be able to retrofit existing coal generation facilities with any of these technologies or will they apply only to new plants?

On the issue of sequestration, we also have distinguished witnesses who can inform us as to the availability of storage sites in the U.S., the capacity of such sites and the legal issues that arise from storing huge volumes of CO^2 underground for long periods of time. To date, the committee has not spent a great amount of time studying carbon capture and sequestration but the issues raised by CCS are familiar to our work on hazardous waste and environmental contamination issues. How do we know that CO^2 injected underground will stay there? Will it affect underground water resources? What do we need to know to assure the public that this is a safe way to proceed? I would also like our witnesses' response on who should manage these locations, who should hold title to the CO^2 after it is captured? The Federal Government, the States, private entities?

Another issue that I hope all witnesses will illuminate for us including our guests from EPA and the Department of Energy is the issue of costs associated with CCS. The Department of Energy currently estimates the cost of capturing and sequestration using current technologies is between $100 and $300 per ton of carbon emissions avoided. This is a rather wide range. It could make a significant difference in the effectiveness of CCS policy. What do we need to do to get better understanding of costs? Will costs come down as a result of technology maturation?

I look forward to the testimony of our witnesses today. I thank them for their presence, and I thank you, Mr. Chairman, for your vigor and your diligence in addressing these questions.

I yield back the balance of my time.

Mr. BOUCHER. Thank you, Chairman Dingell.

The gentleman from Illinois, Mr. Shimkus, for 3 minutes.

Mr. SHIMKUS. Mr. Chairman, I will waive for questions.

Mr. BOUCHER. The gentleman waives.

That completes the opening statements from all Members present. Other statements from members of the subcommittee may be included in the record at this time.

[The prepared statements of Messrs. Barton and Burgess follow:]

PREPARED STATEMENT OF HON. JOE BARTON, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Thank you, Chairman Boucher, for holding this hearing and thanks to our witnesses for sharing their expertise on this important topic.

The stated purpose of these hearings is to produce legislation concerning global warming. Although I understand the political pressure to legislate on this issue, I hope we don't rush to judgment. This is a complex subject involving economics, the environment, energy, science and national security, and getting the balance right is critical.

Long-term problems don't need short-term solutions. We can hit the gas and produce a bill, but legislating like it's a drag race will do what it always does—more harm than good. I'd rather be right than fast.

I think we have agreed that any thoughtful legislation must ensure four things: that the lights stay on, that driving a car stays affordable, that natural gas prices stay low, and that we protect people's jobs. If we think we can achieve those goals without a continuing role for domestic fossil fuels, we're kidding ourselves.

We need to keep promoting renewables, because of their benefits for clean air and energy security. But unless we want to abandon millions of jobs, we must also use our fossil resources until the next great energy source arrives to power our homes, cars, schools and factories. We struck that balance between fossil fuels and renewables in the Energy Policy Act of 2005, and it was the right balance.

Looking at domestic fossil fuels in the context of our own energy security means looking carefully at coal. We have hundreds of years worth of coal in the ground, and provides half our electricity. We're making great strides in cleaner-coal technologies and, looking ahead, we need some that are even cleaner and more efficient than today's.

One of those technologies is carbon capture and sequestration. I have supported this technology in the FutureGen program. In fact, two possible Future Gen sites are in Texas and two are in Illinois. I prefer the one in my district, but I'll support the program wherever it lands because no matter where it is, it will good for America.

Other technologies such as integrated gasification combined cycle, supercritical combustion and oxy-fuel show promise. We have witnesses here today to detail the status of all three.

I welcome the administration. DOE and EPA are working on the promise of a cleaner and more energy secure future.

I am pleased that Jupiter Oxygen is here. I am told the Jupiter Oxygen technology is the only one that can allow for carbon capture on existing coal plants.

I am also pleased to welcome Mr. Jay Stewart who works with the Texas FutureGen team on legal issues related to the long-term storage of CO^2. We should understand legal questions that may arise if facilities with carbon capture and sequestration spring up around the country.

I also welcome the other witnesses and look forward to their testimony.

Finally, I hope to hear a discussion of the costs of these technologies and related regulatory programs. We learned in a hearing last May before this subcommittee that carbon capture and sequestration can spike the cost of electricity produced from coal.

At a hearing last month, we learned that a cap and trade program added 40 percent to the wholesale cost of electricity in Germany and that was, I believe, without any of these technologies. Combined, carbon capture and sequestration and a cap and trade program could lead to a real rate shock for electric consumers. High electricity costs will only drive manufacturers overseas, and American jobs along with them.

Thank you, Mr. Chairman.

PREPARED STATEMENT OF HON. MICHAEL C. BURGESS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Thank you, Mr. Chairman for convening today's hearing on carbon capture and sequestration.

As we've begun to debate the issue of global climate change, there has been a lot of discussion about carbon capture and sequestration and the potential promise that it holds for reducing the amount of carbon in our atmosphere.

These discussions, however, have focused on the carbon capture portion of the equation, and seemed to assume that the sequestration technology is available.

One of the things that I hope to learn during today's hearing is whether that assumption is well founded.

There are several different possibilities for carbon storage: depleted oil wells, unmineable coal seams, injection into the ocean, or storage in saline solutions.

Yet many of these are still in the initial stages of being tested. The world's first commercial deep saline carbon dioxide capture and storage project was started in Norway's North Sea during 2006. That's not that long-ago.

I look forward to hearing from our witnesses on the status of carbon capture and sequestration technology.

One final note before I yield back. Two of the final four sites selected for the location of FutureGen are located in my home State of Texas.

I'm extremely supportive of FutureGen and am hopeful that the FutureGen Alliance will ultimately chose to site the plant in its logical place—the Lone Star State—but let's not forget that this is a demonstration project.

A 10-year, $1 billion demonstration project. And in the end, is only expected to produce 275 Megawatts of electricity, as compared to the 600 Megawatts capacity of most commercial power plants.

There is an enormous amount of time and money being spent to show that this technology is even possible. And I think that it's a sound investment in future technology.

Now, I know that the most difficult part of this project is the hydrogen production component, but it still raises an important question: how far off in the future is the technology of carbon capture and sequestration and how expensive will it be?

Mr. BOUCHER.We are now pleased to welcome our first panel of witnesses: Mr. Thomas Shope, representing the Department of Energy. Mr. Shope is the Principal Deputy Assistant Secretary for Fossil Energy. We welcome him. Mr. William Wehrum and Mr. Benjamin Grumbles represent the Environmental Protection Agency. Mr. Wehrum is the Acting Assistant Administrator in EPA's Office of Air and Radiation, and Mr. Grumbles is the Assistant Administrator for Water.

We welcome each of our witnesses on the first panel, and without objection, your prepared written statements will be made a part of the record. We would welcome your oral summaries of approximately 5 minutes.

Mr. Shope, we will be pleased to begin with you.

STATEMENT OF THOMAS D. SHOPE, PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY, WASHINGTON, DC

Mr. SHOPE. Thank you, Mr. Chairman, and members of the committee. It is my pleasure to appear before you today to testify on the Department of Energy's carbon sequestration program. The overarching goal of this program is to deliver practical lower-cost ways for our Nation to integrate large-scale reductions of the greenhouse gas CO^2 where none now exist.

First, let me be clear about carbon capture. We can capture CO^2 today. What we cannot do is capture the CO^2 of combustion and maintain prices that we can afford for electricity and other energy-intense consumer products. What we do not yet understand fully, and I emphasize the word yet, is how to develop the capacity to initiate and maintain safe, large-scale geologic storage for hundreds and thousands of years. Finally, we need to develop a nationwide infrastructure to align the CO^2 sources being captured with the available storage sites or sinks.

The sequestration program of the Office of Fossil Energy addresses these questions. It began 10 years ago as a small-scale investigation of technical viability. Then the administration made it a critical component of the President's technology initiatives to provide concrete means of dealing with concerns about climate change. Program investment to date is in excess of $300 million. In fiscal year 2008, the President has requested an additional $79 million. That represents a four-fold increase from the $18 million appropriated in fiscal year 2001. Today the program is dedicated to preparing America to reduce CO^2 from fossil energy use without detriment to our energy security or economic well-being. It seeks to eliminate the harmful effects of using our most abundant and lowest cost energy, coal. It recognizes that coal is the backbone of our electric power supply which is the backbone of the economy. Today we are engaged in pioneering and world-class research, development and demonstration of technologies for affordable CO^2 capture and for safe long-term storage.

The carbon sequestration program has two main parts: the core research and development element and the deployment and demonstration element. The core research element includes capture, sequestration, breakthrough concepts and the monitoring, mitigation and verification of CO^2 in geologic storage. It also includes mitigation of non-CO^2 greenhouse gases. The portfolio contains more than 70 projects designed to find solutions. Lowering the costs of capture is a critical driver of our efforts. Our focus is on pre- and post-combustion capture and oxycombustion, which produces a flue gas strain composed largely of CO^2 and water vapor. It includes providing retrofit capability for pulverized-coal plants, currently in use and for those that are planned. Our overall goal is 90 percent capture and 99 percent storage permanence by 2012 with no more than a 10 percent increase in the cost of energy services. We want to have ready by 2012 a portfolio of technologies capable of market penetration after 2012. Objectives to achieve this goal include post-combustion capture and a cost of power no more than 20 percent above that of a non-capture plant and pre-combustion capture for

IGCC generation at no more than 10 percent above the non-capture plant.

The second element of our program, our deployment and demonstration element, centers on the seven regional carbon sequestration partnerships. These partnerships involve more than 400 entities in 41 States, four Canadian provinces and three Indian Nations. Their mission is to develop sequestration capacity and infrastructure, and their work is critical to technical achievement and public acceptance of CO^2 capture and storage. The partnerships have already assisted our National Energy Technology Lab in compiling the National Carbon Sequestration Atlas. These efforts have helped us identify all large-point sources of CO^2 as well as what may be the biggest prize in carbon capture and storage, the vast potential geologic CO^2 storage locations that exist. In this country alone, we have deep underground formations sufficient to store hundreds of years worth of CO^2 emissions, not just from the power sector but from all sources of CO^2. Current regional partnership activities also involve 11 projects dealing with terrestrial sequestration and 25 diverse field tests in geologic storage. As we move from characterization to validation, we look forward to expediting the demonstration of large-scale tests. Our large-scale testing phase will involve up to seven large-volume tests and could identify candidates for the class of new near-zero-emission power plants in the future modeled on FutureGen. FutureGen will integrate various technologies of capture and storage in the world's first-of-a-kind coal-based power with near-zero emissions. It will deliver electric power, hydrogen fuel and other byproducts. It will also test subsequent advances from the core research effort, and most important, FutureGen will be the prototype for a line of zero-emission plants based on coal gasification here in the U.S. and around the world.

In conclusion, our program is demonstrating that while there is no practical alternatives to continued use of fossil fuels in the foreseeable future, coal in particular, carbon capture and storage technologies coupled with our array of clean coal efforts will allow fossil-fuel use in a carbon-constrained world without harming the environment and without constraining economic growth.

Mr. Chairman, members of the committee, that concludes my spoken remarks.

[The prepared statement of Mr. Shope appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you, Mr. Shope.

Mr. Wehrum.

STATEMENT OF WILLIAM WEHRUM, ACTING ASSISTANT ADMINISTRATOR, OFFICE OF AIR AND RADIATION, U.S. ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, DC

Mr. WEHRUM. Good morning, Mr. Chairman, members of the subcommittee. Thanks for the opportunity to testify on behalf of EPA. My name is Bill Wehrum. I am the Acting Assistant Administrator for EPA's Air Office. With me this morning is Ben Grumbles, the EPA's Assistant Administrator for Water.

As you know, the President and his administration are firmly committed to taking sensible action on climate change. The administration's policy is science-based, encouraging research breakthroughs that lead to technological innovation and harnesses the power of markets to commercially deploy those technologies. As my colleague from DOE explained, the administration is actively investigating the prospects for carbon dioxide capture from power plants and other industrial sources and long-term storage and geologic formations. Our testimony today will focus on EPA's role in ensuring the carbon capture and storage is developed and deployed in a manner that safeguards the environment. We are focusing that effort on two fronts, which I will explain.

But before discussing each of these efforts, I would like to briefly discuss the role of coal in our Nation's energy future. As you know, coal is an essential fuel to achieve energy security and increase economic prosperity in the United States. Currently, about 50 percent of electricity in the United States is generated from coal and at current rates of consumption, U.S. coal reserves are large enough to meet our energy needs for more than 200 years. To achieve our goal of energy security, coal must continue to play a major role in the generation of electricity in this country. Carbon dioxide capture and storage can potentially make a significant contribution to reducing greenhouse gas emissions from coal-fired electricity generation while allowing continued use of our ample coal reserves.

To address the potential environmental impacts of coal-fired power plants, EPA, DOE and others are exploring technological innovations that would allow coal to be burned more efficiently and with lower emissions. Recognizing the importance of advanced coal technology, EPA is already working to ensure that these new technologies are deployed in an environmentally responsible manner.

EPA is examining how we can facilitate the use of advanced coal technologies through the efforts of a recently convened work group of private and public stakeholders. At the recommendation of the Clean Air Act Advisory Committee, EPA established the Advanced Coal Technology Work Group in January of this year to discuss and identify potential barriers and opportunities to create incentives under the Clean Air Act for the development and deployment of advanced coal technologies. The work group includes widely diverse participants. The work group is developing a set of recommendations that could be undertaken to accelerate the development and use of advanced coal technology. In its work to date, the work group has discussed a wide range of issues associated with commercial use of advanced coal technologies.

With respect to carbon dioxide capture and storage, key issues identified by the work group include the availability and cost of capture technologies for new and existing pulverized coal and IGCC power plants, measures to accelerate the pace of carbon capture and storage, the siting of power plants including availability and location of pipeline capacity, monitoring and verification to ensure storage of carbon dioxide is effective, liability concerns associated with carbon capture and storage, legal issues involving property rights and other issues.

EPA is also developing risk management strategies to ensure that carbon dioxide injection and long-term geologic storage are conducted in an environmentally responsible manner. The underground injection of carbon dioxide is subject to the Underground Injection Control program, or UIC program, of the Safe Drinking

Water Act. In carrying out our responsibilities under the Safe Drinking Water Act, the EPA's goal is to ensure protective, effective storage of carbon dioxide injection in suitable geologic formations.

EPA has more than 30 years of experience working with its State partners to implement the UIC program. There is a significant amount of expertise in transporting and injecting carbon dioxide, particularly in the oil and gas sector. Approximately 35 million tons of carbon dioxide are injected annually and in the Southwest United States, there is an extensive infrastructure to transport and inject carbon dioxide for enhanced oil and gas recovery. The knowledge gained from these activities is extremely useful but we still need to gain experience with integrated carbon dioxide capture and storage technologies on a commercial scale for coal-fired power plants.

DOE's research efforts to integrate and demonstration carbon dioxide capture and storage will go a long way toward reducing costs and providing needed data. My DOE colleague's testimony lays out the Department's plans to develop this critical technology including implementation of field tests throughout the country in a variety of geologic settings and a smaller number of larger tests and ultimately commercial-scale projects such as FutureGen.

To support these efforts, the EPA has developed UIC guidance that recommends treatment of injection wells associated with R&D projects as class V experimental technology wells which are covered under our existing regulations. Our goal is to provide guidance that facilitates permanence while encouraging environmentally responsible injection activities. Another goal of the guidance is to promote information exchange between project proponents and regulators which will eventually support the development of a long-term management strategy and answer public questions about the emerging technology. The guidance recommends a workable UIC permitting approach for the next several years while more data are gathered to determine the most appropriate management framework.

Thank you once again for the opportunity to be here. Mr. Grumbles and myself will be happy to answer any questions you may have for us.

[The prepared statement of Mr. Wehrum appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you, Mr. Wehrum. Mr. Grumbles, do you have a statement for us at this time?

Mr. GRUMBLES. No.

Mr. BOUCHER. All right. Thank you.

I would like to thank both Mr. Shope and Mr. Wehrum for their testimony this morning.

Mr. Shope, let me begin my questioning with you. You mentioned that you have a target date of 2012 in order to have determinations made by the DOE with regard to the adequacy of technology for CO^2 storage. How confident are you that we will have that information by that date?

Mr. SHOPE. I am very confident in the 2012 time frame that we will have at that period a portfolio of technologies that are available. The 2012 time frame again does not envision the wide-scale deployment at that time. That means we have the technology that is then available, that portfolio, and a portfolio that is available at a reasonable cost, the targets I had indicated to you, no more than a 20 percent cost increase for PC, or post-combustion capture of CO^2, and a 10 percent cost increase for IGCC-type technologies, pre-combustion capture. But we are on the path to meet that 2012 portfolio.

Mr. BOUCHER. What we are interested in is having a projected date when we can have the assurance that reliable geologic storage is available for the quantities of CO^2 that will be emitted by the Nation's coal-fired power plants. I can say that my goal is to make sure that electric utilities under whatever carbon constraints we adopt have the ability to continue to use coal pretty much the same way they are using it today in those quantities, and my personal goal also is to protect the ability of coal to continue to grow as a percentage of the total fuel mix for electricity generation. So I am particularly very interested in making sure that we team the arrival of regulations with the availability of these technologies for commercial deployment.

So when are we going to have that assurance? Is that 2012 or is that some later date?

Mr. SHOPE. Well, I wish I could provide exact dates, Mr. Chairman, but I will tell you that again we are on that path from the 2012 time frame, but in addition to that, that would allow us to have that portfolio technology available. That also marries up well, as I indicated in our testimony, our FutureGen project, which ties them together not only the sequestration opportunities but then IGCC capture, energy production with hydrogen co-production and the storage, marrying that all together. We would have in the 2012 time frame getting the first testing of our FutureGen plants. Down the road from that, it would be approximately 10 years before that technology is then widely available for commercial deployment and you could envision full-scale the technology of choice deployment in the 2045 time frame.

Mr. BOUCHER. So are you saying that it would be 10 years beyond 2012 before the technology would be available for wide-scale deployment?

Mr. SHOPE. That is correct.

Mr. BOUCHER. OK. That is a longer time frame than others have suggested. Let me ask you this. How much money is now being devoted to your R&D efforts? You have seven regional partnerships. How much money is being devoted to those at the present time?

Mr. SHOPE. Our 2008 request is for $79 million. To date we have already spent $300 million on the sequestration piece. Now, of course, that is a subset of our larger clean coal budget, and again, there is some overlap obviously between all the technologies that we are working on under the clean coal program are directly applicable and they are all driving towards the same goal, which is that zero-emissions power plant, carbon capture and storage. But in our sequestration piece alone, we have used $300 million to date. Again the 2007 request is currently being discussed right now for our operating plans and will be submitted soon. Our 2008 request is $79 million.

Mr. BOUCHER. And you are getting about $60 million in 2007. Is that right?

Mr. SHOPE. Well, again, Mr. Chairman, those operating plans are being discussed right now at the Department in light of the continuing resolution.

Mr. BOUCHER. What did you have in 2005?

Mr. SHOPE. It was 60.

Mr. BOUCHER. So it is roughly 60 presently and you are anticipating 80-plus for 2008.

Mr. SHOPE. That is about right.

Mr. BOUCHER. If more money were provided for this effort, could you accelerate your time frame for the arrival of these technologies with commercial reliability?

Mr. SHOPE. Of course, I support the budget that we have that is on——

Mr. BOUCHER. I understand that but——

Mr. SHOPE. But in answer to the hypothetical question is yes, of course, there are some technology constraints, particularly in the testing area. We are engaging in our 25 geologic tests looking to expedite our larger-scale tests. If we had additional funds, then we could develop—hypothetically speaking, if you were to double our program budget, we could reduce the amount of time for that full deployment, so the answer is yes.

Mr. BOUCHER. Thank you, Mr. Shope. I assumed that was going to be the answer.

My time has expired. I have some further questions which we will defer to a later time.

I am now pleased to recognize for 5 minutes the gentleman from Illinois, Mr. Hastert.

Mr. HASTERT. Thank you, Mr. Chairman. I have a series of short questions, and if you could be as explicit in the answers as possible, we will get through them.

First of all, back two decades ago when we needed to clean these plants up and you did the scrubbers and those types of things, that was technology that you put on top of old plants. Basically this technology means that you have to build new plants, right?

Mr. SHOPE. Well, we are working on existing plant technology as well as far as capture goes, that is, post-combustion capture on existing PC plants.

Mr. HASTERT. Well, let me lead into a sub-question off that then. You say you have a 12,000-megawatt plant. Isn't this stuff coming out so fast and so quick that it is really hard to capture all the CO^2 coming out of the stacks?

Mr. SHOPE. That is correct. Also, you have a much lower concentration of CO^2 so you have a larger volume to process and it is expensive. That is correct. It is expensive to add on technology to existing plants.

Mr. HASTERT. When you carry out these studies, I know you are far enough into it, what effect do you think this has on retail electric prices? For instance, if you put a new plant in and you put it in the right base, what do you see the increase in prices roughly?

Mr. SHOPE. Under our current scenario, for a PC plant, you are looking at a cost of electricity penalty anywhere from 40 to 85 percent. Now, on an IGCC, a plant with hydrogen co-production today, you are looking at a price penalty of 20 to 55 percent. Our targets are to drive those obviously much lower.

Mr. HASTERT. So we could be hypothetically paying half again increase in the price of electricity, whatever our price may be.

Mr. SHOPE. Based on current technology, that is correct.

Mr. HASTERT. I think you said this, but I want to make sure it is clear. Time-wise to have these plants in place, to have a plant in place would probably almost be 16 to 17 years. Is that what you are talking about?

Mr. SHOPE. Approximately. That is correct. Now, when I mentioned the 2045 time frame, that would the technology of choice, full-scale deployment. That would be the out year. FutureGen will be coming online in 2012, 3 years of testing, about 10 years following that, you are looking at a 2025, 2026 time frame for deployment.

Mr. HASTERT. I have a couple questions I want to ask about sequestration. I have limited time here but first of all, the science of this sequestration. You drive this gas deep into the ground, 5,000, 6,000, 7,000 feet and it is ingested by the chemicals, whether it is brine, whether it is existing coal beds, and absorbed. Is that correct?

Mr. SHOPE. It stays in place, and it is important to note, sir, that it would be a liquid so when you put it down, you are putting a liquid down although we refer to it as gas. Under those pressures and depths, it becomes a liquid.

Mr. HASTERT. So it is liquid carbon dioxide but it is not frozen carbon dioxide? It is not dry ice, for instance?

Mr. SHOPE. That is correct.

Mr. HASTERT. OK. Then what could happen? Today we are talking about Yucca Mountain where people want to make sure that that thing is absolutely safe for 10,000 or 20,000 or I don't know how many years, a lot of time. What happens now when this gas is down there? Is there any adverse effect that we have to worry about, liability issues, for instance?

Mr. SHOPE. Well, there is always going to be concerns about liability but I would say first and foremost, the important measure is that it is CO^2. It is not a hazardous substance. In fact, it is a commodity right now. We use CO^2 in various processes from carbonation on out. The concerns of course would be what happens to it in those deep formations. Does it spread out, how far does it spread out, is there any leakage associated with it. These are all the things that we are looking at through our validation phase right now with our 25 geologic tests that are going throughout the country in different formations, different geologic formations, different areas of the country. Those are the things that we are exploring right now.

Mr. HASTERT. One of the things that they say that you can take the CO^2 out of the atmosphere. That is one of the technologies you are looking at. So you are taking this huge amount of just air and you are taking CO^2 out of it, putting it in the ground. The byproduct of that is oxygen. Is that one of the things you use the fluidize or to burn, or what is happening?

Mr. SHOPE. I am not sure I understand the question or have the scientific background. The director of our national lab happens to be here. I would let the director of our national lab answer that.

Mr. BOWER. Congressman, thank you for the question. When you take the CO^2 out of the flue gas, it has already come through the combustion process, or if it high pressure from a gasifier, it is already part of the process. When you talk about the oxycombustion, you would actually separate oxygen off and put it through from the air, instead of pure air going into combustion, you shoot pure oxygen. So either way you are taking the CO^2 at a high concentration. It doesn't make oxygen. It actually just is a separate component of the air. You take it, pressurize it, put it in the ground. At that depth you are below solid layers of rock. It is not a void it is going into but it is permeating with other rock down there so it is like putting it into a sponge more likely, and the chance of it going anywhere is part of what we are evaluating. It looks very solid right now that it is going to stay where it is. We just have to confirm some of those things as far as transport.

Mr. HASTERT. So the effluent from that process, there is absolutely no CO^2 or hardly any CO^2?

Mr. BOWER. The effluent from the flue gas or the gasifier stream, the CO^2 is taken off. Whatever else is left will go into the atmosphere. If there is some nitrogen, it will be left off in the atmosphere. If there were some other elements, they would go off. We would clean out the sulfur obviously and all the other things that we are concerned about in our normal regulatory process.

Mr. HASTERT. Thank you, Mr. Chairman.

Mr. BOUCHER. Thank you, Mr. Hastert. And let me ask the director of the national lab if he would identify himself for our record, please.

Mr. BOWER. I am sorry, Mr. Chairman. My name is Carl Bower, director of National Energy Technology Laboratory.

Mr. BOUCHER. Thank you very much.

The gentleman from Massachusetts, Mr. Markey, is recognized for 8 minutes.

Mr. MARKEY. Thank you, Mr. Chairman.

Mr. Shope, the testimony submitted by the Natural Resources Defense Council witness who will be appearing on our panel, Mr. Hawkins, argues that we need to limit CO^2 emissions through a cap and trade system and adopt a performance standard for emissions of CO^2 from coal-burning plants in order to transform the economics of the coal utility industry so that instead of choosing to build a dirtier coal plant that releases carbon pollution into the air, it makes economic sense to build plants that do carbon capture and sequestration. Do you agree?

Mr. SHOPE. Congressman, I am going to defer on the question just because again, my expertise is on the technology——

Mr. MARKEY. Please don't defer. We have a deadline that is very closely approaching. Can you please give us an answer?

Mr. SHOPE. Again, the focus of the Office of Fossil Energy is on the technology end of the program, regardless of the particular emissions strategy that you are going to pick, we all have a common technology goal and that is what-

Mr. MARKEY. Do you think changing the economic structure here of the incentives for the coal industry would make a big difference in terms of telescoping the time frame it would take to get an affordable technology that the coal industry would in fact play?

Mr. SHOPE. Again, Congressman, the problem that we see, we perceive it as a technology problem and there is a technology path forward that is needed.

Mr. MARKEY. Your testimony says, sir, that the technology is already there.

Mr. SHOPE. What I testified to was that we do capture carbon today through EOR. That is enhanced oil recovery. The problem is that those technologies have different goals, different motivations. In an EOR situation, you are capturing the carbon dioxide with the number one goal of pushing out the oil, enhancing the oil recovery.

Mr. MARKEY. I appreciate that, but the basic technology already exists, sir?

Mr. SHOPE. That is correct.

Mr. MARKEY. And that is what your testimony indicates?

Mr. SHOPE. That is.

Mr. MARKEY. And I just think that it is one more example of the Bush administration avoiding the central question that America wants to know the answer to, which is whether or not they are going to use technology and a cap and trade system in order to accomplish the goal, and your testimony is not helpful towards getting the answer to that question.

Mr. Wehrum and Mr. Grumbles, in the NRDC testimony, Mr. Hawkins suggests that operating a coal-burning plant with carbon capture and disposal can be done safely, “if an effective regulatory regime is put in place to license and monitor operations of disposal sites.” He further notes that EPA already has the authority to write such rules but that direction from Congress is needed to ensure they are written in a timely manner and suggests that this committee direct EPA to write rules governing large-scale carbon injection and sequestration facilities within the next 2 to 3 years. Would EPA support such legislation?

Mr. GRUMBLES. Congressman, what we are focused on right now is in working together with the environmental community and the States and Department of Energy, is taking an adaptive management incremental step forward aggressively to first get guidance out. We have issued guidance regulating the injection of CO^2 under class V UIC programs under the Safe Drinking Water Act under the experimental technology wells provision. We are also going to be convening workshops and bringing in——

Mr. MARKEY. Would you support legislation to advance that goal, sir?

Mr. GRUMBLES. My recommendation right now would be, we are on the best path working with Congress——

Mr. MARKEY. So you are on a better path than legislation so right now you don’t support legislation. Is that correct?

Mr. GRUMBLES. I think as we learn more about this proven——

Mr. MARKEY. How much more time do you need?

Mr. GRUMBLES. Well, when I look at the aggressive roadmap that we are laying out——

Mr. MARKEY. What is aggressive under the Bush administration?

Mr. GRUMBLES. I would say when it comes to carbon sequestration, we have an aggressive roadmap and that is, it is going to take—we are just now issuing——

Mr. MARKEY. All right. You are 6 years in so does that aggressiveness indicate that you will get an answer before the next President is elected?

Mr. GRUMBLES. Well, I think the science drives the results and the technology is promising but it is unproven.

Mr. MARKEY. Sir, science does not drive the decisions of President Bush and Vice President Cheney. Politics does. Ideology does. I am afraid that your evasiveness is just a continuation of——

Mr. GRUMBLES. Congressman, I would respectfully disagree and just simply say——

Mr. MARKEY. I would say that your testimony at that juncture on that subject is completely at variance with the facts.

Does the other gentleman wish to answer?

Mr. WEHRUM. Thank you, Congressman. I will reiterate what my colleague said. We made a very crucial determination recently that is directly relevant to your question. We had to ask and answer whether we believe we have legal authority under the UIC program to regulate carbon injection and sequestration in geologic formations, and we determined the answer is yes and that was very important because what that allowed us to do is issue guidance, which has just been signed, that calls for the permitting of these activities under the program right now under an existing classification called class V. So what we are now committed to do is exactly what you described, which is develop a set of regulations specifically for CO^2 injection and——

Mr. MARKEY. And when will those regulations be coming out?

Mr. GRUMBLES. What we are committed to is a management framework that looks at the long-term——

Mr. MARKEY. Give me a timetable. How many months?

Mr. GRUMBLES. Well, I think it depends on public dialog.

Mr. MARKEY. July?

Mr. HALL. Mr. Chairman, regular order, please.

Mr. MARKEY. Can you get it done by July? Can you get it done by July?

Mr. GRUMBLES. What we can get done by July is having informed debate and dialog with——

Mr. MARKEY. That doesn't help us. Let me move on.

Mr. Shope, some of the testimony that we received for today's hearing raises concerns about provisions of the 2005 Energy Policy Act that provides significant subsides for coal plants that don't actually capture CO^2 but merely have a carbon capture capability. It has been suggested that this provision of the law is not being implemented in a way that distinguishes between an ordinary integrated gas combined cycle plant and one that actually has been designed with early integration of carbon capture and sequestration in mind. There are also concerns that some of the language relating to loan guarantees allows loan guarantees for carbon sequestration optimized coal plants but fails to define what that means. What is the Department doing to ensure that these provisions of law are only used for plants that are actually being designed and built in anticipation of early adoption of a full carbon capture and sequestration capability so that we aren't subsidizing dirty plants with the provision designed to promote clean ones?

Mr. SHOPE. Well, I would say, Congressman, that there is a technology path. You have to learn how to capture the carbon effectively. You can't immediately get to the end goal. It is a technology path forward and that is what the Department is working on. That is what our solicitations have given, the loan guarantees——

Mr. MARKEY. If I were a utility executive and I built a standard pulverized-coal-burning plant but with a big open building attached to it that I claimed was designed to accommodate installation of carbon capture technologies, do I quality for the subsidy?

Mr. SHOPE. Well, I would have to look at the particular.

Mr. MARKEY. So maybe——

Mr. SHOPE. Each of the projects——

Mr. MARKEY. Saint Augustine used to say: Oh, Lord, make me chaste but not just yet. These utility executives are saying oh, Lord, make me carbon-free but not just yet; I am getting ready to be carbon-free but I will leave a space there, maybe in another 20 years. That is what Saint Augustine used to say about chastity.

So we are going to need more specifics from each of you in terms of what the deadline is in order to accomplish these goals.

I thank the chairman.

Mr. BOUCHER. The Chair thanks the gentleman and is pleased now to recognize the gentleman from Texas, Mr. Barton, the ranking Republican member of the full committee, for 5 minutes.

Mr. BARTON. Thank you, Mr. Chairman. I am delighted to be at this particular hearing. I know we have had it scheduled and postponed but I am still looking forward to the hearing where we actually try to talk about the science a little bit before we rush to judgment on all these proposed solutions. I am still not convinced that this is quite the earthshaking, earth-changing problem that it is presented to be. But having said that, I think it is important to have a discussion of some commonsense carbon capture mechanisms, so I welcome this hearing.

My first question is to Mr. Wehrum, who is the air and radiation representative from EPA. Can you tell me what the pollutants are that the Clean Air Act currently regulates?

Mr. WEHRUM. Yes, Congressman. We primarily regulate the six criteria pollutants. Most importantly for power generation, they include SO^2 and NOx and particulates, I should add. We made a determination a couple years ago that those——

Mr. BARTON. Can you enumerate them? That is three of them. What are the other three?

Mr. WEHRUM. Lead—I knew you were going to put me on the spot here.

Mr. BARTON. Particulate matter is one.

Mr. WEHRUM. SO^2, NOx——

Mr. BARTON. Mercury. You just added mercury.

Mr. WEHRUM. Well, we regulate mercury as an air toxic, not as a criteria pollutant. So the answer is, we actually regulate a wide, wide variety of pollutants.

Mr. BARTON. CO^2 is not one of them, is it?

Mr. WEHRUM. No. We made a determination that CO^2 is not a pollutant that we regulate.

Mr. BARTON. COs is not a pollutant. Now, why are these others regulated? Why do we regulate the ones that we regulate?

Mr. WEHRUM. Because the Clean Air Act directs us to do so.

Mr. BARTON. No, but why do we do that in the Clean Air Act? It is because they are harmful to public health, to individual health. People get sick. They have an adverse health reaction because of that if they are subjected to large amounts of whatever the pollutant is. But you don't have that with CO^2, do you?

Mr. WEHRUM. Well, again, Congressman, we made a determination a couple years ago and now in fact the question is currently before the Supreme Court as to whether the Clean Air Act requires us or authorizes us to regulate CO^2.

Mr. BARTON. No, that is a lawsuit by some of the radical environmentalists but the point of fact is, under current law we don't regulate CO^2 because it is not a health hazardous.

Mr. MARKEY. That is the State of Massachusetts you are talking about.

Mr. BARTON. I rest my case.

Mr. MARKEY. It is Mitt Romney that brought the case.

Mr. BARTON. I think that is an important point. SO^2 and mercury, lead are directly harmful to human health. CO^2 is not. It is not. There is this theory that CO^2 somehow over time is increasing the temperature and increased temperature does things to the climate that over time might be harmful to human habitation of the Earth. That is a theory. It is not a fact. It is also a fact that if we pick one of these carbon capture methods, the most benign estimate we have right now is a 50 percent increase in cost. Now, a 50 percent increase in cost is going to cost somebody their job. In fact, it is going to cost a lot of somebodies their job. That is a fact. I am just totally tied up in knots that our new Speaker wants a bill out of this committee by June 1. That is an artificial deadline. It is also in my opinion wildly unrealistic. The same people that are now pushing for a bill are some of the same people that were telling me when I was chairman not to even hold hearings on this issue because of how difficult it would be to find consensus.

My second question on CO^2 is, can any of our panelists tell us the volume, just the volume of CO^2 that comes out of a smokestack that is using coal as a fuel source of the emissions? What percentage of those emissions coming out of a smokestack in the average plant in the United States is CO^2?

Mr. SHOPE. I can tell you on total, the total just by way of——

Mr. BARTON. I don't want a total number. I want a percent number. We hear all these tons and tons and tons. We never hear what the percentage is.

Mr. SHOPE. On a PC, a pulverized-coal plant, you are looking at about 10 percent.

Mr. BARTON. Ten percent. Is that average?

Mr. SHOPE. That is average for a pulverized-coal plant. That is correct.

Mr. BARTON. So one of the problems we have as you are going to capture it is, it is just not a high percentage of the smokestack.

Mr. SHOPE. That is correct, Congressman. It is a very low concentration per volume of emissions.

Mr. BARTON. We also might want to put in the record, and I see my time has expired, that of the total percentage of the atmosphere, the number I have for CO^2 is 0.03 of 1 percent, 0.03 of 1 percent. It is very, very hard to imagine that 0.03 of 1 percent of anything is causing some of these catastrophic problems that are credited. I am told that of the total greenhouse gases, 95 percent of all the greenhouse gas is water vapor and that 90 percent of that is created by the oceans.

With that, I yield back, Mr. Chairman.

Mr. BOUCHER. Thank you, Mr. Barton.

The gentleman from Texas, Mr. Gonzalez, for 8 minutes.

Mr. GONZALEZ. Thank you very much, Mr. Chairman. I was engaged here with Mr. Markey and it is always an interesting conversation but I didn't have the microphone on. But in essence he said blaming the oceans, it was nice to have an alternative to Ronald Reagan's trees. I think that is what he was saying.

Anyway, let me ask Mr. Shope real quick, I was reading in the materials that were provided us and it said in 2005 the Intergovernmental Panel on Climate Change, the IPCC, estimated there were 128 operating gasification plants worldwide. How many of those are in the United States? I don't have the answer. I am really asking in good faith.

Mr. SHOPE. Most of them operating are not IGCC.

Mr. GONZALEZ. In the United States, how many of the 128 gasification plants identified by the panel on climate change are located in the United States? I mean, if you don't know, you don't know.

Mr. SHOPE. There are two IGCC plants operating in the United States right now.

Mr. GONZALEZ. All right. And then they went to the next statement which address what you are saying. Integrated gasification combination cycle, IGCC, is a form of gasification and there are only four identified by the IPCC as existing worldwide, and you are saying that two of those are in the United States?

Mr. SHOPE. There are two in commercial operation in the United States.

Mr. GONZALEZ. With the present technology, I look at these as kind of the Holy Grail of coal-fired plants. Would you agree?

Mr. SHOPE. The next generation of them. You can have an IGCC plant that is air blown. What we are looking for, what the real prize would be an oxygen-blown IGCC plant with hydrogen co-production.

Mr. GONZALEZ. I guess I am getting to the overall plan that you have, but realistically, what is being built, licensed and regulated and permitted today in the United States as it relates to coal-fired plants? None of this, right? Not of what I just referred to.

Mr. SHOPE. Under our CCPI program, there are plants that are being built now that are ready to take on that pathway, which is the IGCC pathway getting back towards our FutureGen plant, which would be again the culmination of all these technologies which would have electricity generation as with hydrogen co-production and sequestration, and that is——

Mr. GONZALEZ. What percentage of plants that are being built or in the planning stages or in the permitting stages would you say would meet the criteria that you were just outlining?

Mr. SHOPE. The FutureGen-type plant with——

Mr. GONZALEZ. How many FutureGen-type plants do we have right now?

Mr. SHOPE. There are none. That is why we are heavily engaged in that research because we are driving to that conclusion.

Mr. GONZALEZ. Who permits and licenses the building of these new plants, the ones that are on the drawing boards, the ones that are being proposed, the ones that are part of the initiative by any particular energy company. That would be the State, wouldn't it?

Mr. SHOPE. Congressman, a wide variety of legal and regulatory approvals are needed to site and construct a power plant including, for instance, air permits that are necessary under the Clean Air Act.

Mr. GONZALEZ. All right, but primarily wouldn't you say it is a State regulatory commission entity that the process goes through, I mean, starts with and pretty much is dependent on getting the green light?

Mr. WEHRUM. Congressman, I can speak for the environmental side, and what I know is that getting an air permit for a new coal-fired power plant is one of the most critical approvals that is necessary and something we as an agency spend a lot of time and energy focusing on.

Mr. GONZALEZ. I actually have plenty of time if you guys want to discuss this. I think we need to deal with what you have on the table. No one here is espousing that we stop dead in its tracks the building of coal-fired plants. Is that correct?

Mr. SHOPE. Again, the problem that we are getting at is that current plants, the technology, yes, we can capture that carbon dioxide but you are looking at almost up to 80 percent of a price penalty, and that is where the rubber meets the road. That is why the technology path forward is the solution to bringing those costs down so that it becomes more much of an occurrence so that the next time we have these percentages they would be much higher but it doesn't exist yet today at a reasonable cost.

Mr. GONZALEZ. Well, two things that we need to be working on, Congress and the administration, that we don't present unrealistic expectations. Nothing worse than dashed hopes because that really does equate to misrepresenting and misleading the American public, and that is my fear as we engage in this particular debate that we are on the fringes of this thing rather than trying to come to the middle and figuring out of course addressing the environmental needs and concerns and yet the economic realities out there of providing energy for the consumer, the citizen, the constituent. All I am saying is, we are identifying the technologies. Where are we now? If you really believe—and you may have to clarify this because I wasn't sure. DOE, the program on the initiatives the Federal Government is taking, one, to ensure 90 percent capture of CO^2 from power plants to store 99 percent of the sequestered CO^2 for over 100 years and add no more than 10 percent to cost. That is the objective?

Mr. SHOPE. That is correct.

Mr. GONZALEZ. And you would like to have all that in place for adoption or as we adopt it by 2012?

Mr. SHOPE. That is correct. We want to have that portfolio available so that someone building a plant in 2012 would have those technologies available at those costs.

Mr. GONZALEZ. I am going to go back to where I started. In the interim, all the permitting, all the licensing, all the building really will not be meeting that goal. It may be somehow built in a way that it might accommodate it more easily but this is something truly that you won't have in place until 2012 for adoption prospectively?

Mr. SHOPE. That is correct. Now, I will state of course there is going to be incremental gains along the way. We are going to continue to gather the requisite data where the small-scale are going to be coming to completion. We are looking to expedite large-scale testing. All that information will then be available for people who are building these plants along the way.

Mr. GONZALEZ. And I do thank you, and I thank the panel that will follow you. Unfortunately, I will only be here for about 45 minutes of it. They may have some strong disagreement with the timetable and the manner in which the administration is attempting to accomplish this. But thank you all for your testimony today.

I yield back.

Mr. BOUCHER. Thank you, Mr. Gonzalez.

Mr. Walden from Oregon is now recognized for 8 minutes.

Mr. WALDEN. Thank you, Mr. Chairman. I appreciate that.

I know you all are looking principally at power plants and ways to reduce carbon emissions from power plant, but as I read through some of the literature, it appears there are other things that could be attempted and I wondered if either of your agencies are looking at things, especially involving America's forests or global forests. I know in my State, we had a fire a few year ago at the BMB complex, fire that the scientists now have estimated produced six times the level of carbon dioxide into the atmosphere as the entire State for that year, and there are other discussions about other facilities that emit carbon: cement production, rice paddies that produce methane. And then we have this whole issue of how this is a global problem with I think India and China planning to put 650 coal-fired plants online in the next few years that will emit more carbon that the entire Kyoto Accords combined hope to reduce. Can you address some of these issues?

Mr. SHOPE. Sure, I will take an initial stab at it. First you were talking about the forests. There are of course terrestrial sequestration as something we look at. It is a smaller part of our program yet it is an element. We have 11 terrestrial projects that are ongoing right now. The reason the majority of our focus is on carbon capture and storage from power plants is just because that is the biggest chunk that we have to focus our efforts on, and I will say that all the technologies we are developing in this area certainly are applicable to all the other segments of industry, not just for coal power. Now, that is where our focus is, particularly on the capture side of that. We are spending an inordinate amount of effort on those but even in the storage end of things, those will directly be applicable to CO^2 regardless of the source.

Mr. WALDEN. Mr. Wehrum?

Mr. WEHRUM. And if I may, Congressman, the administration has a wide variety of programs that address many of the issues that you described and I will just touch on a couple of them without trying to be comprehensive. For instance, energy efficiency is a key piece of our domestic energy security strategy and the Energy Star program that EPA and DOE jointly implement is a great example of how much success we can have by focusing on reducing the demand for energy in the first instance as a way of managing power generation.

Mr. WALDEN. Sure.

Mr. WEHRUM. Another good example, you mentioned methane and non-CO^2 greenhouse gases. We have very successful domestic methane programs focused on oil and gas production and distribution, agricultural emissions, coal mines and a wide variety of other sources and we in fact are trying to leverage the success that we have had domestically to an international partnership group where we hope similar opportunities can be found throughout the world.

Mr. WALDEN. Mr. Shope?

Mr. SHOPE. That reminded me as well, speaking of the international partnerships, to address your question about internationally. The United States is the Chair of the Carbon Sequestration Leadership Forum. That is something the Department of Energy helped to get moving and is actively participating in now. We have 21 countries plus the European Commission that meet on a regular basis to look at these technologies, look at carbon capture and storage issues associated with them to make sure that they are widely deployed throughout the world, not just here in the United States.

Mr. WALDEN. But I want to get back to this issue of forests because I think it is important, and I of course come from an area that has very productive forests, and global forests currently store just over half of the carbon residing in the terrestrial ecosystems. The total biosphere carbon pool is estimated at 2,190 petrograms. Of this, approximately 1,000 petrograms is in forests. It is roughly 50 percent more carbon that now resides in the atmospheric pool and about 20 to 25 percent of the carbon pool stored in the remaining accessible fossil fuels, and I guess the point is, as you read through some of the scientific literature, we are losing something on the order of 45 million acres of forests across the globe every year and yet forests seem to be one of the great carbon sinks we have, and I am just wondering why we are not focusing more on both forest health, fire prevention, managing for old-growth characteristics, the things that the scientists say will help remove carbon and produce oxygen in the atmosphere.

Mr. SHOPE. Again, Congressman, we are spending some effort on that and our regional partnerships also each have an element and particularly the ones that would cover your State are certainly probably looking at that heavier. I could get you more information on that. I would be happy to do that. Again, the problem with terrestrial sequestration though is in the long geologic scale of things, it is a temporary holding so that is why we are really focusing on the long-term permanent storage issues, the deep saline reservoirs and formations, because that is securing that carbon dioxide through eternity.

Mr. WALDEN. And I am not saying not to do that. Don't misread me at all. I am just saying it looks to me like as I read some of this literature there are some other opportunities out there that this Congress has addressed in some measure and not in others that could help reduce—I mean, if one forest fire in Oregon puts out six times the amount of carbon dioxide as the entire State's automobiles, manufacturing, you name it, for a year, it seems to me we could be doing a better job on that front.

Mr. SHIMKUS. Would the gentleman yield on your forestry question?

Mr. WALDEN. Sure.

Mr. SHIMKUS. Because you said temporary. Can you explain the temporary nature of terrestrial carbon sequestration?

Mr. SHOPE. We are talking over geologic time. The trees eventually are going to decay and rot and give off the CO^2.

Mr. SHIMKUS. And they give up what they have consumed, so you pay for it. The only reason why I mentioned this is, there is a big buzz now about zero carbon footprint. It is all the rage out in Hollywood. But they are not going to be there. First of all, their math is wrong. Secondly, that carbon will eventually get emitted.

Mr. WALDEN. And if I could reclaim my time. U.S. forests currently offset about 12 percent of annual U.S. greenhouse gas emissions from all sectors.

Mr. SHOPE. Absolutely. I am talking about geologic time as opposed to——

Mr. WALDEN. Sure. And of course now we are seeing as temperatures are rising in Alaska and elsewhere, some of these stored carbons are now starting to come to light literally as the permafrost melts and so some of what has been stored is now being released and it is a real push-pull relationship. And so it is just an issue I think we need to address.

The other question I want to get to, you mentioned this international organization you are involved in. Are China and India part of that?

Mr. SHOPE. Yes, China and India are both active member of the CSLF.

Mr. WALDEN. One of the disadvantages of being out in the west coast and on the Pacific Rim is the polluted air that is being generated in those countries comes right over us. There is another story today about it in the Oregonian. And I am just trying to figure out how come they get off apparently scot-free while a lot of us are trying to do the right thing for the environment. They are not under the Kyoto Accords, are they?

Mr. SHOPE. That is correct.

Mr. WALDEN. So we could in effect do incredible things here that we all do in the name of improving air quality, some of which we probably should continue to do, and meanwhile people who are competing against us economically are somehow free to go ahead and add carbon and other pollutants into the atmosphere and in effect even hurt the forest health in the Northwest. Is that right?

Mr. SHOPE. That is correct and that is certainly a concern when we talk about fuel switching in this country because even if the United States were to stop emitting, certainly the developing nations are going to continue to use those fossil fuels that are available to them.

Mr. WALDEN. So this is either a global issue or it is not.

Thank you, Mr. Chairman.

Mr. BOUCHER. Thank you, Mr. Walden.

Mr. Inslee for 8 minutes.

Mr. INSLEE. Thank you.

I didn't think it was possible but I think the administration has simultaneously spent way, way too little on carbon sequestration and way, way too much on carbon sequestration simultaneously, which is quite a feat, and the reason I say that is, is that this budget proposes to spend less than we spend in Iraq in 2 days on one of the largest national challenges we have in the entire U.S. economy which is to find a way to sequester carbon dioxide. You are spending about 379, we spent about 502 days in Iraq. This is not even close to cutting the mustard to this national challenge and I have to take issue with Mr. Barton. He said this is not a health impact. Tell it to the people who are getting infected by malaria with malaria increasing in Africa, moving up in elevation because of increasing exposure to these mosquitoes. People are dying today because of global warming. So we are not spending enough to get this job done but we are also spending way, way too much because your $379 million is a total waste of money because nobody is ever going to build one of these plants under your policies, because under your policies these plants can continue to put CO^2 up the stack for nothing. They don't have to pay a dollar to do it because you are against a cap and trade system. And even though you waste my taxpayer's money for $370 million and you actually developed this technology, it will never be deployed because there is no reason to do it as long as somebody can build a dirty plant and put the CO^2 up the stack.

Now, I just want to give you a chance to respond to that. Why would anyone ever spend money, the 10 percent for the CGCC and the 20 percent you project on pulverized coal, why would anybody ever spend that if the Bush administration policies of allowing pollution for free would continue?

Mr. SHOPE. Well, let me start by just suggesting that the technologies that we are talking about also bring efficiency along with them, that is, lower the cost. Aside from carbon capture and storage, they are lowering the cost of electricity. So I think that there is a market incentive to provide cost-efficient, effective electricity and I believe that if the technology is there, it will be used, it will be deployed.

Mr. INSLEE. So what you are telling me is that the only justification for your technology is to the extent that it can improve efficiencies? Is that what you are telling me?

Mr. SHOPE. No, I am telling you that the technologies that we are working on are going to lower the cost of carbon capture and storage and are going to increase the reliability of the technologies that will——

Mr. INSLEE. So what you are telling us if we do implement a cap and trade system, it will actually not cost the U.S. economy anything because you are going to develop efficiencies in the system and everything the President has been telling us, that a cap and trade system is going to wreck the U.S. economy, is a bunch of bunk? Is that what you are telling us?

Mr. SHOPE. No, that certainly is not what I am telling you.

Mr. INSLEE. Well, which horse do you want to ride?

Mr. SHOPE. I would like to ride the technology path forward.

Mr. INSLEE. Right, and I agree with that, and I agree with that horse which is not the one George Bush is riding right now. He is riding a horse that says we are too stupid to figure out how to sequester CO^2 in an economically efficient way so that if we do a cap and trade system, it will wreck the U.S. economy. Now, what you are telling me is, you agree with me that there is a good likelihood that we can sequester CO^2, have a cap and trade system, leave an environment for our kids and now wreck the U.S. economy. Is that what you are telling me?

Mr. SHOPE. No, I am suggesting that the technology path forward regardless of the emission-reduction strategy that you choose, whether it is cap and trade or regulation or whatever in a carbon-constrained world, whatever the mechanism that we follow to get to that emissions-reduction strategy is dependent upon technology.

Mr. INSLEE. And I am not going to let you off this hook this easy. I just heard you tell me that you were going to develop efficiencies that would reduce the cost of these plants so that they could do carbon sequestration using their efficiencies and not cost any more money. Now, if that is true, the principal objection of the President of the United States to a cap and trade system that is going to cost Americans all this money and everybody is going to go bankrupt is bunk. Now, do you agree with that?

Mr. SHOPE. No, I do not.

Mr. INSLEE. OK. Then apparently you agree that your previous statement that we are going to do this and increase efficiencies so there is no more cost is wrong. Is that what you are doing?

Mr. SHOPE. I never said there would be no more costs. I said we are going to increase the efficiencies which would increase the cost of electricity——

Mr. INSLEE. Now you are back to telling me that these plants are going to cost more money if we do this.

Mr. SHOPE. That is correct.

Mr. INSLEE. OK. And if they are going to cost more money, then my original statement is, nobody is ever going to do it unless we have a cap and trade system. Now you agree with that statement?

Mr. SHOPE. Again, my comment to you is that we need to follow the technology. We need to get the technology developed. We need to lower the cost of that technology. We need to increase the reliability of those technologies to make them available.

Mr. INSLEE. By the way, I don't hold you personally responsible for the President's position. I was sort of using your language to articulate my position.

I want to make sure we understand that when we are talking about carbon sequestration, we are not talking about a coal-to-liquids technology, and I want you to clarify that because a lot of people in Congress think that if we do a coal-to-liquids plant, to use liquid fuel, for instance, in cars or even in various turbines, that that is going to be net CO^2 neutral. I have been advised that although you can do some CO^2 removal in the process, when you eventually end up burning the liquid in a coal-to-liquid transformation, you then release CO^2 and you do not get any net CO^2 benefits except very marginal ones. Is that the case?

Mr. SHOPE. The technology for coal-to-liquids can be used. Gasification technology certainly can be used and that is the path forward that the administration is looking for.

Mr. INSLEE. Right. I want to make sure that we understand that the coal-to-liquid-fuel technology, not hydrogen, we are talking about some other non-hydrogen fuel, and people are talking about a massive increase in that industry in this country right now. That technology does not help us on CO^2 because when you burn the gas, the non-hydrogen gas, you then release essentially the same equivalent amount of CO^2 as you do from a gallon of gasoline. Isn't that the situation? And the reason I ask you this is I asked Governor Schweitzer about this last week and he agreed with me on this.

Mr. SHOPE. Yes. Again, we need to separate the two issues. That is correct. When you are creating, making the coal-to-liquid fuel, you can do that cleanly with gasification technologies. Once you have the fuel, it would be equivalent to petroleum products.

Mr. INSLEE. Now, the reason I point this out is, I think it is very important for Members of Congress to understand this fundamental distinction between a coal-to-hydrogen technology with sequestration, which we have been talking about this morning, which I believe has the capability of getting close to zero CO^2, and I believe research in this area is important and critical and I support it. But a secondary distinct technology, which is coal-to-liquid fuels, which somehow gets wrapped up in the first one, which is entirely separately, that second technology has benefits of energy independence but does not have any benefits on CO^2 emissions. Is that a fair statement?

Mr. SHOPE. No, I would disagree with that.

Mr. INSLEE. Well, let me rephrase my question to see if we can get one you agree on. Compared to burning gasoline, compared to going from a gasoline-based transportation sector, for instance, to a coal-to-liquid gasification process, according to the best research, which is a DoD study—I can't find any DOE studies on this but a DoD study indicated there is about 2 to 3 percent reduction in the cycle production CO^2. Is that your understanding?

Mr. SHOPE. What I know is that if you are producing the coal-to-liquid fuels and using gasification for it, you are going to be much—that is a very clean technology just as the technology we have been discussing this morning and cleaner than any of the emissions that are given off during a normal——

Mr. INSLEE. Well, I will try to send you the DoD study. Their conclusion was, no net benefit.

Thank you.

Mr. BOUCHER. Thank you very much, Mr. Inslee.

Mr. Hall for 5 minutes.

Mr. HALL. Mr. Chairman, thank you, and I thank you, Mr. Shope for mentioning the word "cost." That is a word they don't want to hear. That is the one thing that none of them that are pushing global warming now don't want to mention is cost and what is the cost that the world's greatest polluter, China, won't pay. What is the cost that Russia won't pay. What is the cost that Mexico won't pay, India won't pay. Those are necessary parts of solving all these major problems, and there is today is a major assault on energy all over this country, assault on fossil fuels, assault on coal and some of them are just trying to get some kind of an international award and I think, Mr. Shope, despite Mr. Markey's remarks that you are not helpful, I think what he really means is, you are not helpful to his testimony and I thank you for the testimony the three of you are giving.

I want to ask this question, something that involves my State. As I understand it, current permit practice as taken by States such as my State, these current permit practices classify carbon capture and geologic sequestration as class V experimental technology wells, right? Has the EPA taken any further actions regarding classifying such wells as a subclass of class II or even a new classification altogether?

Mr. GRUMBLES. Congressman, we have been working and I know in particular with State of Texas on a couple issues, the one you mentioned and also on the pass-the-salt initiative looking at ways of safe and acceptable ways to dispose of brine. We are looking at that. We also recognize that as we move forward with this new guidance under class V UIC program, a regulation under the Safe Drinking Water Act, that we want to work very closely with States and Texas in particular has shown leadership in using class II for enhanced oil recovery and also for a particular project under class V. So we are working with the State and I think we can learn a lot by working with all of the States on future regulatory approach to carbon sequestration using the UIC program.

Mr. HALL. And we thank you for that.

Does the EPA believe that the inclusion of non-enhanced oil recovery carbon capture and geologic sequestration wells under class I or class V of the UIC program would be appropriate?

Mr. GRUMBLES. I heard you say class I.

Mr. HALL. Yes. Would it be class II or would it be classified such as wells as a subclass of class II or as a new classification altogether?

Mr. GRUMBLES. Well, we certainly want to take that very seriously. I don't have a specific answer to you other than to say that as we are issuing this guidance on the use of class V, we also want to work with the States on class II enhanced oil recovery. Congressman, we intend to have a process that involves the public and the States to help us decide what is the best long-term management strategy to help us move from the pilot stage of these carbon sequestration projects to longer-term potential commercial application and I think the point you are making about looking at different types of classes under the UIC program is very important to keep our eyes open to regulatory flexibility.

Mr. HALL. And you do these through partnering with industry and the carbon sequestration program?

Mr. GRUMBLES. Yes, sir.

Mr. HALL. Who are some of the major partners for the record?

Mr. GRUMBLES. The first partner that I think of is the partner that EPA has a memorandum of agreement with, and that is the Interstate Oil and Gas Compact Commission, the associations, the agencies that regulate oil and gas but also some of the different industries as well as industry trade associations, Edison Electric, also the Groundwater Protection Council and also important partner are the non-governmental organizations including the environmental organizations.

Mr. HALL. What is the current status of the FutureGen project and when do you anticipate it might break ground?

Mr. SHOPE. Congressman, the FutureGen project is on path on our projected schedule. We are working on the NEPA requirements right now. We hope to issue the Record of Decision this summer. We are looking forward to site selection this fall and moving forward with construction would begin in approximately 2009 after we finalize all the site selection and characterization and permitting work that is associated with it.

Mr. HALL. I thank you.

I yield back my time.

Mr. BOUCHER. Thank you very much, Mr. Hall.

The Chair will recognize Mr. Doyle for 5 minutes.

Mr. DOYLE. Thank you, Mr. Chairman.

Mr. Shope, the President's budget request for 2008 is seeking to take $257 million from the clean coal technology account and place $108 million of those funds into this pie-in-the-sky FutureGen program. In fact this concept program is being funded at the expense of clean coal power initiatives and core fossil energy and R&D programs. Unlike the concept of FutureGen, these programs have the very real potential for making a major impact in the near term as well as the long term. At best, FutureGen is a high-risk initiative that is still years away from becoming a reality. If it becomes a reality at all, it will require continued appropriations from Congress as well as a real commitment from industry, a commitment that I believe is far from present today. By providing $108 million for FutureGen and canceling the remaining $149 million in the clean coal account, the administration is also reneging on previous commitments to existing clean coal power initiative projects and jeopardizing their success. This robbing Peter to pay Paul mentality that we have seen in this administration and this Department has got to stop. It isn't even so much that I am against FutureGen. What bothers me is that we steal money from accounts that have the potential to benefit us right now today and see deployment. We take the money right as we are getting close to deploying these new technologies and we shift that money into a project that is years and years down the road that we don't even know is going to happen.

I think you answered the question I was going to ask, and that is in a perfect world where money wasn't the culprit and you could fund FutureGen but not by stealing the money off of the clean coal power initiative programs, what could you do and how could we have deployment sooner if money weren't the issue and you weren't shifting these funds like you do every year?

Mr. SHOPE. Well, let me address first the pie-in-the-sky nature of FutureGen, which I would flatly reject. I think FutureGen is a very promising technology. There is plenty of industry support to go along with that. There is international support to go along with that. We have 12 alliance partners on the private side that are providing substantial dollars for the project.

Mr. DOYLE. If that is the case, why not fund it then? Why are you taking money out of the clean coal technology programs to fund it?

Mr. SHORE. The clean coal technology programs, any of the projects that were issued under the clean coal technology program are still ongoing. They have been funded. The remaining balance that is unused under that technology program has been moved forward to support our clean coal power initiative. Those are the same types of projects that we are talking about that are more in the near term that would lead up to the FutureGen project as well as FutureGen. It is again a technology path forward so we are looking at all the different time frames along the way. But those dollars are being used for clean coal research, and again, the President has made good on his promise to put in $2 billion over 10 years. We have delivered on that promise early and have used——

Mr. DOYLE. You are taking money out of programs that are—I will give you an example. Right in eastern Pennsylvania, the WMPI project, you almost pulled the plug on that. We had Secretary Bodman here a couple weeks ago and——

Mr. SHOPE. That project was awarded under the CCPI program.

Mr. DOYLE. Yes, and then you pulled the plug on it, $100 million interest-free loan which you pulled the plug on until we made an issue of it just 2 weeks ago and now it has been re-examined and I understand the money has been restored. The situation that we have in the Department where money and clean coal technology programs are always the—you know, those are the monies that get taken first and put into these projects that are down the road. It is important if FutureGen is the technology down the road and I believe it can be, then we should be funding both of them. We shouldn't be stealing money from one program to fund these programs that are further down the road. There should be a commitment on this administration to say this is important to America and this is important to our future and we ought to put our money where our mouth is, and our complaint isn't so much the programs, is this constant robbing Peter to pay Paul that goes on. I know that is not your call in your Department. That is above your pay grade. But it is frustrating to hear people say how important this is to our country and then when it comes time to put our money where our mouth is, we don't fund the projects.

I want to ask you another question. I understand that DOE is currently planning on conducting 25 field validation tests under its regional carbon sequestration partnership program. What if instead of doing that, large-volume tests like the type we really need to test this process were conducted in the seven regions involved in the partnerships? Would the validation test still be needed, and how will these projects help us understand sequestration in our country, and finally, will the NETL continue to have the lead in conducting these partnerships?

Mr. SHOPE. Yes.

Mr. DOYLE. An answer I enjoy hearing.

Mr. SHOPE. We need to walk before we can run, and that is why these geologic tests are so vitally important to us. The 25 tests are important. We are going to gain important information from those tests, the validation of the modeling, again what happens to the

CO^2 once it is put into the ground, what happens under different geologic formations and that is why the real attractiveness of the regional partnership because it is going to be looking out throughout the United States including into Canada, what are our best potential for these larger-type sites. Once we have that information, then we will lead right into the larger-scale tests. In our 2008 budget, I think you probably have seen in there that we looking to expedite those large-scale tests. We want to get to them as much as anyone does but we want to do it in the right way. So are looking for in 2008 to start using dollars to lay the groundwork for those larger-scale tests.

Mr. DOYLE. And NETL will have the lead on that?

Mr. SHOPE. Yes. NETL has the cooperative agreements, holds the cooperative agreements with the regional partnerships, and we are very proud of that fact.

Mr. DOYLE. Thank you, Mr. Shope.

Mr. BOUCHER. Mr. Shimkus is recognized for 8 minutes.

Mr. SHIMKUS. Thank you, Mr. Chairman. What is going to be fun is watching the Democrats give a consistent position on this because here they are saying go faster, faster than technologically available because that is what FutureGen is about is to prove sequestration. That is what this hearing is about. But then on Yucca Mountain they say oh, go slow, we need more time. We can't have it both ways. This is a very frustrating hearing for many of us.

And I have to respond on the coal-to-liquid issues. I think Honda did a study in 2004 which says when you change from gas to diesel, there is a 30 percent reduction in carbon dioxide.

And the other part of this debate is they would rather burn Arab carbons or Venezuelan carbons than U.S. carbons. I mean, that is kind of the premise of the debate. We are a carbon-based economy and so the coal-to-liquid application, which is what—I don't want to speak for the chairman but I do on this—that we are going to be pushing for is energy independence, cleaner, and also in particulate matter. So I hope we get some consistency across the board we move this issue. And it is very important because we do think we can sequester carbon, having FutureGen as successful, which I believe it will be, and then on the coal-to-liquid applications, then we can sequester the carbon in the coal-to-liquid production. So I am very excited about what the administration has been doing. You don't get enough credit.

The President announced FutureGen in 2005 long before the change in Congress, long before—he keeps getting beat up on this global warming thing which Chairman Barton has issues with but FutureGen is designed to start addressing that, not just within the United States but it is a consortium. It addresses the for-profit entities because they are part of the FutureGen. They have buy-in. It addresses the international debate because you have foreign countries involved in FutureGen, and so if FutureGen is successful, it can then he shared to our competitors in India, to our competitors in China, to other countries that want to use the same, addressing an international concern, and if it is an international concern, that is why FutureGen has to continue and move forward. The funding issue, my understanding, the funding issue is primarily projects that have been completed or projects that no longer have an application. Yes, it is true. We want our cake and we want to eat it too. We want to go to zero carbon emissions but we still want low-cost power. Even in your evaluation, and I am glad you didn't take the bait on a lot of my colleagues, we are still saying a 10 percent increase by 2012 or maybe a 20 percent increase. There is still going to be an increase in moving in this direction. So let us talk about the manufacturing base. Let us talk about jobs. If you have a foreign country that is not complying with these standards and having low-cost power, you just give them another reason to move overseas. Low-cost power is a critical component in this whole debate, and that is why it is important for us to continue to address this.

Let me ask a question on FutureGen. FutureGen will sequester—and that is the reason why we have it—that is to permanently store in geological terms, which we talked about, a large portion of carbon dioxide emitted from the demonstration project. Could you describe for the committee the various technological uncertainties and the costs currently associated with the sequestration of carbon dioxide?

Mr. SHOPE. Costs associated with the capture technology, the additional costs that are in there, again, we have to prove out the technology that we have today with increasing our turbines, costs associated with hydrogen membranes and developing the efficiency way of handling the gas streams that are involved within gasification and improving the technology along those lines from the capture standpoint, increasing our efficiency of those. On the storage end of things, we have to again examine what kind of measuring and monitoring and verification technology is available, enhance those tools that are available to us, take a good look at what will happen to the CO^2 once it gets into the ground, the element of permanence, the element of seepage, where the CO^2 could migrate to once it is underground. All these different elements have to be—we have to progress along the path in order to pull them all together for our FutureGen project.

Mr. SHIMKUS. You said carbon dioxide was stored as in essence a liquid. Natural gas, does that turn in a liquid also at those levels?

Mr. SHOPE. Under those pressures, then it would be in liquid formation.

Mr. SHIMKUS. Because we obviously store natural gas in this country. We have done so for decades. If some type of regulatory program to govern carbon dioxide emissions is enacted, is there needed a uniform Federal program to govern carbon dioxide sequestration or could this be addressed by each State?

Mr. GRUMBLES. Congressman, from an EPA perspective, and I am speaking on behalf of the water program, when we look at the carbon sequestration, right now where we are is that we have made the determination that the Safe Drinking Water Act provides regulatory framework based on what we know in using the Underground Injection Control program, and we think that the guidance that we are issuing will be extremely helpful in learning, providing information and also having the regulatory flexibility for States who are our partners in the UIC program to learn more and develop more information about these promising but unproven technologies. So we will see as we have workshops and have public and scientific input on the longer-term future of the control program but we think the framework under the Safe Drinking Water Act is a good one.

Mr. SHIMKUS. I like the way you said that: promising but unproven. So it is important for us to make sure it is proven before we mandate, and that is FutureGen. That is why we have it.

With that, my time is close to expiring. I can't get in another question. I will yield back.

Mr. BOUCHER. Thank you very much, Mr. Shimkus.

The gentlewoman from California, Ms. Harman, for 5 minutes.

Ms. HARMAN. I hail from Los Angeles where a little movie starring Vice President Al Gore just won an Oscar, and a lot of attention is now being paid to "An Inconvenient Truth." I just would observe that the answers to an inconvenient truth are also inconvenient and we need to face up to that, and that is why I applaud you, Mr. Chairman, for holding this hearing on carbon capture and sequestration because I do think that coal is a big part of the answer and we have to face up to it and we have to understand what is good, what is bad, where we can push technology, what the environmental impacts are, et cetera. But I think we are going to have to move on carbon capture and sequestration of coal. We are going to have to do it. As inconvenient as it may be, as expensive as it may be, we are going to have to do it. So hopefully this committee, which does have the right jurisdiction, will learn a lot about this, and obviously some Members know a lot more about this than I do, and we will figure out the right path forward together, at least I hope and would believe we would.

I just want to focus on a few real-life examples because maybe we can sort of come down to Earth and see how we are doing. I do know that in the next panel, which I am probably going to have to miss, we are going to hear about a coal gasification plant with carbon capture technology which is being designed for construction in Carson, California, which is just outside my Congressional district, and I would like to know more about it. If any of you know about that, please speak up.

But what about the Wayburn project? That is something you all know about. Why don't you just assess it? How is it going? What problems have you encountered in construction and operation and what is the promise of the Wayburn project?

Mr. SHOPE. Well, the Wayburn project is an enhanced oil recovery—basically an enhanced oil recovery project where in North Dakota, lignite is being gasified and the CO^2 is being captured and shipped approximately 200 miles into Canada to be displaced into the Wayburn field to enhance oil recovery. Again, as I mentioned in my opening remarks, enhanced oil recovery has been going on for some time. However, the goals are somewhat different. In enhanced oil recovery, the main goal is to get additional oil out of the ground. The focus is not placed on permanence of the CO^2 underground. So that being said, Wayburn presents us with an excellent opportunity to take a look at a field where they are putting in approximately a million tons a year of CO^2 into these formations and we can use that for testing, for monitoring, measuring and verification. We are involved with that, that is, the Department of Energy is involved with that project in the sense of looking at some tools and techniques that we can use to measure and monitor the CO^2 underground so it provides an excellent opportunity for laboratory essentially.

Ms. HARMAN. And what are we learning? And I would welcome the EPA witnesses commenting on this too. And if you know anything about the Carson design and construction project in my last minute and 16 seconds, I would welcome your answer.

Mr. SHOPE. Again, preliminarily from the Wayburn project—I will just address that and pass it on—there are very optimistic signs that CO^2 can be stored permanently underground, and that is a very optimistic sign.

Mr. WEHRUM. I would just say I think our colleague from the Department of Energy adequately addressed Wayburn. We have caucused very quietly here. We are not familiar with the Carson project but we will be more than happy to answer questions on the record further with regard to that project.

Ms. HARMAN. Well, I will appreciate that, and I know that the next panel of witnesses is more familiar but it is a collaboration between General Electric and BP and it is being built in southern California where there are a lot of cars and a huge demand for fuel.

I think it may have some good lessons for us.

Mr. SHOPE. Yes, they are producing CO^2 for other applications. Again, a little bit of a change of focus than what we were talking about as far as FutureGen where our main focus is to make electricity along with hydrogen and their focus is producing CO^2 for other purposes. So while there are certainly synergies, there are differences as well.

Ms. HARMAN. But there will be sequestration, so I would welcome answers for the record, and if I have to miss the second panel, I will try to catch up with it.

I thank you, Mr. Chairman, for exploring all of these issues, however inconvenient the answers may be. Thank you.

Mr. BOUCHER. Thank you, Ms. Harman.

Mr. Sullivan for 5 minutes.

Mr. SULLIVAN. Thank you, Mr. Chairman. I appreciate everyone on the panel for being here today.

Also, we are talking about a lot of complex environmental issues. The Democratic leadership and Speaker Nancy Pelosi says they want to get something done by I believe June. I would like to ask each of you, do you think we can address all these concerns adequately by June and address these complicated issues by June?

Mr. WEHRUM. I will just start by saying, I think as you well know, the administration's position is that mandatory measures are not appropriate at this time. We do believe, in response to many of the comments that have been made today, that we have an aggressive and a coherent strategy for dealing with the issues as we see them today that involves significant investment in basic research, significant investment in technology development, which is most of what we have talked about today. We are very, very active on the international front in a wide variety of forums and we are taking prudent actions domestically against the President's goal of an 18 percent reduction in greenhouse gas intensity. So I believe the administration has a very focused and effective policy in place and we are happy to have the opportunity to talk about it today.

Mr. SULLIVAN. What do you think, sir? Do you think June we can get it all done by then?

Mr. SHOPE. I will agree with Mr. Wehrum's comments and leave it at that. From a technology standpoint, there are a lot of issues that are yet to be addressed and that is why we are again focusing our efforts on a technology basis.

Mr. SULLIVAN. It would be difficult, wouldn't it?

Mr. SHOPE. It would be difficult.

Mr. SULLIVAN. And sir, I am sorry, I can't see very well.

Mr. GRUMBLES. I would agree with Mr. Wehrum. What we are committed to within EPA is laying out a roadmap that involves science and public sector and the regulated community and the State groundwater protection officials and oil and gas regulators and identifying the most promising technologies and learning more and continuing to be committed to advancing carbon sequestration in particular and ensuring that it protects underground sources of drinking water and also helps make significant progress in confronting serious challenges in the environment.

Mr. SULLIVAN. I appreciate those approaches, working through it, and it does take time, I know.

I guess, Mr. Grumbles, this will be directed to you or anyone else that wants to add anything, but in 2006, it started in 2006, a project, I can't pronounce the project name but in Norway's North Sea is the world's first commercial deep saline carbon dioxide capture and storage project. What have we learned from this, if you know? Have Government subsidies been involved in this project, and what would it take to become economic?

Mr. GRUMBLES. I think locally and globally we are all learning more and doing more to confront the serious challenge of global climate change. I know a lot of research, international research is being carried out. I know of the Norwegian North Sea research and development project. They have operated a geologic sequestration project successfully for over 10 years, injecting millions of tons of CO^2 deep in formations beneath the North Sea. The volumes though are still small, relatively small compared to what we can expect with full-scale implementation of geosequestration activities in the U.S. so I think the point for us is that we are all still very much on the learning curve internationally and domestically but we are optimistic just as the Intergovernmental Panel on Climate Changed recognized. We are optimistic about the technologies this approach of geosequestration compared to risks of other activities. We think the risks are not great but of course, we are committed to analyzing that risk and also the potential and promising technologies to manage geosequestration.

Mr. SULLIVAN. I agree, we are on a learning curve, that is good, but it does show great promise, wouldn't you agree?

Mr. GRUMBLES. I would.

Mr. SULLIVAN. Also, sir, can you explain how the EPA's 30 years of regulatory experience with the UIC program correlates with the States 30 years of regulating injection of CO^2 in the subsurface for enhanced oil recovery? For instance, does EPA have any expertise regulating the disposal of acid gas or the storage of natural gas in the subsurface?

Mr. GRUMBLES. Thank you, Congressman. I would say that the States, as you noted, have decades of experience with permitting the class II enhanced oil recovery wells. I think one of the areas where EPA can really step in and help though is when you recognize that no State currently has experience with long-term large-volume storage of CO^2, for example, commercial sale geosequestration in the U.S., and because those activities are significantly different with respect to the risks they present to underground sources of drinking water and public health, we believe that a combined approach, a Federal and State approach, working together using the regulatory tools under the Safe Drinking Water Act is the way to go and it will be essential in developing a cogent management framework for the long-term success of these promising but unproven technologies.

Mr. SULLIVAN. I think that is good, a combined approach but don't you think there are some States that have greater expertise and experience in this than the EPA? Wouldn't you agree with that?

Mr. GRUMBLES. I would agree, for instance, we embrace the fact that the States, 34, 35 States are the primary implementers of the Underground Injection Control program under the Safe Drinking Water Act. They do so under the national standards that EPA sets so definitely there is opportunity for continued State leadership but we think it is very important from an EPA perspective to lay out an overall framework to help manage this area.

Mr. BOUCHER. The gentleman's time has expired.

Mr. Wynn from Maryland for 5 minutes.

Mr. WYNN. Thank you, Mr. Chairman.

Mr. Grumbles, you confirmed that EPA has authority under the Safe Drinking Water Act Underground Injection Control program over the injection of CO^2. Is that correct?

Mr. GRUMBLES. Yes.

Mr. WYNN. Now, have you developed a regulatory concept with respect to how the Federal Government would regulate this injection to protect our consumers?

Mr. GRUMBLES. Thank you, and that is the key question, and the answer is, yes, we are working on an overall management framework. The first and more critical step that Mr. Wehrum and I described was that the two offices, the Air Office and the Water Office, working together are issuing guidance to help oversee and maintain the success and safety for pilot projects, experimental projects under the class V Safe Drinking Water Act UIC program.

Mr. WYNN. This guidance, does that rise to the level of absolute regulations or are these——

Mr. GRUMBLES. It is guidance to the regulators using their authorities under the Safe Drinking Water Act so it is a regulatory framework. The goal though for anything that is experimental and early in terms of the promising but not yet proven technology stage is to provide some flexibility for the regulators to experiment and see what works on a small scale. We are committed to that.

Mr. WYNN. All right. Thank you. You said that you favored a combined regulatory approach between the States and the Federal Government. How does that work?

Mr. GRUMBLES. Our success over the years with the Underground Injection Control program of the Safe Drinking Water Act is that it works by EPA issuing overall guidance and regulatory framework and then having a process where States meet certain criteria and then are delegated the authority to run the program.

Mr. WYNN. So EPA would set the minimum standards for the State? Is that basically the bottom line?

Mr. GRUMBLES. We would set the basic standards under the Safe Drinking Water Act.

Mr. WYNN. OK. Now, has there been any study of whether any other contaminants might travel with the CO^2 as it is injected?

Mr. GRUMBLES. Well, I know that there is a lot of research that is going on about the potential risks of CO^2. I think one of the things that was important to me was that when the Intergovernmental Panel on Climate Change looked at the issue, the potential for carbon sequestration, geosequestration, they concluded that carbon sequestration offered minimal risk, that we all need to learn more about the potential for——

Mr. WYNN. Minimal risk to drinking water specifically?

Mr. GRUMBLES. That is correct. While everyone agrees further research is needed but the basic statement was is that they estimate CO^2 could be trapped for millions of years and that formations are likely to retain over 99 percent of the injected carbon dioxide over 1,000 years.

Mr. WYNN. But the length of actual testing is only about 2 years? The longest we have actually tested this injection process in terms of the possibility of leaking is only 2 years, right?

Mr. GRUMBLES. Well, it underscores the point that——

Mr. WYNN. Well, is that true? We have only tested for 2 years?

Mr. GRUMBLES. Well, I am not sure what the 2-year——

Mr. WYNN. Well, it says that this North Sea project has been in operation since 2005. Is there a test or an example that is longer than two——

Mr. GRUMBLES. The North Sea example, my information indicates 1996, over 10 years they have been successfully——

Mr. WYNN. Ten years?

Mr. SHOPE. Yes, or 11 years. We have been following it for about 5 years but they have been injecting for about 11 years.

Mr. BARTON. Will the gentleman yield?

Mr. WYNN. Yes.

Mr. BARTON. I don't know what kind of test you are talking about but they have been injecting CO^2 for enhanced oil recovery for decades. I don't know that that is under the kind of the conditions the gentleman from Maryland wants to allude to in terms of specific tests but it has been done for decades in Texas, Colorado and New Mexico, I know.

Mr. WYNN. Thank you.

I yield back the balance of my time.

Mr. BOUCHER. The Chair thanks the gentleman and recognizes Mr. Whitfield for 5 minutes.

Mr. WHITFIELD. Thank you very much, Mr. Chairman, and thank you all for being with us today. I think it goes without saying that coal is going to by necessary continue to play a major role in the production of electricity in this country and today I guess it is producing around 52 percent of all the electricity we use in our country, and I think Mr. Shimkus pointed out an important point, and that is that with China and India and a lot of other developing countries continuing to build coal-fired plants and for the U.S. to start penalizing itself for doing that, making us less competitive in the worldwide economy is something that many of us will find unacceptable. So all of us are quite excited about the FutureGen process, Mr. Shope, and just for clarification, of course, it is a production of emission-free coal, sequester all the CO^2 and produce hydrogen, and it is my understanding that in the U.S. now, sites have been reduced to four. Is that correct?

Mr. SHOPE. That is correct.

Mr. WHITFIELD. And when do you anticipate a final decision will be made on a site?

Mr. SHOPE. We are undergoing the NEPA process right now and we hope to have that Record of Decision out this summer. That would lead us to making site selection this fall.

Mr. WHITFIELD. And how many other countries are involved with the private sector in exploring the FutureGen possibility?

Mr. SHOPE. The FutureGen, it is set up in a private alliance. There are the 12 companies that I mentioned previously. They are actually operating the FutureGen facility. The counties are involved in what is called the Government Steering Committee. Right now we have commitments from India that has already made contributions to the Government Steering Committee. The governments of South Korea, China and Japan have also expressed interest as well as some other governments that we are currently working with.

Mr. WHITFIELD. And do you anticipate that a FutureGen project would ever be constructed in those countries?

Mr. SHOPE. Well, that would certainly be the hope at the end of the day. That is why we are doing FutureGen, to get this technology out and in place, not just here in the U.S. but around the world so that again their global emissions are taken care of.

Mr. WHITFIELD. But in your discussions with them, are you finding them really engaged in this, the other countries, or is it——

Mr. SHOPE. Absolutely. This is not just a commitment. This is a financial commitment on behalf of these governments, $10 million from each government just to be a part of the Government Steering Committee. That doesn't put them into the private FutureGen alliance that is actually operating the plant so they are paying $10 million just to be a part of the effort and to obtain as much information as they can and share with us, to have a front-row seat to the entire project. So yes, there is certainly significant interest.

Mr. WHITFIELD. And Mr. Wehrum, you referred to the Supreme Court case on whether or not the EPA had authority to regulate CO^2 emissions under the Clean Air Act. Is that correct?

Mr. WEHRUM. That is correct.

Mr. WHITFIELD. When do you anticipate that decision will be made?

Mr. WEHRUM. The issues were briefed up late last year. Oral argument has already occurred and we are waiting for a decision from the court.

Mr. WHITFIELD. Now, if you were in the rotary club in Hopkinsville, how would you explain for a layman the decision of the Federal Court of Appeals on that issue?

Mr. WEHRUM. Well, the DC circuit upheld our determination and each of the judges on the panel expressed a bit of a different view with one dissent of course but voted to uphold our decision. So our determination was based on a careful reading of the Clean Air Act and consideration of the relevant policy issues and our ultimate conclusion was, we don't believe we have authority under the Clean Air Act to regulate CO^2 for its impact on global climate change.

Mr. WHITFIELD. So it is your position that it would require legislation for you to be given authority to regulate CO^2 emissions, correct?

Mr. WEHRUM. That is correct.

Mr. WHITFIELD. Now, are any of you on the panel aware, of all the CO^2 emissions throughout the world today, what percent of those emissions are manmade?

Mr. GRUMBLES. We would be happy to dig into it and get back to you on the record. I don't have that information in front of me right now.

Mr. WEHRUM. Just to hazard a guess, about 3 percent.

Mr. WHITFIELD. Three percent?

Mr. WEHRUM. But we would put something on the record for you to give you more——

Mr. WHITFIELD. Well, I mean, I heard anywhere from 2 to 5 percent, so of all the CO^2 emissions that we are talking about, only a minute part is manmade, correct?

Mr. SHOPE. That is correct.

Mr. WHITFIELD. Thank you, Mr. Chairman.

Mr. BOUCHER. The Chair thanks the gentleman and recognizes the gentleman from Illinois, Mr. Hastert, for a motion.

Mr. HASTERT. Mr. Chairman, I move that all Members have 5 business days to submit written questions and ask that the panel would respond to those.

Mr. BOUCHER. Without objection, so ordered.

I want to say thank you to this panel of witnesses for your presence here today and for your answers to what have been probing questions from the members of this subcommittee to you. The information you have provided will be very helpful. There will be follow-up questions sent to you. I have some. I know that other Members do. And your attention to those and your timely response would also be appreciated.

So with that, we will dismiss this panel and welcome to the table the second panel of witnesses for this afternoon.

Our next panel has seven witnesses beginning with Mr. John Fees, who is the chief executive officer of the Babcock and Wilcox Company. Mr. David Hawkins is the director of the Climate Center for the National Resources Defense Council. Following Mr. Hawkins will be Mr. Edward Lowe, who is the general manager for Gasification Market Development for the General Electric Company. Dr. S. Julio Friedmann from the Carbon Management Program at the Lawrence Livermore National Laboratory. We have Mr. Mark Schoenfield, the senior vice president and general counsel for Jupiter Oxygen Corporation. Mr. Stu Dalton represents the Electric Power Research Institute on today's panel. And finally, we will hear from Mr. Jay Stewart, an attorney with the firm of Hance Scarborough Wright Woodward and Weisbart in Austin, Texas.

The prepared written statements of all of the witnesses will be made a part of the record and we will welcome your oral summary and we would ask that you keep your oral summary to approximately 5 minutes.

Mr. Fees, we will be happy to begin with you.

STATEMENT OF JOHN A. FEES, CEO, THE BABCOCK & WILCOX COMPANY, LYNCHBURG, VA

Mr. FEES. Thank you, Mr. Chairman, Mr. Hastert and members of the subcommittee, my name is John Fees and I am the chief executive officer of the Babcock and Wilcox Companies which employs over 20,000 people working on advanced energy solutions worldwide. I have a degree in industrial engineering and operations research from the University of Pittsburgh and a master's of engineering from George Washington University.

Mr. Chairman, it is a particular pleasure to come before you representing the Babcock and Wilcox Companies with our headquarters in Southwest Virginia, Lynchburg specifically, where we employ nearly 2,500 employees and where my wife, Jill, and I have made our home for the last 28 years.

Congressman Hastert, the Babcock and Wilcox Company also has the privilege of working with the University of Chicago at the Argonne National Lab as we develop advanced nuclear technologies for the future.

Today, however, I am here to testify before you on combustion-based technology alternatives available to limit carbon dioxide emissions from electrical power plants. I am also here to ask Congress to ensure that any draft legislation on carbon capture promotes achievable solutions, allows the market to select technologies through competition and to set standards that will allow the emergence of improved technologies.

B&W has a long history of providing technology solutions for efficient base load electrical generation throughout the United States and North America and around the globe. Babcock and Wilcox was founded in 1867 and the first utility plant in the United States had a boiler designed and supplied by B&W. B&W has literally written the book on steam, which is here, "Steam, Its Generation and Use for Power Generation." This is the longest continually published engineering textbook of its kind in the world, first published in 1875. In the 1950's, B&W became a major supplier of components for the Navy's fleet of nuclear-powered ships and submarines and we are the only United States manufacturer of the heavy components required for the emerging civilian nuclear power renaissance.

B&W understands that we must provide realistic solutions to the climate challenge on a timely basis, and we are doing just that. Coal-fired and nuclear power plants provide over two-thirds of all domestic-generated electricity and they are the foundation for our economic competitiveness, our energy security and a basis of our standard of living. With coal, B&W has been an environmental technology leader at the forefront of developing solutions for mercury, SOx and NOx emissions and particulates.

In power generation, B&W has recently been awarded a number of new highly efficient supercritical coal-fired power plant projects in the United States and the first ultra-supercritical coal-fired power plant in the United States in many decades. These plants with their higher efficiencies enable the production of electricity at lower carbon intensity than older subcritical plants and ongoing efforts will deliver even higher performance in the future.

B&W is also working on an array of potentially significant breakthroughs for carbon-friendly technologies. Some of these technologies could dramatically lower the cost of carbon capture and storage.

B&W is working to commercialize oxy-coal combustion technology that inherently produces carbon dioxide with no needs for a separate capture technology. Oxygen combustion produces a concentrated stream of carbon dioxide that is ready for enhanced oil recovery or geological storage. We expect to deploy this technology as the first commercial-scale near-zero-emission coal-fired plant with carbon storage in North America, and let me repeat that. It is the first commercial-scale, near-zero-emission coal plant with carbon storage in North America and we are confident that oxy-combustion technology can provide the most cost-effective solution for many new power plants and for retrofitting some existing fossil-fired plants. The first wave of near-zero-emission coal plants will start operation around 2012 and improvements will inevitably follow and oxy-coal will be among the first of these first-wave projects.

There is a building consensus that Congress should establish practical emission targets and that CO^2 reduction will be most effective if there are a portfolio of technologies. Congress should establish targets within the industry grasp and permit the market forces to work here.

We believe that regulatory and technological obstacles to the long-term storage of carbon dioxide for electrical power plants could be the limiting factor in reducing carbon emissions. Legislation therefore should support the acceleration of R&D associated with carbon storage, clear policies regarding the legal ownership and liability of the injected CO^2, and overcoming local concerns with large annual injections at storage sites.

I thank you for the privilege to testify before the subcommittee, and I have also provided a written statement and ask that it be included in the record. Thank you.

[The prepared statement of Mr. Fees appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you very much, Mr. Fees. We appreciate your testimony today, and also let me acknowledge how much we appreciate your presence in the western part of Virginia, not my congressional district but close enough. We are glad to have you here.

Mr. Hawkins.

STATEMENT OF DAVID G. HAWKINS, DIRECTOR, CLIMATE CENTER, NATURAL RESOURCES DEFENSE COUNCIL, WASHINGTON, DC

Mr. HAWKINS. Thank you, Mr. Chairman.

Four years ago, I testified in this room before this committee under then-Chairman Barton on the same topic and a lot has happened in the last 4 years, not as much as needs to happen but a lot has happened. First, we have an increasing awareness of the urgency to act on global warming. Second, we have a lot more knowledge about CO^2 capture and disposal from coal-fired power plants. And third, the growth rate in new coal plants in the pipeline in the U.S. and globally has increased dramatically, and that is because coal is very abundant. Right now coal plants are being built somewhere in the world about ten large coal plants every month. Unfortunately, those ten coal plants are not equipped to capture their CO^2, and to make coal use and climate protection compatible, we have to begin to capture CO^2 for geologic disposal at new coal plants without further delay.

Some of the statistics are pretty startling. The new coal plants that are forecast to be built just in the next 25 years, if they are not equipped with CO^2 capture systems, will emit about 750 billion tons of CO^2 during their operating life. That is about 30 percent more CO^2 than had been released from all previous human use of coal just from a 25-year period of investments. If we don't apply CO^2 capture and disposal to these coal plants, we are going to make protesting the climate very much more expensive, if not impossible.

The good news is, we know enough today about how CO^2 capture and disposal works in order to be able to apply it right now to plants that are being designed. Capture systems have been demonstrated at commercial scale for some coal processes and others are being developed, as Mr. Fees just testified. Experts appointed from our Government and others under the Intergovernmental Panel on Climate Change have conclude that based on existing experience, disposal operations can be conducted safely if we have an effective regulatory regime. That effective regulatory regime we believe should be carried out by EPA and we believe that if this committee presses on EPA to get the job done, it can be done quite quickly.

Experts have also concluded that we can have confidence that if we properly select and operate a disposal site, that the CO^2 that we put there will stay there. Storage capacity in the United States and globally is very substantial, likely enough to be able to accommodate all of the CO^2 from 100 to 200 years worth of global fossil power operation, depending on just how much fossil fuel we burn over the next 100 years or so. But policies to limit CO^2 emissions and set performance standards are the key here. They are essential to promote a market reason to actually use CO^2 capture and disposal technologies at the required scale and pace. Those policies we believe can and should be enacted in this Congress. Well-designed measures can phase in CO^2 capture and disposal on new coal plants with only very modest impacts on retail electricity prices.

One approach I discuss in my testimony is a low-carbon-generation obligation that would phase in a very small fraction of kilowatt hours initially from coal resources that would be equipped with CO^2 capture and storage in order to meet a performance standard without specifying a particular technology. Combined with a cap and trade program, such an approach could result in quite rapid deployment of carbon capture and disposal and provide new American technology leadership while dramatically cutting emissions.

So I would say that my key message here is that we really have to avoid building new coal plants without CO^2 capture and disposal. There is no reason to delay that. There is no reason to build additional capacity without applying those techniques. We know how to do it. Cost reductions are going to be driven by learning from commercial experience. They are not going to be driven by R&D expenditures by the Federal Government.

Finally, I just would say in closing that CO^2 capture and disposal is an important tool but it is one of several tools available to cut global warming emissions. The fastest and cheapest method to attack global warming remains energy efficiency and increased reliance on renewable energy resources is another important tool.

Thank you very much.

[The prepared statement of Mr. Hawkins appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you, Mr. Hawkins.

Mr. Lowe.

STATEMENT OF EDWARD C. LOWE, GENERAL MANAGER, GASIFICATION MARKET DEVELOPMENT, SCHENECTADY, NY

Mr. LOWE. Good afternoon, Mr. Chairman and members of the committee. I am Edward Lowe, general manager of Gasification Market Development at GE Energy. GE appreciates the invitation to participate in this hearing.

I would like to thank this committee for recognizing the need for cleaner coal in the 2005 Energy Policy Act. Three coal IGCC projects and a petroleum-coke hydrogen-to-power IGCC project were recently awarded investment tax credits. These projects are a vital first step to accelerating the deployment of IGCC and positioning coal as an economic fuel in a carbon-constrained world.

Today I will, one, discuss the differences between pulverized coal technology and IGCC; two, show that IGCC is proven and cleaner; and three, address why technology has not been rapidly deployed and what is needed for it to achieve its potential. The first slide, please.

[Refer to slides beginning on page 133.]

A diagram of a PC plant and an IGCC plant is shown on the screen. In PC plants, coal is ground and burned in a boiler. Pollutants such as particulates, sulfur dioxide and mercury are captured in large post-combustion pollution control systems. IGCC is fundamentally different than PC. It converts the coal into a high-pressure natural-gas-like fuel that is then burned in a gas turbine. Precombustion removal of pollutants in an IGCC plant is more efficient and less costly because only one one-hundredth the volume of gas needs to be treated compared to a PC plant.

Next slide.

[Slide shown.]

IGCC is proven. GE technologies are used in over three gigawatts of IGCC plants around the world. IGCC is also cleaner than pulverized coal technology. GE's 630 megawatt IGCC plant will have 93 percent lower sulfur, 75 percent lower nitrogen oxides and 33 percent lower particulate emissions than the average of recently applied for and permitted PC plants plus it will consume 30 percent less water. You can turn off the screen.

CO^2 can also be removed pre-combustion with IGCC. According to a 2006 Department of Energy study, achieving 90 percent capture in a bituminous coal plant with IGCC will have a 23 percent lower cost of electricity compared to a pulverized-coal plant using currently available technologies. With all of these advantages, it is fair to ask why isn't IGCC being widely deployed. First, an IGCC plant is currently estimated to be 20 to 25 percent more expensive than a PC plant. IGCC is beginning to move down the experience cost learning curve but more plants need to be built in the near term to accelerate the cost reduction.

Second, IGCC's ability to cost-effectively capture carbon has no value in today's marketplace. In summary, carbon capture-ready IGCC is commercially available now. All of the key processes and equipment required for carbon capture in IGCC are being used in the chemical and refinery gasification applications today.

For low-carbon coal power to be deployed, a national policy is also required. Without long-term clear, consistent policy direction that creates a market price for carbon, low-carbon coal technologies including IGCC will not be widely adopted.

What is needed are, first, an expansion of current Government incentives to get the first 12 plants built, thus driving down the capital cost of IGCC, and second, a policy that includes a cap and trade program to establish a value for carbon.

We hope that the information that we have provided today will give you confidence to move forward with legislation to address climate change and the role that coal can play in a carbon-constrained world.

Thank you for the opportunity to address this committee.

[The prepared statement of Mr. Lowe appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you, Mr. Lowe.

Mr. Friedmann.

STATEMENT OF S. JULIO FRIEDMANN, CARBON MANAGEMENT PROGRAM, LAWRENCE LIVERMORE NATIONAL LABORATORY, LIVERMORE, CA

Mr. FRIEDMANN. Thank you, Mr. Chairman, Representative Hastert and members of the committee. I thank you for inviting me to testify today on the technical aspects of carbon capture and sequestration. I am pleased to be here in the capacity as the leader of the Carbon Management Program at the Lawrence Livermore National Laboratory.

Carbon capture and sequestration can be a vital element of a comprehensive energy strategy that includes efficiency gains, conservation and carbon-free energy supplies such as renewable or nuclear power. It can also support environmentally sound development of domestic transportation fuels including biofuels, coal-to-liquids and hydrogen.

To summarize my testimony upfront, opportunities for rapid deployment of geological sequestration exist in the United States today. There is enough technical knowledge to select a safe and effective storage site, to plan a large-scale injection, to monitor CO^2 and to remediate and mitigate any problems that might arise such as well bore leakage. However, national deployment of commercial CCS poses technical challenges and concerns due to the operational scale. An aggressive research, development and deployment program could answer all key technical questions, especially those that could advise a regulatory and legal framework to protect the public without undue burden to industry.

Carbon capture and sequestration has two components. The first is the separation and concentration of CO^2 from point source flue gases like power plants. The other panelists in the previous panel talked about that. The second step is geological carbon sequestration, or geologic storage, which involves injection of CO^2 into porous rock formations below the surface. I will focus my testimony on that.

The most promising reservoirs are porous and permeable rock bodies at depth generally greater than 1 kilometer, where pressures and temperatures where CO^2 to act like a dense liquid-like gas. The potential reservoirs include saline formations, depleted oil and gas fields, and unminable coal seams. Saline formations are likely sites for most geological sequestration because of broad distribution and large capacity. However, initial projects will probably start with depleted oil and gas fields due to the quality of existing data and the potential for economic return through enhanced oil recovery. Available pore space and suitable formations is a new natural resource, and I would like to repeat that: available pore space and suitable formations is a new natural resource. Once the CO^2 is injected into the subsurface, it remains there indefinitely because of physical and chemical properties of the Earth's shallow crust. Four different mechanisms trap CO^2 in place: physical trapping, capillary trapping, dissolution and mineral precipitation. What this means is that over time, CO^2 sequestered in the crust becomes less mobile and more permanently bound into the rocks themselves.

Geological disposal is very similar to oil and gas production, natural gas storage, hazardous waste disposal and enhanced oil recovery, as other members have mentioned. A key difference is the goal which is to keep CO^2 in the ground and out of the atmosphere. Therefore, careful pre-injection site characterization and monitoring and verification programs are important to avoid hazards, to detect unexpected leakage from the formation and to properly credit effective storage.

Today the U.S. emits annually 7 billion tons of carbon dioxide totaling 2.2 billion tons of this from large point sources, mostly coal power. The volumes of CO^2 at depth represented by this mass exceed current U.S. oil and natural gas production combined. Just 1 billion tons of anything is more mass than all the human beings on this planet. It is the necessary scale of sequestration deployment that represents the challenges we face.

The good news is that the U.S. appears to have more than enough capacity to deploy CCS at large scale. Conservative estimates are that the U.S. has over 2,000 billion tons, 2 trillion tons of capacity, enough capacity to comfortably inject all of our current point source CO^2 emissions for more than 100 years. Large sequestration resource occurs in the Midwest, in Texas, the intermountain West and substantial opportunities also exist in California, the Dakotas, Michigan and offshore the eastern United States. The costs of geological storage are much lower than the costs of capture and sequestration. Estimated costs of storage in the U.S. range from only one to 12 bucks a ton but in most cases range from about $5 to $8 a ton. This is roughly 10 percent of the cost of capture and separation. The cost of monitoring the CO^2 is much lower than that, with estimates of about 25 cents to $1 per ton. The cost of the geological assessment and site characterization are even less, estimated to be much less than one cent per ton.

I was asked to comment on what we know about carbon sequestration as an option for addressing climate change, what we don't know, what work needs to be done and understanding those things we don't know. I won't have time to go into it, but from a technical basis, the potential for successful CCS deployment is only limited by the local geology.

Thank you again for the opportunity to present.

[The prepared statement of Mr. Friedmann appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you, Mr. Friedmann.

Mr. Schoenfield.

STATEMENT OF MARK K. SCHOENFIELD, SENIOR VICE PRESIDENT, OPEERATIONS, JUPITOR OXYGEN CORPORTATION, SCHILLER PARK, IL

Mr. SCHOENFIELD. Thank you, Mr. Chairman, Mr. Hastert, members of the committee.

Carbon capture requires technologies that can effectively, efficiently and economically actually capture carbon, keep our coal-fired power plants running and give us affordable power. I am the senior vice president of operations and general counsel of Jupiter Oxygen, a small energy technology company that is privately held, which has developed a particular oxy-fuel, that is, using oxygen without air, with coal or other fossil fuels, technology process that makes it both practical and cost-effective for coal-fired power plants to be truly capture-ready now. It also can be used for retrofits, which makes it different than many of the other approaches that have been tried. The ability to retrofit the existing fleet of coal-fired power plants is essential for our economic and energy needs and our energy security, and although our focus may be coal, I just want to note that this technology also can address natural-gas-fired plants which also emit CO^2 and have NOx issues.

The Jupiter oxy fuel combination technology uses pure oxygen as the combustion agent instead of air, which contains nitrogen. The resulting exhaust gas contains almost no NOx and concentrates the CO^2 for efficient capture. In other words, you don't have to separate out from all that nitrogen in the air because air is 80 percent nitrogen. That makes it much more efficient and much less costly to do, and by having an undiluted high-flame-temperature process, you save fuel. At the same time, you can address the NOx, SOx, mercury and particulate issues effectively.

Now, this process actually began in the 1990's in an aluminum recycling and manufacturing plant. Strictly it started out for fuel efficiency purposes. At that plant, however, what was learned was, in aluminum re-melting you cut your fuel usage by 70 percent by using this and therefore you have 70 percent CO^2 avoidance because when you don't burn the fuel, you avoid making the CO^2.

Since 2001, Jupiter Oxygen has tested its technology and moved from industrial furnaces to power plants, working under research agreements with the National Energy Technology Laboratory. In 2002, we tested our technology in a steam boiler, making good steam sufficient to make electricity while firing both natural gas and coal, so we are talking about a technology that has been tested with actual firing in an up to half-a-megawatt size unit. This is not tabletop research. It is not a simulation. And what we found was, that you create fuel efficiencies, you burn less fuel, and then we combined our technology with an integrated pollutant removal technology called IPR, which kind of follows that name, developed by the National Energy Technology Lab itself at its Albany research center. Our technology with its fuel efficiencies and other benefits enables that system to perform in an economical and efficient manner to capture the CO^2 and to do it in a cost-effective way. This means that coal supplies can be used in an environmentally friendly fashion now and that we can use coal into the future.

Now, the problem we have is that utilities are reluctant to anything and be first, so we have started a retrofit project with the Department of Energy to do about a 25-megawatt retrofit project which could be done now which would actually use oxy fuel firing and have a truly capture-ready plant because capture-ready ought to mean that you have all the equipment on it and all you got to do is hook up a pipeline and you are good to go with the CO^2 if that is what we decide to do.

The problem we have is that the administration's budget and the Department of Energy have not made this a priority. The administration's budget has nothing in it for retrofit of coal-fired power plants, does not address oxy fuel combustion, and we need the continued support of Congress. You have passed section 1407 of the Energy Act of 2005 which authorized $100 million of funding for undiluted, high-flame-temperature oxy fuel work and yet nothing has been appropriated under that. We need the funding. We are just a little company. We need funding from the Federal Government to bridge between the research that has been done and an R&D retrofit project which will provide the data so that utilities, the Government, consumers and everyone else can see what this technology combination can do for the American public.

Thank you.

[The prepared statement of Mr. Schoenfield appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you, Mr. Schoenfield.

Mr. Dalton.

STATEMENT OF STU DALTON, ELECTRIC POWER RESEARCH INSTITUTE, PALO ALTO, CA

Mr. DALTON. Thank you, Mr. Chairman and members of the subcommittee. I am Stu Dalton. I am the director of generation for the Electric Power Research Institute headquartered in Palo Alto, California. EPRI appreciates the opportunity to provide testimony to the subcommittee on the topic of carbon capture and sequestration. We are a non-profit and collaborative R&D organization.

I plan to make the following points in the testimony today. Carbon capture technologies can feasibly be integrated into virtually all types of new generation after the scale-up and storage is demonstrated. CO^2 capture can be added to integrated gasification combined cycle to pulverized coal, and circulating fluidized bed combustion, and it can be incorporated in processes like oxy fuel combustion.

Although CO^2 capture appears technically feasible for all technologies, it represents substantial engineering challenges, requiring investments in R&D and in demonstrations, and it comes at considerable cost. Analysis by EPRI and the Coal Utilization Research Council suggests that once the substantial RD & D investments are made, the cost of capture and storage becomes manageable. Geologic storage has been proven effective by nature, and evidence suggests that depleted oil and gas reservoirs and similar capped sandstone formations as has been discussed containing saltwater and nonpotable water, have been capable of storing CO^2 for millennia or longer. Licensing and regulatory requirements for these are uncertain, however.

There is still much work to be done before CO^2 storage can be implemented on a large scale enough to significantly reduce CO^2 emissions into the atmosphere. Regarding CO^2 capture, the technologies can feasibly be integrated into all types of power plants with integrated gasification, pulverized coal and fluidized bed and variance. We believe that several will need to be demonstrated at large scale and CO^2 stored to prove the technology. For those building new plants, it is unclear which type of plant would be economically preferred if built to include CO^2 capture. All may have relative competitive advantages under various scenarios based on available coal types, plant capacity, location and opportunities for byproduct sales.

Although CO^2 capture appears technically feasible for all these technologies, there are substantial challenges requiring scale-up in size and major investments. Analysis by EPRI and the Coal Utilization Research Council suggests that once these are made, the cost can come down to approximate the current cost of electricity in constant dollars. That is a long-term prospect. It is not today's situation.

Where is it now? Post-combustion CO^2 separation processes placed after the boiler in the power plant are currently used commercially in very small-scale food and beverage and chemical industries, literally to make the CO^2 for soda pop, for freezing chickens and to make sodium bicarbonate. Those are actual installations. They are very small, much smaller than needed for power plants producing large-scale power. Current post-combustion processes are large energy consumers and could reduce the power plant electrical output by 30 percent.

CO^2 separation processes for IGCC plants are also used commercially in the oil and gas and chemical industries at a scale closer to that ultimately needed and they use less energy than current post-combustion processes, but their application necessitates development of modified systems with integrated CO^2 capture. EPRI's most recent cost estimates suggest that for pulverized-coal plants, the addition of CO^2 capture using the currently most developed technical option would add about 60 to 80 percent to the wholesale cost of electricity in life cycle terms. That is not including any storage site monitoring, liability insurance, et cetera, which is unknown at this point. The current cost premium for CO^2 capture in IGCC plants along with drying compression and storage is about 40 or 50 percent in our estimation. This is a lower cost percentage increase than for PC plants but we estimate that IGCC plants initially cost more than PC plants, as you have heard testimony. Thus, the bottom-line cost to consumers for power from IGCC plants today is likely to be comparable to PC plants with capture. The cost premiums listed vary depending on the coals and the physical chemical properties, desired plant size, CO^2 capture process and degree of integration and plant elevation and the value of co-products. IGCC often shows economic advantages with bituminous coals such as in the State of Virginia, and PC often shows advantages to low-rank coals, as you can see in some of the western coals.

EPRI stresses that no single advanced technology has clear-cut economic advantages across all applications. The best strategy for meeting future needs while addressing climate change concerns and economic impact lies in developing several options to allow choice by the power producers.

Let me just briefly mention a couple of the R&D——

Mr. BOUCHER. Well, why don't we ask you those questions. You are about a minute over, and we do need to move forward, so I intend to ask you about R&D requirements going forward. That is question No. 3 I have listed here.

[The prepared statement of Mr. Dalton appears at the conclusion of the hearing.]

Mr. Stewart.

STATEMENT OF JAY B. STEWART, ATTORNEY, HANCE SCARBOROUGH WRIGHT WOODWARD & WEISBART, LLP, AUSTIN, TX

Mr. STEWART. Thank you, Mr. Chairman and members of the committee. Thank you for the opportunity to discuss with you today the State of Texas's experience with legal issues regarding injection and storage of carbon dioxide.

For the record, my name is Jay Stewart. I am an attorney who practices regulatory law in Austin, Texas. As part of my practice, I represent entities and individuals before the Railroad Commission of Texas and the Texas Commission on Environmental Quality regarding oil and gas and injection activities. I have also been retained to work with the FutureGen Texas team regarding the State's efforts to site a clean-coal project in Texas.

I come before you today to discuss the Texas experience with CO^2 injection and the existing and prospective regulatory framework necessary to ensure successful and secure geologic sequestration of CO^2. Evaluating and licensing CO^2 injection in Texas has a regulatory track record that spans back more than 30 years. The prolific Permian basin in West Texas began utilizing CO^2 injection as a recovery technology in 1973. Once the traditional extraction of oil and gas has exhausted itself, secondary and tertiary recovery technologies are used to extract the vast remaining reserves. Recent data indicates that up to 70 licensed enhanced oil recovery projects utilizing CO^2 were in operation in the Permian basin of West Texas alone. Over 5,800 wells have reported injection of CO^2 with a total injection of 25 million metric tons per year. It is estimated that more than 55 million barrels of annual crude oil production resulted from these enhanced recovery efforts. With more than 30 years of history of using CO^2 as a commodity for oil recovery, these operations have a safety record of no major accidents.

From a legal, regulatory and engineering standpoint, CO^2 injection into geologic formations for productive use is nothing new in Texas. The developed regulatory framework exists to evaluate and judge each and every project. The Railroad Commission of Texas regulates injection of water and CO^2 for enhanced oil recovery operations. It also has decades of evaluating and regulating the common practice of brine and oil and gas waste injection into geologic formations, ensuring that those formations are not productive of oil and gas and they do not contain usable groundwater. The Texas Commission on Environmental Quality regulates injection of nonhazardous waste, hazardous waste and experimental wells. Both these agencies have experienced staff that routinely judge the available technologies for injection and geologic evaluation. It is only after these experts have approved an injection project that a project license is allowed to proceed.

Acknowledging the experience in oil and gas and geologic evaluation of both the State's regulators and its industry, Texas courts have consistently developed case law that clearly delineates the liability of the actors and the neighbors of these projects. Evaluation of legal liability rests primarily in the common law. Liability for negligence or malfeasance in the construction and operation of a facility utilized for capture and injection of CO^2 would rest in traditional tort law causes of action. There is no liability forgiveness for bad actors that operate negligently. Legal challenges to the activity of injection, however, have been thoroughly adjudicated in Texas and those causes of actions are limited under the common law. Actions for trespass, nuisance and negligence are severely limited in Texas so long as the operator has a valid license from the State agency and that operator has acted in accordance with the license and applicable regulations. Texas has adjudicated the public policy implications of injection activities within its borders and has consistently ruled with the State agencies charged with enforcing those requirements.

I have discussed the legal treatment of liability in Texas to the practice of injection of CO^2 and its use under existing regulatory framework. Carbon sequestration intended to be permanent adds a significant new component to the legal analysis. Liability for the unlikely possibilities of release or migration of sequestered CO^2 that could occur well beyond the time frames that are occasioned by present operations should be evaluated. Proper geologic and technical considerations are the first requirements to avoid possible liability for long-term events. Carbon sequestration into proven, confined geologic formations is paramount. Proposed storage of CO^2 in depleted oil and gas formations, deep saline formations, salt caverns and unminable coal beds all have containment and absorption characteristics that minimize the possibilities of any release or migration. Before a license is granted, the operator must prove to the agency experts the radius of influence or plume that the injected material will form in the injection formation. The pressures of the injection and of the injection formation must be shown to be compatible with what is being injected and permanently stored. Thorough evaluation and study of the injection proposal and target formation is the first and foremost check on potential future liability of permanent geologic storage of carbon. As with any good legal analysis, the lawyer must then ask the question, "but what if". In Texas, we answered this question by passing into law a transfer of ownership of the CO^2 from the FutureGen facility to the State of Texas. Acknowledging the goal of permanence of carbon sequestration, the permanence of the State is the only entity that can provide the necessary notice and monitoring beyond what one could expect in a private entity's life span. The State is protected by the principles of sovereign immunity while it cares for the injected CO^2, that is, by State law, its property and responsibility.

Finally, I would like to add that many States including Texas through a task force of the Interstate Oil and Gas Compact Commission are very far along in developing a model legal and regulatory framework for the geologic storage of CO^2. I understand that the IOGCC hopes to have published within a year a guidance document for States which includes this model framework.

I have attached a legal brief discussing in more detail my testimony regarding applicable law and ask that it be entered into the record. Thank you, sir.

[The prepared statement of Mr. Stewart appears at the conclusion of the hearing.]

Mr. BOUCHER. Thank you, Mr. Stewart, and thanks to all of the witnesses for joining us here today.

I am going to defer to Mr. Hastert for his questions. He has a very important meeting at 1:00 and I am going to recognize him first for 5 minutes.

Mr. HASTERT. I thank the chairman for his courtesy.

Mr. Schoenfield, I listened to your testimony and I think maybe what I heard isn't what you meant. I just want to clarify that. You made a statement that says if you don't burn the fuel—I am kind of summarizing— you don't produce the effluent. It is not the fuel, it is the combined air, right?

Mr. SCHOENFIELD. Well, whenever you burn fuel, even if you don't have air in there, you are going to produce CO^2. That is why with even oxy fuel firing, you do produce CO^2, Congressman Hastert. So it is the fuel reduction. In other words, there is a one-to-one relationship. If you don't burn the fuel, you are not going to make the CO^2.

Mr. HASTERT. All right. Fine. Then let me go back on that. When you burn this fuel with oxygen, the next step is, how do you get the oxygen? Do you separate the oxygen from the air on site or——

Mr. SCHOENFIELD. We would recommend separating the air from the oxygen on site although there are pipelines that produce oxygen.

Mr. HASTERT. If you do it on site, then in a sense you sequester CO^2 at the same time, right?

Mr. SCHOENFIELD. Well, air is 79 percent nitrogen, 21 percent roughly of oxygen, so you are not sequestering the CO^2. What you have is, you are separating it into oxygen and then you have a nitrogen byproduct which is actually salable in parts of the country as well.

Mr. HASTERT. What happens with the CO^2 that is in there?

Mr. SCHOENFIELD. Well, you don't start out with CO^2. The CO^2 is a product of combustion, so——

Mr. HASTERT. So there is no CO^2 in the air prior?

Mr. SCHOENFIELD. Well, you have some but the amount of CO^2 in the air, parts per million, is very, very small, as has been discussed, so there is some CO^2 in there but——

Mr. HASTERT. But it is not worth trying to segregate that?

Mr. SCHOENFIELD. It is not worth trying to segregate that, no.

Mr. HASTERT. OK. Now, when you burn this oxygen in these burners and you said you can retrofit, I would think if you burn something with air, that is one degree of burning and efficiency and heat. When you put pure oxygen in there, you are really kicking up the heat, aren't you?

Mr. SCHOENFIELD. Absolutely, sir.

Mr. HASTERT. Will that be a danger of melting these boilers? I mean, can you really retrofit these things?

Mr. SCHOENFIELD. We have done it successfully at that half-megawatt level with a 1973 Keeler D boiler. What you have to do is, you have to shape the flame properly, make sure the space is proper, cut back the amount of fuel so that the amount of energy that enters the water walls is exactly the same amount of energy as there was with air firing.

Mr. HASTERT. So in a sense you are using less fuel and creating the same amount of energy?

Mr. SCHOENFIELD. Yes, sir.

Mr. HASTERT. Then when you do this, you are having air come in and you still have CO^2, you go through that process. Do you get less CO^2 than you would—what I am getting at, when you bring air in and you blow air in here and you burn the fire, you are really just burning the oxygen out of the air, right?

Mr. SCHOENFIELD. Yes, sir.

Mr. HASTERT. And all the rest of this effluent and a lot of the effluent is the mass of air which happens to be nitrogen and other things that are going up the stack and so if you are trying to get this CO^2 out of there, you have a lot of air moving through and again the CO^2 is a very small amount of what you are trying to extract from that stack of effluent. Is that correct?

Mr. SCHOENFIELD. Yes. With oxy fuel firing, you don't have to separate out the nitrogen at the end. The flue gas stream is approximately 20 to 25 percent of what it would be with air firing.

Mr. HASTERT. And so are you saying the efficiency there, you are still trying to get the CO^2 out of the flue gas stream?

Mr. SCHOENFIELD. Well, you basically can compress it at that stage depending on the grade you need, whether you have to remove sulfur or other things for food processing or other requirements but basically you have a pretty relatively pure CO^2 stream at that stage.

Mr. HASTERT. All right. That is helpful. Thank you.

The gentleman from Texas, Mr. Stewart. When you inject CO^2 into the ground whether it is an old coal mine, whether it is forest rock, whether it is saline solutions or saltwater, do you change the physical nature of the host in any way?

Mr. STEWART. The CO^2 is absorbed so yes, but also whatever you are injecting the CO^2 into, it binds up the CO^2 so it doesn't become a new substance. It is a combination of whatever the two——

Mr. HASTERT. Otherwise you are not creating saltwater into some kind of acid or something?

Mr. STEWART. No, sir.

Mr. HASTERT. Thank you.

Thank you, Mr. Chairman.

Mr. BOUCHER. Thank you very much, Mr. Hastert.

Mr. Dalton, let us go back to where we were with you. You wanted to talk about the research needs and I want to ask you about that. It has been suggested that something on the order of $11 billion might be required in research funding over approximately the next decade if we are to achieve within somewhat more than a decade reliable separation and storage technology. Is that the right number or is there a different number?

Mr. DALTON. Thank you, Mr. Chairman. Mr. Chairman, I believe that number represents the portfolio of work that was outlined by the Coal Utilization Research Council and EPRI as a combined set of efforts, not just the CO^2 capture and storage work, but that is a significant part of that. There are elements of that work that relate to almost every one of the technologies we have heard talked about here—combustion work, oxy-fuel, gasification and also the CO^2 capture. It is putting the integrated system together that really makes it all work. In the written submission, I do have two graphics and they show both the efficiency increase with time against a series of time and cost decrease for both combustion technologies and for the gasification technologies. We believe both will improve with time and learning.

Mr. BOUCHER. And you have numbers associated with the research requirements for that?

Mr. DALTON. Yes, sir. There are numbers associated with each of the elements in the EPRI/Coal Utilization Research Council integrated plan.

Mr. BOUCHER. Thank you.

I would like to pose to the entire panel some questions regarding time frames upon which we can expect the arrival of reliable technologies both for separation for capture of CO^2 and also as a separate matter for storage of CO^2. Let me start with capture and talk about initially integrated gasification combined cycle.

I understand, Mr. Lowe, that from your testimony you believe that technology to be available today. First of all, is it in fact available today? Second, at what cost in comparison to a pulverized-coal facility, and for purposes of that comparison, would this be using IGCC without the separation technology as compared to a pulverized-coal facility also without any sort of control technology for CO^2?

Mr. LOWE. OK. First of all, yes, this technology is available today with IGCC. There are 25 gasification facilities operating around the world that separate CO^2 because that CO^2 is valuable in a number of processes.

Mr. BOUCHER. Well, what I am looking for immediately in the first set of questions is, just the availability of IGCC without CO^2 capture added to it, and the cost of that in comparison to today's generation of pulverized-coal plants. I understand it is more costly.

Mr. LOWE. Yes. As I indicated, the estimate today is that IGCC is approximately 20 to 25 percent more expensive in capital costs.

Mr. BOUCHER. Now, how many IGCC units will have to be built before you have comparable costs for IGCC and pulverized coal? I understand after perhaps a dozen of these you reach that point. Is that accurate?

Mr. LOWE. We would estimate that after a dozen of units you could end up shrinking that premium by at least half so it would be down to a maximum of 10 percent premium.

Mr. BOUCHER. Now, how much does adding the carbon separation component increase the IGCC cost?

Mr. LOWE. As I referenced in a DOE study that was done, the indication was that the cost of electricity, the cost coming out of the plant, would go up about 25 percent, and that was the same range that DOE referenced.

Mr. BOUCHER. Mr. Fees, would you like to comment on your post-combustion separation technology where you take CO^2 out of the flue gas?

Mr. FEES. Well, I think there is two ways to think about this. One is with oxy firing. There is no separate separation technology. So what you have is, you have a pure stream of carbon dioxide that comes out the backside that is ready for injection and/or other purposes. So there isn't an incremental cost beyond the cost to deploy that technology.

Mr. BOUCHER. And your technology is based on oxy firing?

Mr. FEES. On oxy firing.

Mr. BOUCHER. That is the same way that Mr. Schoenfield's technology is?

Mr. FEES. It is different. We generate something that resembles ambient air and in ambient you have 20 percent oxygen and 80 percent of other things.

Mr. BOUCHER. OK. Well, without diving into the technical differences, what is the cost of your oxy firing technology in comparison with the cost of IGCC with carbon separation? Can you make that comparison?

Mr. FEES. Around 35 to 40 percent.

Mr. BOUCHER. Yours is more costly than the IGCC with carbon separation?

Mr. FEES. Yes. However, if you take a look at pulverized coal without oxygen firing with separation on the back end, there are a lot of studies that compare those in many ways and right now with the lack of development of commercial scale in either of those circumstances, right now looking at their future, it looks like about a wash.

Mr. BOUCHER. Mr. Lowe, when will we see commercial availability of IGCC with carbon separation? When do you think that date arrives?

Mr. LOWE. There was a question earlier by Ms. Harman from California regarding the BP project out in Carson, California, and this is a project that utilizes petroleum coke instead of coal and an IGCC process. The carbon is separated and the carbon will be put into a pipeline for use in enhanced oil recovery, and GE and BP have done initial design on that plan with an expected commercial operation date of 2011.

Mr. BOUCHER. I am going to ask about storage in a second round of questions to this panel.

I am now pleased to recognize for 5 minutes Mr. Hall.

Mr. HALL. I yield to the former chairman of Energy and Commerce, showing my good judgment to Mr. Barton for my time.

Mr. BARTON. I normally wouldn't even mind but I am supposed to managing the OBJ bill on the floor right now, so I appreciate Mr. Hall's yielding to me.

I have a confession to make before I get into my questions. It is going to hurt my reputation I know, especially with my friends in the environmental community, but I have long been a supporter of carbon capture in the form of the FutureGen project. I also happen to support the development of many of these technologies that you gentlemen are talking about today and I put my money where my mouth is back in the Energy Policy Act of 2005 and we made sure that we authorized, which is all a committee like ours can do, we can't appropriate but we authorized specific sums of money in the hundreds of millions and in some cases the billions of dollars to develop these technologies. So I am not quite the stick in the mud maybe that I am portrayed to be. I do think there ought to be a cost-benefit test to this technology because that is ultimately what the ratepayers and the consumers have to pay.

My first question goes to a statement that Mr. Dalton made. Does everybody on the panel generally accept that whichever these technologies we decide to adopt, that in the beginning there is going to be a substantial premium in terms of plant construction? The EPRI gentleman said 60 to 80 percent. Does everybody accept that it is going to cost more? Mr. Schoenfield is shaking his head no. Your retrofit technology won't cost more?

Mr. SCHOENFIELD. No, sir. I mean, the retrofit technology when we project, for example, at 400 megawatts, is $170 million to fully retrofit NOx, SOx, particulates, CO^2, mercury, everything, and at $180 a kilowatt or $1,600 a kilowatt, you are talking about new plants at $640 million to $720 million so retrofitting is less.

Mr. BARTON. Your retrofit is about a 25 percent.

Mr. SCHOENFIELD. Right. On a new build plant against present technology which doesn't capture CO^2, doesn't address the rest of the pollutants the same way, the projections we made with the Albany research group of the National Energy Technology Lab had us in the same ballpark as present costs, that is, around 1.7 cents a kilowatt production cost and about 5.1 cents a kilowatt fully loaded and amortized capital costs.

Mr. BARTON. Well, the chairman indicated in his first round of questions, he was concerned about the cost. I too am concerned about the costs. I don't think this is a free lunch that we can technology our way to no cost increase to our rate consumers although I do think over time as the learning curve comes down that we can hopefully minimize that cost.

Mr. Hawkins, we are glad to have you back. You are certainly one of the most distinguished leaders in the environmental community and also, in my opinion, one of the most commonsense ones, which may mean you are the only one that shows any common sense, but that is just a personal opinion of mine. Were you involved at all with the TXU proposal for the coal-fired power plants down in Texas?

Mr. HAWKINS. Yes, Mr. Barton.

Mr. BARTON. OK. What technology were they proposing to use in their plants?

Mr. HAWKINS. They proposed 11 plants initially, all of them using pulverized-coal technology.

Mr. BARTON. Some sort of, as I understood it, supercritical combustion cycle that would reduce emissions. Is that correct or incorrect?

Mr. HAWKINS. Some of them were proposed as supercritical units, which means a higher operating pressure and a slightly higher efficiency.

Mr. BARTON. But they did not propose the use of the Babcock and Wilcox IGCC. Is that correct?

Mr. HAWKINS. They didn't propose to use the Babcock and Wilcox oxy-fuel technology nor IGCC.

Mr. BARTON. Or the GE.

So the environmental community just didn't believe that their plants would operate at the reduced emissions level. Is that fair to say?

Mr. HAWKINS. The opposition to those plants had to do with both the conventional pollutants as well as carbon dioxide and the modest reductions in carbon dioxide from a slightly more efficient plant still meant that you would be building a new plant that would have somewhere like 80 to 85 percent of the same plants that our grandfathers built and so that is not seen as acceptable progress.

Mr. BARTON. There is not a requirement that you build plants for laws that haven't been passed yet, is there?

Mr. HAWKINS. Well, in this area, Mr. Barton, the laws are lagging common sense and common sense in the business community are actually getting out ahead of the laws and we hope with the efforts of this committee that you will catch up soon.

Mr. BARTON. Well, I hope that we get a dose of common sense at some point in this process because I too am an industrial engineer and have a master's degree in various things like the Babcock and Wilcox gentleman. We were taught that you base decisions based on facts, not on theories, and it is yet to be proven to me that CO^2 is the cause of all the catastrophic things that is has been accused of. As these hearings go forward, we will have a chance to get some of those scientists before us and hopefully get some of that information out on the table.

My time has expired, Mr. Chairman. I appreciate your courtesy.

Mr. BOUCHER. Thank you very much, Mr. Barton.

Mr. Inslee for 5 minutes.

Mr. INSLEE. Mr. Barton had pointed out earlier that humans are responsible, I think he uses the figure of 5 percent of the total CO^2 emissions into the atmosphere, and one of my colleagues asked me about that and I have heard numbers in that ballpark, and that seems like no big deal but I want to ask about that. That is a 5 percent increase over what would have happened had we not had an industrial revolution basically and 5 percent doesn't sound like much but I was thinking, if I weigh 200 pounds, which is close, and I gain 5 percent weight a year, cumulative putting it into the atmosphere in my waist line, I would weigh over 400 pounds on 20 years. Now, I think that is kind of analogous to the situation we have here where we are headed to at least twice CO^2 pre-industrial levels. That seems to be the target we are all trying to stop it at.

Mr. Hawkins, is that sort of a fair metaphor to this discussion?

Mr. HAWKINS. Thank you, Congressman. Actually the 5 percent number is a very misleading number. The oceans and the terrestrial systems—trees—release CO^2 into the atmosphere. That is correct. But that same CO^2 is taken out of the atmosphere by the same sources. So until we started mining fossil fuels a couple of hundred years ago in significant quantities, the net emissions to the atmosphere were zero. Just as much goes in as comes out. So if the question is what are the actual net emissions to the atmosphere caused by human beings, it is 100 percent, sir.

Mr. INSLEE. And we are heading to double pre-industrial levels by the end of the century. Is that our best estimate?

Mr. HAWKINS. We are headed to double pre-industrial levels by about 2035 at the current pace.

Mr. INSLEE. And I am very glad you seven people—I compare you to the Mercury Seven astronauts. I think you are heroes in trying to figure out what to do about this because we have got to reduce levels by probably on the order of 70 to 80 percent to be able to get down to stop it. Even to stop it at double levels, we have got to that level of reduction. So this technology is incredibly important.

I want to ask Mr. Fees and Mr. Lowe, I have this concern that we are going to allow what I will just call dirty-coal plants with no sequestration technology to be built in the next decade and lock ourselves in to another horrendous amount of CO^2, and I am just wondering what you can advise us as to what we can realistically do to insist that we in the plants as they go forward to embrace this technology to not allow another 50 years of dirty coal to get locked in. What can we do realistically in that regard?

Mr. LOWE. What I think we need to do, as I indicated in my testimony, is without some kind of policy that ends up putting a value on carbon, that is exactly what is going to happen, and what we think is a very strong approach would be a cap and trade approach for CO^2.

Mr. FEES. I believe there is a timing issue in play. There is a timing issue of what is available in the technology and what can be done versus when we would like to get it deployed. If we start making short-term requirements, we might not have all the technology to get there and it may get into fuel-switching issues on a local basis that may affect economies and may affect us nationally. If you take a look at the technologies that are being developed, I think they are all good. I think it would be a cheap marketing ploy for me to try to talk about IGCC versus pulverized coal because they both have a chance and they have an equal chance under where things are going, and we are going to invest in excess of $40 million of our money into R&D this year looking at how we can improve pulverized coal and how we can capture CO^2 on the back end. And the thing that I am trying to get to there is, I think this body, it is very important that they have an unbiased approach relative to technology because I think it would limit what we might accomplish.

Mr. INSLEE. Mr. Friedmann, I want to ask you about sort of projections. You made some projections about cost, and I wrote down one figure, either 21 or 25 percent more with sequestration, but does that take into consideration some of the projected improvements in efficiencies? There is a company called RamGen out in Washington State that has a compression technology they have told me they think they can reduce capital costs by 30 percent and deal with some of the heat issues to actually put heat to use.

Mr. FRIEDMANN. I am actually familiar with RamGen and I am familiar with other novel compression strategies that people are trying. Those were not included in my cost estimates. Conventionally, the way that our community handles things is, we put capture the separation piece, transportation, construction of pipelines and shipping and the compression, all of those costs get integrated into what we call the capture half; and then there is the storage half when you basically go from the well head down, and those were the costs I had talked about.

Mr. INSLEE. Mr. Chairman, would you indulge me one more question? I am over my time.

Mr. BOUCHER. Sure.

Mr. INSLEE. Thank you. I appreciate that.

Could you give us some estimate of the existing coal plants where they are located today, what percentage of them have a good chance of having geology that would allow sequestration within whatever *X* miles we think transportation will work out? Is there any estimate you can give us today in that regard?

Mr. FRIEDMANN. It is very well documented that coal basins, which is where coal plants tend to be built, are highly prospective places to store CO^2. The geology works well in terms of saline aquifers, depleted oil and gas fields and coal seams, and all of them occur generally in abundance where you have a lot of coal. So the chance of finding within, say, 150 kilometers or 200 kilometers of a power plant a good sequestration site is extremely high.

Mr. INSLEE. Thank you.

Mr. BOUCHER. Thank you very much.

Mr. Hall for 5 minutes.

Mr. HALL. Mr. Chairman, thank you.

Mr. Dalton almost answered the question I have when he said all systems had to be put together if they are going to work, and

Speaker Hastert entered into a little bit about the cost and of course you have to consider cost on everything because that is going to be the final determination as to what is selected and how well it works.

But Mr. Schoenfield, you addressed the issue of oxy-fuel in your testimony and it has been kicked around here pretty well. I know this committee heard testimony last year from MIT, I believe it was a Dr. Katzer from MIT gave some testimony to Energy and Air Quality Subcommittee on clean coal technology. I don't know if you were here and heard his testimony or have read it, but he gave testimony about the relative cost of various clean coal technologies. Can you be more specific about the cost of oxy-fuel relative to other technologies that we would have to compare them with?

Mr. SCHOENFIELD. I am familiar with the testimony, Congressman. I have also spoken to Professor Katzer. I think the presentation at MIT had to do much like EPRI's with taking technologies that they consider more conventional levels and analyzing those, and I think their conclusion was that at this point there is not enough known to have a clear cost winner. So we have done our projections based on the testing today as I stated with those numbers and those I find it hard to compare because I am not sure what reliable numbers there are on some of these other technologies either, just like Professor Katzer stated in his testimony.

Mr. HALL. Has DOE given any priority to having an actual retrofit with oxy-fuel on the grid so everybody can see how it really works?

Mr. SCHOENFIELD. No, sir, and it has been very frustrating since part of the technology is their own technology developed by their lab.

Mr. HALL. In regard to their IPR system, explain why it works with your oxy-fuel technology.

Mr. SCHOENFIELD. Yes, sir. Because there is no nitrogen to separate out and because there is less fuel used and there is less CO^2, their system can be smaller, more efficient, more economical. What it basically does is compress that CO^2. It has a series of wet and dry heat exchangers to capture latent heat. It has filters to take out the mercury and sulfur and the particulate and in the end you get a CO^2 stream that is as pure as you need it, depending on whether you are doing food processing, enhanced oil recovery or just plain old sequestration.

Mr. HALL. I thank you.

I yielded my time to Mr. Barton, and there are others to make some inquiries, and it is a little past noon so I will yield back my time, Mr. Chairman.

Mr. BOUCHER. Thank you very much, Mr. Hall.

Mr. Dingell for 5 minutes.

Mr. DINGELL. Thank you very much for your kindness.

Gentlemen, as you have all observed in your testimony, there are a number of questions needing to be answered. The Department of Energy's witness has testified earlier that the goal of DOE's carbon sequestration program is for commercial deployment by 2012 of capture technologies that achieve 90 percent CO^2 capture at less than a 10 percent increase in the costs of the energy. Now, starting with Mr. Stewart, if you please, gentlemen, is that an achievable goal, yes or no?

Mr. STEWART. Mr. Chairman, I can't opine on the technology because I am not that experienced with it but I can tell you in Texas, we have an established regulatory framework where we can today permit at least the FutureGen project for sequestration. That does not achieve your 90 percent goal, no, sir, but there is our experience and the regulatory framework and the experience of regulators does exist today to accomplish that.

Mr. DINGELL. Thank you.

Mr. Dalton?

Mr. DALTON. Technology can be built by that date but it will not have established the long-term storage and the safety of that storage at that point.

Mr. DINGELL. Alright.

Our next witness?

Mr. SCHOENFIELD. Congressman, the retrofit project for oxy-fuel technology that has been started can be completed in 18 to 24 months. It will require about 6 to 12 months of data collection and then some dissemination of data, and assuming it works based on the projections and the testing to date, it would then be ready for deployment.

Mr. DINGELL. You said assuming it works.

Mr. SCHOENFIELD. Right. We are confident it will work, sir, but I can't sit here until it works to say for 100 percent certainty. I am 100 percent certain but I would say assuming because that is how it has been presented when we have conversations with the DOE.

Mr. DINGELL. Thank you.

Our next witness, please, sir.

Mr. FRIEDMANN. The most outstanding questions associated with deployment of storage technology can be answered with a handful of large tests quickly. Currently, within the DOE's program, they are trying to accelerate some of those steps. That is one pathway towards doing that. I think there are many ways that one could accelerate the deployment of large tests to provide the information needed to operators and to regulators to develop standards.

Mr. DINGELL. Next witness, please, sir?

Mr. LOWE. Yes. I think that as I indicated, carbon capture technology will be demonstrated in 2011 at Carson for IGCC and I think that it is entirely likely that we are going to see costs going down both for the capture of carbon and also the sequestering of it in something like saline aquifers going forward.

Mr. DINGELL. Thank you.

Mr. Hawkins.

Mr. HAWKINS. Thank you, Mr. Chairman. The performance goals in the DOE program are already demonstrated. I mean, cost goals can be achieved but not by the DOE program alone. To achieve those costs, you need to engage the private sector. To do that, you need the power of emission limits to move this forward at a required pace.

Mr. DINGELL. Last witness, please.

Mr. FEES. Yes, and if you take a look at it, we believe that what is underway at DOE will work. However, our concern is that it will not be enough, that the combustion technologies will be there much earlier and a broader-based deployment of the combustion technologies may be limited by the availability of storage, and that is our concern, that we may actually limit our ability to deploy new plants with the new technologies because we won't have anywhere to put the CO^2.

Mr. DINGELL. Now, gentlemen, I have so little time. It is so very hard to do this and I have to verge on discourtesy here. If you would, please, yes or no to this question. Will it be possible to deploy the leading CO^2 capture technologies in the U.S. at a cost that isn't significantly going to increase the retail price of electricity and if adoption of a carbon-constraint policy is speeded up, will that help if we do that?

If you please, Mr. Stewart?

Mr. STEWART. It will increase the cost but a government policy from the Federal Government certainly would inspire and order industry to respond.

Mr. DINGELL. Next witness, please, sir?

Mr. DALTON. I believe it will increase the cost but firm policies on storage particularly would help.

Mr. DINGELL. Sir?

Mr. SCHOENFIELD. Our projections are that the cost of capture can remain approximately the same as the cost of electricity today.

Mr. DINGELL. Same, sir, please?

Mr. FRIEDMANN. From a technical basis, the cost of storage will be a very small component of the total aggregate cost of electricity.

Mr. DINGELL. Next witness, please, sir?

Mr. LOWE. Yes, there will be an increase initially in the cost of electricity but with a carbon policy, we are going to see a stimulation of new technologies coming forward that will end up reducing that cost.

Mr. DINGELL. Mr. Hawkins?

Mr. HAWKINS. Yes, the cost increase can be modest and yes, policies are needed to make it happen.

Mr. DINGELL. Sir?

Mr. FEES. It will cost more. Our R&D objective is to try to limit that cost below 20 percent, and a policy would certainly stimulate more development in R&D.

Mr. DINGELL. Thank you, gentlemen.

Mr. Chairman, I note that my time has expired. I have some more questions but I thank you for your courtesy.

Mr. BOUCHER. Thank you, Chairman Dingell.

Mr. Shimkus for 5 minutes.

Mr. SHIMKUS. Thank you, Mr. Chairman.

Mr. Schoenfield, just following up on the chairman's question, you are not including the capture and storage of CO^2 in your no-net increase in cost, are you?

Mr. SCHOENFIELD. I am including the capture——

Mr. SHIMKUS. But not storage?

Mr. SCHOENFIELD. But not storage or transport.

Mr. SHIMKUS. Because there is going to be a cost increase. Everybody needs to get prepared for that, and the question is how much. Marginal? What is marginal? Twenty percent, 10 percent? Those are things that will have to be addressed as we move this forward.

Mr. Lowe, I appreciate this. I have been trying to understand, and I visited a lot of plants in pulverized coal and IGCC, but Mr. Schoenfield, your Jupiter oxygen would be kind of in between, would it not? It is retrofitting pulverized coal plants with oxygen to get a better return and the ability to capture the emittents and then sequester them. Is that correct?

Mr. SCHOENFIELD. That is correct.

Mr. SHIMKUS. Can I ask, we addressed this in the EPAC bill in 2005 in section 1407. How are you using the funds that have been provided by Congress in your rollout here?

Mr. SCHOENFIELD. Well, so far, Congressman, we have received only the first $10,000 of 2005 money because since this is not a priority, it has been a very slow process to get through all the levels of paperwork and everything else. We have received none of the 2006 money yet.

Mr. SHIMKUS. That is why I always talk to people who are coming to us for help because we are not really reliable partners in the funding stream in the world in capital risk and deployment, and I am sorry to hear that. We are trying to do our best to work with DOE. So DOE in essence hasn't been helpful with respect to the EPAC legislation in that section yet?

Mr. SCHOENFIELD. They have not made it a priority, and in that sense, that is correct.

Mr. SHIMKUS. Maybe I can ask our chairman to help me readdress the Department of Energy on this section.

Mr. BOUCHER. Yes. Well, let me just respond to the gentleman by saying that we had Mr. Shope here earlier and he did not talk about the loan guarantee provisions, which have been a major source of discouragement for some of the applicants but the gentleman is right in saying that full partnership with DOE is going to be necessary in order to achieve the goals we are discussing here today.

Mr. SHIMKUS. Thank you.

Mr. Hawkins, I think your organization has said you want IGCC with carbon sequestration. Is that correct?

Mr. HAWKINS. We want coal plants to meet CO^2 performance standards that can be achieved with CO^2 capture. We don't care what the technology is to turn coal into electricity.

Mr. SHIMKUS. But you are really empowering this sequestration issue in this debate.

Mr. HAWKINS. We believe that continuing coal use makes it essential to do CO^2 capture and storage.

Mr. SHIMKUS. And you are still a supporter of using coal for electricity generation in this country, are you not?

Mr. HAWKINS. We think it is a fact of life that a lot of coal will be used for a long period of time.

Mr. SHIMKUS. Do you also support nuclear power?

Mr. HAWKINS. Our position on nuclear power is that if there is a level playing field and we get rid of some of the subsidies in current law, if we address the waste issue and if we address the nuclear proliferation risks, then it should play a role.

Mr. SHIMKUS. Wow. All right. Let me ask you about the permitting and transportation of carbon dioxide. Under what circumstances would you support or oppose any transportation or sequestration issues?

Mr. HAWKINS. We think that the regulatory system to cover transportation is already in place. Pipeline transportation regulations apply to existing commercial pipelines.

Mr. SHIMKUS. Have you ever opposed transportation and siting of carbon dioxide sequestration projects in the country?

Mr. HAWKINS. No.

Mr. SHIMKUS. Would you support an expedited process for permitting and siting?

Mr. HAWKINS. I think an expedited process may not be the best way to gain public confidence for a new technology. I think that a good process that involves the affected communities is the best way to get these technologies accepted.

Mr. SHIMKUS. I am always vague in expediting because as I said earlier, we want to move quick but on some things we want to move slow. Now we are saying we need to move quick but we also hear that the Federal bureaucracy does not move quickly so once I figure out what expedited means and if we can do it in a timely and safe manner, then we may get a chance to visit it again. But I understand your concerns.

Thank you, Mr. Chairman.

Mr. BOUCHER. Thank you, Mr. Chairman.

Mr. Markey for 5 minutes.

Mr. MARKEY. Thank you, Mr. Chairman.

Mr. Fees, Mr. Lowe, Mr. Schoenfield, all three of your companies have developed new technologies that you say would allow us to burn coal cleanly, capturing and disposing of the carbon pollution that currently gets released into the environment. If I were an electric utility CEO and I wanted you to build one of those plants today, could you build a 300-megawatt plant for me right now?

Mr. FEES. We are building a 300-megawatt oxy-fired plant and we are in cooperation with Saskatchewan Power doing that today. We have a third——

Mr. MARKEY. I could buy one right now?

Mr. FEES. Yes, sir.

Mr. MARKEY. And how much would it cost me?

Mr. FEES. It depends on the location and the coal and the development that is going on this summer.

Mr. MARKEY. Can you give me a range?

Mr. FEES. Not today.

Mr. MARKEY. Three hundred-megawatt plant?

Mr. FEES. Yes, we have a 300-megawatt plant.

Mr. MARKEY. No, I am saying, but you couldn't give me any price at all?

Mr. FEES. It depends on the location and the coal.

Mr. MARKEY. Mr. Lowe?

Mr. LOWE. Yes, we could build a 300-megawatt plant although with the economies of scale, we would encourage going to approximately 600 megawatts.

Mr. MARKEY. And how much would it cost me?

Mr. LOWE. Again, that is very specific to what you have for the location of the plant but right now approximately 20 percent more than you have for pulverized-coal units.

Mr. MARKEY. OK, good, and Mr. Schoenfield?

Mr. SCHOENFIELD. Congressman, we would need to complete that retrofit project before going up to 300 megawatts but the projected cost based on the testing that has been done and all the firing which are consistent for the process would indicate that the cost of that 300-megawatt plant would be approximately the same cost it would be to build it with conventional technology today.

Mr. MARKEY. So you are saying a plain old pulverized-coal plant without any carbon capture or sequestration would be built for the same prices you could build me one of these new plants right now?

Mr. SCHOENFIELD. That is what has been projected based on the testing to date and the cost——

Mr. MARKEY. Well, let me ask the other two gentlemen. Can you do that for me too? Could you build me the same plant for the price of a pulverized-coal plant no matter where I am?

Mr. FEES. With carbon capture included for the same price?

Mr. MARKEY. Without any carbon capture. He just said he could do it for me without carbon capture, same price with and without carbon capture.

Mr. FEES. I can build a pulverized-coal plant and I do it every day.

Mr. MARKEY. But can you do it for the same price you build one of the new plants that would capture the carbon?

Mr. FEES. As I indicated earlier in my testimony, we thought that our oxy fire technology which we are doing today and can be back retrofit to existing pulverized-coal plants is about 35 to 40 percent more than the existing——

Mr. MARKEY. So it is 35 to 40 percent?

Mr. FEES. Which is about the same cost of IGCC, in our estimation.

Mr. MARKEY. And Mr. Lowe?

Mr. LOWE. Yes, I have indicated that it would be a premium versus what a non-carbon-capture plant is and IGCC with carbon capture would be about 20 percent.

Mr. MARKEY. Twenty percent. OK. And how would that compare to the cost of building a modern combined cycle natural gas plant to produce the same 300 or 600 megawatts?

Mr. LOWE. Any solid fuel coal plant is going to be substantially——

Mr. MARKEY. Can you give me a percent range generally?

Mr. LOWE. I would say that it is probably in the range of an additional 300 percent.

Mr. MARKEY. Three hundred percent.

Mr. Schoenfield?

Mr. SCHOENFIELD. I don't know that range offhand but the cost of the fuel difference makes a tremendous difference as well in the operating costs.

Mr. MARKEY. Just give me a range.

Mr. SCHOENFIELD. I do not have the capital costs, Congressman, on that one.

Mr. MARKEY. Mr. Fees?

Mr. FEES. You need to look at the cost of the fuel because today they are——

Mr. MARKEY. We are trying to make some decisions here so factor in what you think is reasonable and give us a price comparison.

Mr. FEES. Right now today natural gas is not competitive in a lot of markets because of the price of fuel and on a 20-year levelized cost of electricity dollars per megawatt, pulverized coal with CO^2 capture is 62 bucks.

Mr. MARKEY. So you are saying for a CEO right now it is a rational decision to build a coal-fired plant with this new technology as opposed to a natural-gas plant?

Mr. FEES. I think it is a rational decision to build existing technology as well as approach the new technology, yes, sir.

Mr. MARKEY. Mr. Hawkins, you heard DOE's response to the questions that I posed earlier regarding the potential for utilities to exploit loopholes in the 2005 Energy Policy Act to get subsidies for coal plants that don't actually capture CO^2 but are merely capture-capable or carbon capture- optimized. Did you find DOE's answers reassuring?

Mr. HAWKINS. No.

Mr. MARKEY. What should we do about the loophole in the law?

Mr. HAWKINS. Well, I think in the appropriations bill, there should be specifications that limit the appropriations authorities to the top priority technologies which are those that actually do capture CO^2.

Mr. MARKEY. Mr. Hawkins, in your testimony you say policies to limit CO^2 emissions and set performance standards are essential to drive the use of CCD at the required scale and pace, and then you say, however, a CO^2 cap and trade program by itself may not result in deployment of CCD systems as rapidly as we need. What sort of performance standards do you envision in order to drive the deployment of carbon capture and sequestration technologies?

Mr. HAWKINS. Well, one that we think is quite interesting and is in a bill introduced in the other body, it is 309, is a performance obligation modeled on the renewable portfolio standards. It basically says that if you generate coal-fired power starting in 5 or 6 or 7 years from now, a certain small fraction of your total kilowatt hours need to come from coal plants that meet a performance standard.

Mr. MARKEY. And what fraction——

Mr. BOUCHER. The time of the gentleman has expired.

The Chair is going to recognize at this time the gentleman from Texas, Mr. Burgess.

Mr. BURGESS. Thank you, Mr. Chairman.

Mr. Fees, let me just be sure that I understand this correctly. If Mr. Markey's 300-megawatt plant is built today but it uses natural gas as a fuel, is carbon sequestration something that is going to happen at that natural-gas plant as well?

Mr. FEES. We don't build natural-gas-fired plants so I can't really comment on how they would capture carbon but I would think the technologies that are being developed could be similarly applied.

Mr. BURGESS. Mr. Hawkins, is it necessary to capture the carbon from the natural-gas plant?

Mr. HAWKINS. Eventually it will. BP is proposing to do that at a plant that it operates in Scotland. It is going to send the CO^2 under the North Sea to enhance oil recovery there.

Mr. BURGESS. Mr. Stewart, let me ask you, we had the Texas Railroad commissioner up here last week and he was talking about the FutureGen project if it were to come to Texas and he said Texas had passed a statute taking title to carbon dioxide for that sequestration project. Am I correct in that?

Mr. STEWART. Yes, sir.

Mr. BURGESS. Now, why did Texas do that? Were there any other options available to the State other than simply taking title to the CO^2?

Mr. STEWART. Well, in the FutureGen process, there were multiple options promoted such as insurance and indemnification and taking title, and what the decision makers in Texas decided was, from a permanence standpoint, you need an entity that is going to outlast any private entity because of the monitoring and eventual care of the CO^2 so they decided that a transfer once it has been captured of the CO^2 to the State is the best management technique from a permanence standpoint.

Mr. BURGESS. Did they consider any other options?

Mr. STEWART. We consider all of them actually, sir.

Mr. BURGESS. Are there any situations in which that model crafted by the State of Texas would not be applicable to CO^2 capture where the State or the longest surviving Government entity were to take title to that CO^2?

Mr. STEWART. That is a public policy decision for each State or the Federal Government to make. We thought it was the most appropriate technique to ensure against long-term liability for the whole project.

Mr. BURGESS. Mr. Fees, is it possible to destroy carbon dioxide rather than to have to pump it back into the Earth?

Mr. FEES. I am going to look at my R&D man behind me and see what he has to say. There is a tremendous amount of energy——

Mr. BURGESS. Well, the reason I ask is because our anesthesiologist at the hospital used to have this little gizmo that trapped CO^2 in these rebreathing circuits and would eliminate the CO^2 from the anesthesia machine but we can't do that——

Mr. FEES. There is a tremendous amount of energy that gets put forth to create CO^2 at the point of combustion so reversing that process is energy heavy. However, we are doing R&D where we are, for example, taking the enzyme that exists inside of your and my lungs and trying to engineer that enzyme in a wet condition that we can put flue gas through it and use the same technology that exists in our bodies to be able to capture that and to turn the CO^2 into calcium carbonate and other things that may be friendly to be able to be used post combustion. But those things are way off and we are doing R&D that is directed in that end, but there are things that can be done.

Mr. BURGESS. Mr. Hawkins?

Mr. HAWKINS. Well, Mother Nature does this every day, Mr. Congressman. The problem is, we are putting CO^2 into the air about a million times faster than Mother Nature can handle it.

Mr. BURGESS. Let me come back to that in just a minute if I could. I wanted to ask Dr. Friedmann, are there some parts of the country that are better for carbon dioxide sequestration than others?

Mr. FRIEDMANN. Yes.

Mr. BURGESS. Which areas are well suited and which are poorly suited?

Mr. FRIEDMANN. I described some of that in my testimony and some of that information is——

Mr. BURGESS. I apologize. We took all morning to save Medicare and I didn't think I could do it, but I did, so I apologize for being late.

Mr. FRIEDMANN. That is OK. Explicitly, I mean my written testimony too, but the Department of Energy has just put—the partnerships have put together an atlas that provides some useful information. From a technical basis in my own estimation, three places stand out right away: Illinois, Texas and the central and northern Rockies but there are actually many other places within the country which have a high capacity and they all look quite good for CO^2 sequestration, and that resource is available there.

Mr. BURGESS. What makes an area of the country absolutely unsuitable for CO^2 sequestration?

Mr. FRIEDMANN. Well, there are three things you need to have a project. You need injectivity, which means you can inject at a high rate; you need capacity, which means if you make 300 million tons of CO^2 you can put it someplace, and you need effectiveness, meaning it has to stay in the crust a long time, and there are places in this country that lack those characteristics. So one example and one that is pertinent is in central Minnesota and Wisconsin, there is a rift basin that goes through the middle of those States that may have those characteristics but we don't know yet. The rest of those States lack those characteristics and could not serve. So the States of Minnesota and Wisconsin are trying to find out quickly whether they have that resource because they would like to be able to use it.

Mr. BURGESS. And how deep do you have to put the CO^2?

Mr. FRIEDMANN. Bare minimum is something like 800 meters. A good rounding number is a kilometer, and the reason why is because otherwise the CO^2 is not dense enough. It doesn't have sufficient density to stay in place a long time. You use a lot of poor volume and it has a strong buoyant force. So at typical crustal conditions, 800 meters to a kilometer.

Mr. BURGESS. Very good. Mr. Hawkins, let me just ask you a follow-up on the CO^2 question. Many more areas in the country in the last 50 years, U.S. Fish and Wildlife and the U.S. Forest Service have gone to great lengths to reestablish grasslands and forest areas. Has this resulted in any accumulation of carbon in those grasslands or forests that would otherwise just simply have remained in the atmosphere?

Mr. BOUCHER. Mr. Hawkins can answer this but this will be the last question.

Mr. HAWKINS. The answer is yes.

Mr. BOUCHER. That was a very efficient answer.

This has continued for quite a time today and I actually have meetings. There are additional questions I would like to ask. I am going to submit those in writing for response by this panel. So let me say thank you to each of the seven of you for the information you provided to us. You have been very patient today in awaiting your turn to testify, and the information you have offered here has been extraordinarily beneficial to us and we appreciate your assistance. We will have two more hearings on climate change this week and further hearings throughout this month and during the month of April and so for those who are interested, there will be no shortage of conversation on this entire range of issues.

Mr. MARKEY. Mr. Chairman.

Mr. BOUCHER. Yes, Mr. Markey?

Mr. MARKEY. May I ask one question?

Mr. BOUCHER. Mr. Markey, yes, for 30 seconds.

Mr. MARKEY. OK. I thank the chairman.

Just back and forth between Mr. Hawkins and Mr. Fees, that is under the contention that Mr. Fees made that his new 300-megawatt commercial plant using his new technology is already commercially available. So my question is, why aren't people buying it?

Why aren't people already investing in them and why aren't they avoiding, in other words, a cap and trade system and all the rest of the headaches? Why isn't the coal industry investing in right now if they are already available and they are, as you are saying, competitive with the alternative technology?

Mr. FEES. We are moving that technology forward through an R&D to deployment phase and it will be deployed, operating and running in 2011. We are in discussions with other customers for the potential of applying the same technology whether it be retrofit against existing boiler locations or for new boiler locations in the United States. But to say that it is up and running and I can point to one that is operating today, that is not correct.

Mr. MARKEY. I see. OK. That is a misunderstanding then.

Mr. Hawkins?

Mr. BOUCHER. Mr. Markey, thank you. Our time really has expired here today.

Gentlemen, thank you very much, and this hearing stands adjourned.

[Whereupon, at 1:45 p.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

Testimony

Carbon Capture and Sequestration

Subcommittee on Energy and Air Quality

U.S. House of Representatives

Stu Dalton

Electric Power Research Institute

March 6, 2007

Introduction

I am Stu Dalton, Director of Generation for the Electric Power Research Institute (EPRI). EPRI is a non-profit, collaborative R&D organization headquartered in Palo Alto, California. EPRI appreciates the opportunity to provide testimony to the Subcommittee on the topic of carbon capture and sequestration.

BACKGROUND

Coal is currently the fuel source for over half of the electricity used in the United States. It is expected to continue to represent over half of the generation mix needed to meet the forecasted U.S. electric demand growth of more than 40% by 2030. In order to address global climate change concerns, we must develop solutions that reduce coal power's net CO_2 emissions. Technologies to reduce coal-based generation's CO_2 emissions are part of a portfolio of CO_2 reducing technologies that also includes energy efficiency, renewables, nuclear power, and plug-in hybrid electric vehicles.

Coal is a stably priced, affordable, domestic fuel that can be used in an environmentally responsible manner. Pollutant emissions from new coal-fired power plants have already been reduced by a factor of ten or more over the last 30 years. By displacing imported natural gas or oil, coal helps address America's energy security and balance-of-payments concerns. With the development of carbon capture and storage (CCS) technologies, coal power becomes part of the solution to satisfying our energy needs in an environmentally responsible fashion.

EPRI's new "Electricity Technology in a Carbon-Constrained Future" study suggests that with aggressive R&D, demonstration, and deployment of advanced technologies, it is technically feasible to slow down and stop the increase in U.S. electric sector CO_2 emissions, and then eventually reduce them over the next 25 years while meeting the increased demand for electricity . Of the technologies that can eventually lead to reductions in CO_2 emissions, the largest single contribution would come from applying CCS technologies to new coal-based power plants coming on-line after 2020.

IMPROVED EFFICIENCY—AN IMPORTANT COMPANION TO CO_2 CAPTURE

In the 1950s and '60s, the United States was the world's pioneer in power plants using thermodynamically efficient "supercritical" and "ultra-supercritical" steam conditions. Exelon's coal-fired Eddystone Unit 1, in service since 1960, still boasts the world's highest steam temperatures and pressures. Because of reliability problems with some of these early units, U.S. designers retreated from the highest supercritical steam conditions until the 1980s and '90s when international efforts involving EPRI and U.S., European, and Japanese researchers concentrated on new, reliable materials for high-efficiency pulverized coal plants. Given the prospect of potential CO_2 regulations (and efforts by power producers to demonstrate voluntary reductions in CO_2 emissions per megawatthour of electricity produced), the impetus for higher efficiency to reduce future CO_2 control costs has gained economic traction worldwide.

The majority of new pulverized coal (PC) plants announced over the last two years will employ high-efficiency supercritical steam cycles, and several will use the ultra-supercritical steam conditions heretofore used only overseas (aside from Eddystone).

EPRI is working with the Department of Energy, the Ohio Coal Development Office, and major equipment suppliers on an important initiative to qualify a whole new class of nickel-based "superalloys," which will enable maximum steam temperatures to rise from an ultra-supercritical steam temperature of 1100°F to an "advanced" ultra-supercritical steam temperature of 1400°F. Combined with a modest increase in steam pressure, this provides an efficiency gain that reduces CO_2 emissions per unit of electrical energy produced by about 20% relative to today's plants. It also reduces the required size of any CO_2 capture equipment. Realization of this opportunity, however, is not automatic. It requires a sustained R&D commitment and substantial investment in demonstration facilities. The European Union has embraced this strategy and is midway through a program to demonstrate a pulverized coal plant with 1300°F steam conditions, which was realistically planned as a 20-year activity.

Efficiency improvement is important for other coal power technologies too. The world's first supercritical circulating fluidized-bed (CFB) plant is currently under construction in Poland. For integrated gasification combined cycle (IGCC) units, supercritical heat recovery steam generators are included in EPRI's CoalFleet RD&D Augmentation Plan.

CO_2 CAPTURE

Carbon capture technologies can be feasibly integrated into virtually all types of new coal-fired power plants, including IGCC, PC, CFB, and variants such as oxy-fuel combustion. For those building new plants, it is unclear which type of plant would be economically preferred if it were built to include CO_2 capture. All have relative competitive advantages under various scenarios of available coal types, plant capacity, location, opportunities for by-product sales, etc. Although CO_2 capture appears technically feasible for all coal power technologies, it poses substantial engineering challenges (requiring major investments in R&D and demonstrations) and comes at considerable cost. But analyses by EPRI and the Coal Utilization Research Council suggest that once these substantial investments are made, the cost of CCS becomes manageable, and ultimately coal-based electricity with CCS can be cost competitive with other low-carbon generation technologies.

Post-combustion CO_2 separation processes (placed after the boiler in the power plant) are currently used commercially in the food and beverage and chemical industries, but these applications are at a scale much smaller than that needed for power producing PC or CFB power plants. These processes themselves are also huge energy consumers, and without investment in their improvement, they would reduce plant electrical output by as much as 30% (creating the need for more new plants).

CO_2 separation processes suitable for IGCC plants are used commercially in the oil and gas and chemical industries at a scale closer to that ultimately needed, but their application necessitates development of modified IGCC plant equipment, including additional chemical process steps and gas turbines that can burn nearly pure hydrogen.

EPRI's most recent cost estimates suggest that for pulverized coal plants, the addition of CO_2 capture using the currently most developed technical option, amine solvents, along with CO_2 drying and compression, pipeline transportation to a nearby storage site, and underground injection, would add about 60–80% to the net present value of life-cycle costs of electricity (expressed as levelized cost-of-electricity, or COE, and excluding storage site monitoring, liability insurance, etc.). This translates into a potentially large hike in consumers' electric bills.

The COE cost premium for including CO_2 capture in IGCC plants, along with drying, compression, transportation, and storage, is about 40–50%. Although this is a lower cost increase in percentage terms than that for PC plants, IGCC plants initially cost more than PC plants. Thus, the bottom-line cost to consumers for power from IGCC plants with capture is likely to be comparable to that for PC plants with capture (the actual relative competitiveness depends on coal moisture content and other factors as described below). It should be noted that IGCC plants (like PC plants) do not capture CO_2 without substantial plant modifications, energy losses, and investments in additional process equipment. As noted above, however, the magnitude of these impacts could likely be reduced substantially through aggressive investments in R&D.

The COE cost premiums listed above vary in real-world applications, depending on available coals and their physical-chemical properties, desired plant size, the CO_2 capture process and its degree of integration with other plant processes, plant elevation, the value of plant co-products, and other factors. Nonetheless, IGCC with CO_2 capture generally shows an economic advantage in studies based on low-moisture bituminous coals. For coals with high moisture and low heating value, such as subbituminous and lignite coals, a recent EPRI study shows PC with CO_2 capture being competitive with or having an advantage over IGCC.[1] EPRI stresses that no single advanced coal generating technology (or any generating technology) has clear-cut economic advantages across the range of U.S. applications. The best strategy for meeting future electricity needs while addressing climate change concerns and economic impact lies in developing multiple technologies from which power producers (and their regulators) can choose the one best suited to local conditions and preferences.

Despite the substantial cost increases for adding CO_2 capture to coal-based IGCC and PC power plants, their resulting cost-of-electricity is still usually less than that for natural gas-based plants at current and forecasted gas prices.

Historical experience with power plant environmental control technologies suggests technological advances rooted in learning-by-doing will lead to significant cost reductions in CO_2 capture technologies as the installed base of plants with CO_2 capture grows. An International Energy Agency study led by Carnegie Mellon University suggested that overall electricity costs from plants with CO_2 capture could come down by 15% relative to the currently predicted costs after about 200 systems were installed.[2]

[1] Feasibility Study for an Integrated Gasification Combined Cycle Facility at a Texas Site, EPRI report 1014510, October 2006.
[2] Edward S. Rubin, et al., "Estimating Future Costs of CO_2 Capture Systems Using Historical Experience Curves," Presented at the 8th Int'l. Conf. on Greenhouse Gas Control Technologies, Trondheim, Norway, June 2006.

Engineering analyses by EPRI, DOE, and the Coal Utilization Research Council suggests that costs could come down faster through CO_2 capture process innovations or, in the case of IGCC plants, fundamental plant improvements—provided sufficient RD&D investments are made. EPRI pathways for reduction in capital cost and improvement in efficiency are embodied in two companion RD&D Augmentation Plans developed under the collaborative *CoalFleet for Tomorrow* program (see figures below).

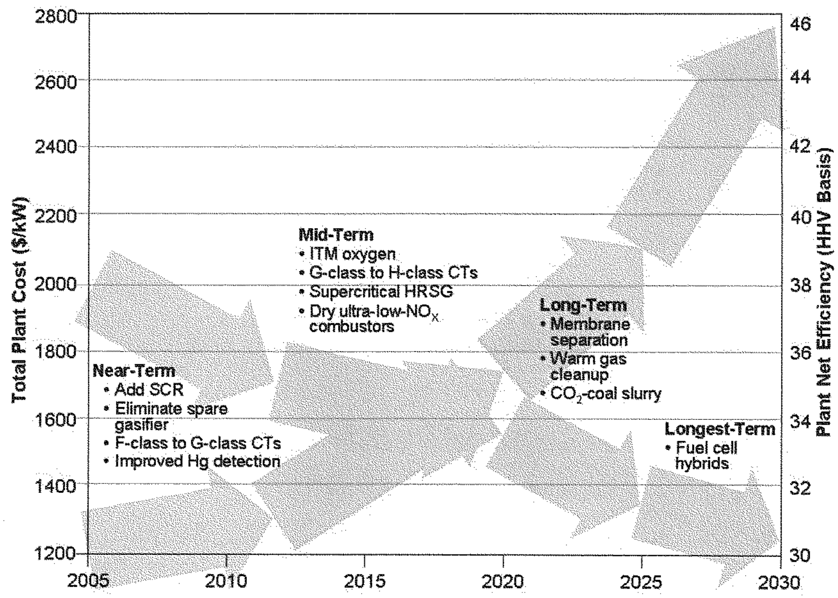


Figure 1: Forecast Reduction in Capital Cost and Improvement in Efficiency Through Implementation of the EPRI CoalFleet IGCC RD&D Augmentation Plan[3]

(Slurry-fed gasifier, Pittsburgh #8 coal, 90% availability, 90% CO_2 capture, 2Q 2005 U.S. dollars)

[3] *CoalFleet RD&D Augmentation Plan for Integrated Gasification Combined Cycle (IGCC) Power Plants,* EPRI report 1013219, January 2007.

Efforts toward reducing the cost of IGCC plants with CO_2 capture will focus on adapting more advanced and larger gas turbines for use with hydrogen-rich fuels, lower-cost oxygen supplies, improved gas clean-up, advanced steam cycle conditions, and more.

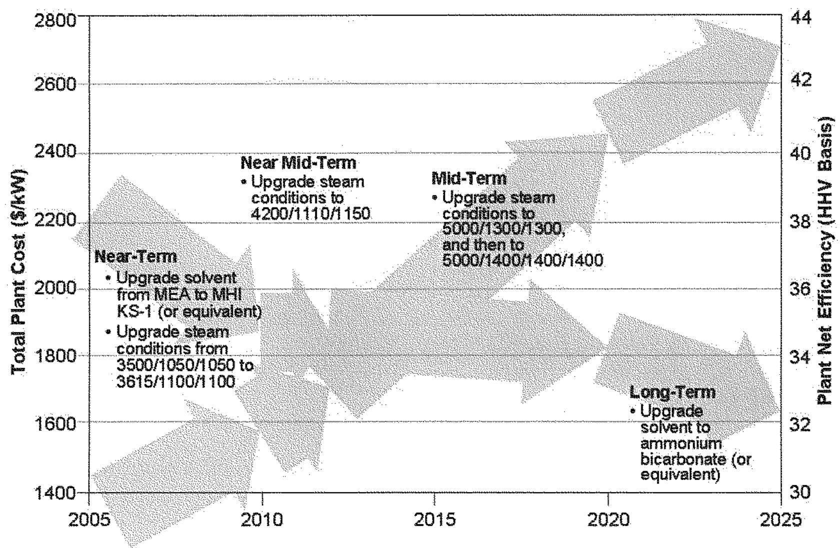


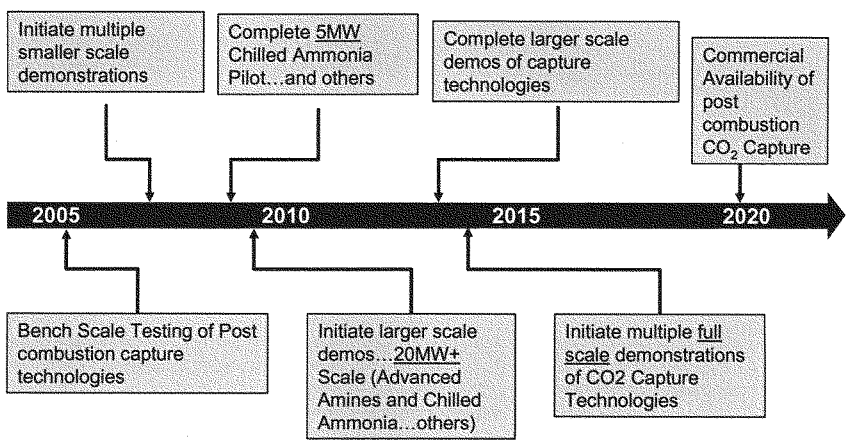
Figure 2: Forecast Reduction in Capital Cost and Improvement in Efficiency through Implementation of the CoalFleet USC PC RD&D Augmentation Plan[4]

(Pittsburgh #8 coal, 90% availability, 90% CO_2 capture, as-reported data from various studies [not standardized])

For PC plants, the progression to advanced ultra-supercritical steam conditions will steadily increase plant efficiency and reduce CO_2 production. Improved solvents are expected to greatly reduce post-combustion CO_2 capture process. EPRI is working to

4 Ibid.

accelerate the introduction of novel, alternative CO_2 separation solvents with much lower energy requirements for regeneration. Such solvents—for example, chilled ammonium carbonate—could reduce the loss in power output imposed by the CO_2 capture process from about 30% to about 10%. A small pilot plant (5 MW-thermal) is being designed for installation at a power plant in Wisconsin later this year; success there would warrant a scale-up to a larger pilot or pre-commercial plant. An EPRI timeline (compatible with DOE's timeframe) for the possible commercial introduction of post-combustion CO_2 capture follows.



The introduction of oxy-fuel combustion may allow further reductions in CO_2 capture costs by allowing the flue gas to be compressed directly, without any CO_2 separation process and reducing the size of the supercritical steam generator. Boiler suppliers and major European and Canadian power generators are actively working on pilot-scale testing and scale-up of this technology.

Assuring timely, cost-effective coal power technology with CO_2 capture entails simultaneous and substantial progress in RD&D efforts on improving capture processes and fundamental plant systems. EPRI sees the need for government and industry to pursue these and other pertinent RD&D efforts aggressively through significant public policy and funding support. Early commercial viability will likely come only through firm commitments to the necessary R&D and demonstrations and through collaborative arrangements that share initial risks and disseminate results.

CO_2 TRANSPORTATION & STORAGE

Geologic sequestration of CO_2 has been proven effective by nature, as evidenced by the numerous natural underground CO_2 reservoirs in Colorado, Utah, and other western states. CO_2 is also found in natural gas reservoirs, where it has resided for millions of years. Thus, evidence suggests that depleting or depleted oil and gas reservoirs, and similar "capped" sandstone formations containing saltwater that cannot be made potable, are capable of storing CO_2 for millennia or longer.

Geologic sequestration as a strategy for reducing CO_2 emissions is being demonstrated in numerous projects around the world. Three relatively large projects—the Sleipner Saline Aquifer CO_2 Storage (SACS) project in the North Sea off of Norway;[5] the Weyburn Project in Saskatchewan, Canada,[6] and the In Salah Project in Algeria[7]—together sequester about 3 to 4 million metric tonnes per year, which approaches the output of a typical 500 megawatt coal-fired power plant. With 17 collective years of operating

[5] http://www.iku.sintef.no/projects/IK23430000/
[6] http://www.co2captureandstorage.info/project_specific.php?project_id=70
[7] http://www.co2captureandstorage.info/project_specific.php?project_id=71

experience, these projects suggest that CO_2 storage in deep geologic formations can be carried out safely and reliably.

In the United States, DOE has an active R&D program (the "Regional Carbon Sequestration Partnerships") that is mapping geologic formations suitable for CO_2 storage and conducting pilot-scale CO_2 injection validation tests across the country. These tests, as well as most commercial applications for long-term storage, will compress CO_2 to a liquid-like "supercritical" state to maximize the amount stored per unit volume underground. As a result, virtually all CO_2 storage applications will be at least a half-mile deep, helping reduce the likelihood of any leakage to the surface.

CO_2 injection technology and subsurface behavior modeling have been proven in the oil industry, where CO_2 has been injected for 30 years for enhanced oil recovery (EOR) in the Permian Basin fields of west Texas and Oklahoma. Regulatory oversight and community acceptance of injection operations are well established.

The DOE Regional Carbon Sequestration Partnerships represent broad collaborative teaming of public agencies, private companies, and non-profits; they would be an excellent vehicle for conducting larger "near-deployment scale" CO_2 injection tests to prove specific U.S. geologic formations, which EPRI believes to be one of the keys to commercializing CCS for coal-based power plants.

Evaluations by the DOE Regional Carbon Sequestration Partnerships and others suggest that enough geologic storage capacity exists in the United States to hold several centuries' worth of CO_2 emissions from coal-based power plants and other stationary sources. However, the distribution of suitable storage formations across the country is not uniform. Some areas have ample storage capacity whereas others appear to have little or none. Thus, CO_2 captured at some power plants would be expected to require pipeline transportation for several hundred miles to suitable injection locations, which may be in other states. While this adds cost, it doesn't represent a technical hurdle because CO_2 pipeline technology has been proven in oil field EOR applications. As CCS is applied commercially, EPRI expects that early projects would take place at coal-based power plants near sequestration sites or an existing CO_2 pipeline. As the number of projects increases, regional CO_2 pipeline networks connecting multiple sources and storage sites (often called "sinks") would be needed.

There is still much work to be done before CCS can implemented on a scale large enough to significantly reduce CO_2 emissions into the atmosphere. In addition to large-scale demonstrations at U.S. geologic formations, many legal and institutional uncertainties need to be resolved. Uncertainty about long term monitoring requirements, liability, and insurance is an example. State-by-state variation in regulatory approaches is another. Some geologic formations suitable for CO_2 storage underlie multiple states. For private companies considering CCS, these various uncertainties translate into increased risk.

SUMMARY AND RECOMMENDATIONS

CO_2 capture technologies can be feasibly integrated into virtually all types of new coal-fired power plants, including IGCC, PC, CFB, and oxy-fuel boilers. Current costs and energy use are significant for all plant types, although not uniformly. Among these plant types, there is no economically preferred technology for generating electricity with CCS.

All have relative competitive advantages under various scenarios of available coal types, plant capacity, location, opportunities for by-product sales, etc. EPRI strongly recommends that R&D investments and climate policies reflect a portfolio approach that enables commercial incorporation of CCS into multiple advanced coal power technologies.

Sites for long-term geologic storage of captured CO_2 are regionally available throughout the United States (although some areas appear to have no nearby options).

There are major challenges to be overcome—both technically and in terms of public policy—before widespread commercial-scale carbon capture and storage can be achieved.

For geologic storage of CO_2 to become commercially viable, multiple large-scale (>1 million tons) demonstrations need to commence as soon as possible, and legal and regulatory frameworks need to be established to guide these demonstrations. EPRI believes that programs like the DOE Regional Carbon Sequestration Partnerships are excellent vehicles for conducting large-scale demonstrations. Regarding legal issues, work with our members and the FutureGen partners has shown that resolution of long-term liability, indemnification, and insurance unknowns is a crucial area where federal policy is needed.

R&D pathways for generating electricity from coal through 2030 have been established collaboratively by EPRI, DOE, and industry groups, such as the Coal Utilization Research Council. Plans for both IGCC and PC technologies show that—with adequate investment and resolution of policy issues—advanced coal-based power plants that capture more than 90% of the CO_2 that would otherwise be emitted could produce electricity at a cost competitive with other low-carbon generation technologies.

The funding needed to execute these R&D plans is a significant step up from current levels of investment, but is within historical percentages of energy R&D for government agencies and private industry. Given the long technology development and deployment lead times inherent in capital intensive industries like energy, investment and policy decisions must be made now or we risk foreclosing windows of opportunity for technology options that we expect will prove tremendously valuable in a carbon-constrained future.

Written Testimony of John A. Fees

Chief Executive Officer, The Babcock & Wilcox Companies

Before The

U.S. House Energy and Commerce Committee

Subcommittee on Energy and Air Quality

March 6, 2007

Chairman Boucher, Mr. Hastert and Members of the Subcommittee:

My name is John Fees and I am the Chief Executive Officer of The Babcock & Wilcox Companies.

It is my privilege to present this testimony on the combustion-based technology alternatives available today, and on the near horizon, that are designed to capture carbon dioxide emissions from electric power plants.

The Babcock & Wilcox Company has a rich legacy of providing reliable engineered technology solutions for efficient, base load electric generation throughout the U.S., North America and across the globe. We have sustained our business by developing and commercializing realistic solutions. Over many decades, we have successfully met the challenges of power generation and provided the technologies and equipment to resolve the associated environmental control issues. We provide commercially viable solutions to meet emissions control requirements of regulated pollutants. We will provide practical technologies to resolve the challenges of greenhouse gas emissions as well. B&W is a premier, comprehensive provider of clean energy.

The Babcock & Wilcox Company was formed in 1867. The first utility power plant in the United States had a boiler designed and supplied by B&W. B&W is the world's expert on steam which is still the most economic medium to generate electricity worldwide. B&W has literally written the book on "Steam." "Steam, Its Generation and Use" a text book produced by The Babcock & Wilcox Company, is the longest continuously published engineering textbook of its kind in the world, first published in 1875 and last updated in 2005.

Our manufacturing capabilities have also powered national security since the start of the last century. Teddy Roosevelt's Great White Fleet was primarily powered by B&W boilers. At the end of World War II, at the surrender of Japan, 395 of the 400 U.S. Navy ships in Tokyo Bay were powered by B&W boilers. In the 1950s, B&W became a major U.S. manufacturer and supplier of components for the U.S. Navy's fleet of nuclear powered ships and submarines.

Beyond defense, nuclear power is a route to carbon-free electricity generation for civilian purposes. We are the only US manufacturer of the heavy nuclear components that will be required for the emerging civilian nuclear power plant build-up. As such we anticipate playing a critical role in the coming nuclear renaissance to provide clean, safe nuclear power. I could easily write a substantial amount on nuclear power and its potential to help reduce carbon emissions, but the principal focus of this paper is coal fired generation and carbon capture.

Coal-fired and nuclear power plants provide the vast majority of the reliable and lowest cost electricity generation in this Country. Coal-fired and nuclear power plants combined comprise 41 percent of the Nation's electric generation capacity. Due to their cost effectiveness these plants generate 69 percent of all the electricity in the Country. These technologies are the foundation of our economic competitiveness, energy security, and increasing standard of living.

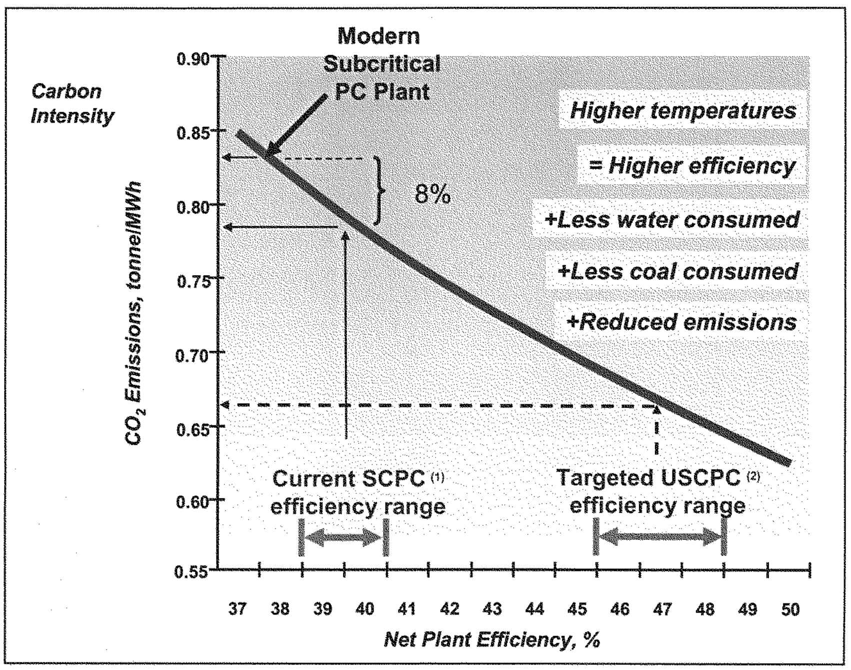
B&W's position as a premier developer and manufacturer of coal technologies and facilities is widely recognized. Thirty-eight percent of US coal-fired boilers have been designed and manufactured by B&W. B&W supplies around one-third of all environmental control technologies and equipment to the US coal power marketplace. We have been selected to provide many of the emission control technology solutions used by electric power generators to meet the strictest requirements under the Clean Air Act, the Clean Air Interstate Rule (CAIR) rule and various stringent air permitting requirements in the states. B&W has also been awarded a number of the new, highly efficient supercritical coal fired power plant projects, including the first high efficiency Ultra Supercritical Power plant in the US in four decades.

Advanced Coal Power Technologies

Efficiencies

Efficiency at a power plant is measured by the ratio of the electricity generated compared to the energy in the fuel used. Increasing steam temperatures and pressures provides more energy to the steam turbine, enabling higher efficiency and allowing the same amount of electricity to be generated by burning less coal. This results in less production of CO_2 and pollutants derived by coal combustion, and reduced fuel costs.

Many existing US coal-fired plants operate with relatively low steam temperatures and pressures (subcritical steam conditions). These old plants are generally used during high electricity demand periods because of the low generation efficiency, typically in the 30-35 percent range. When steam conditions exceed the combination of both 760F and 3200psi, the steam (or working fluid) is said to reach supercritical conditions. Efficiencies of these plants exceed 37 percent. Replacement of a relatively common 37 percent efficient subcritical unit with a 40 percent supercritical unit of same generating capacity would reduce CO_2 emissions by about 8 percent. Supercritical plants with efficiencies around 40 percent are already commercially available and being increasingly deployed. R&D projects with advanced materials and manufacturing methods are underway to permit increases of working fluid temperatures to 1200F, and then to around 1400F. When this happens efficiencies will rise above 43 percent toward 48 percent.



It is important to note when evaluating coal plant performance, that efficiency numbers, taken at face value, can be misleading. The US convention for calculating efficiency, called "higher heating value (HHV)," is different from that used in Europe, "lower heating value (LHV)." One of the factors responsible for the difference is the way moisture in coal is treated in the efficiency calculation. There are other factors that enter into the calculation as well. The result is that, for virtually identical plant performance (coal fuel in vs. power out), the US efficiency (HHV basis) would be reported as being 2 to 4 percent lower than European efficiency (LHV basis).

Pollutants

The emissions from pulverized coal-fired power plants have been reduced tremendously over the past three decades, with this achievement due in part to market based regulatory structures pulling technology forward for deployment. Great strides have been made in SO_2 and NOx reduction through scrubbing and selective catalytic reduction technologies. Fabric filters and improvements in electrostatic precipitators have reduced particulate emissions and more recently, technologies such as wet electrostatic precipitators and sorbent injection are capable of further reductions including fine particulates (PM2.5).

With technologies available to address regulated pollutants and major programs to retrofit the existing fleet in progress, public and industry attention turned to mercury. As a result, commercially available mercury control, for both eastern and western coals are being deployed. Now, concerns about climate change have intensified leading to the pressing need for the development of ways to address carbon dioxide emissions.

Carbon Dioxide Capture

There are several promising technologies to address capture of CO_2 from the use of fossil fuels and all are dependent upon development of a safe means of permanent storage. Assuming storage technologies can be commercialized and enabled, the challenge for coal combustion processes becomes one of extracting the CO_2 from the combustion process. A modern power plant using sub-bituminous coal will produce about 1,800 lbs of CO_2 per MWh. In an uncontrolled state, the CO2 is diluted in the exhaust gas to about 15 percent of its volume; this creates a challenge to produce a concentrated CO_2 stream for storage.

Three approaches are presently seen as plausible carbon capture techniques: 1) Oxy Coal Combustion for new and existing plants that burn coal, 2) amine scrubbing for new or existing plants that burn coal, and 3) pre-combustion processes utilized by IGCC. Oxygen combustion produces a concentrated CO_2 in the combustion process by supplying pure oxygen instead of air for combustion eliminating nitrogen which dilutes the CO_2 concentration. Pre-combustion and amine scrubbing process extract the CO_2 from the gas stream using a regenerable solvent such as monoethanolamine (MEA). Some current studies now show oxygen combustion as the least costly while other studies lean toward pre-combustion or advanced amines, indicating that technology development is underway and competition is strong. None of the technologies has been demonstrated at significant size in an integrated full-scale system for electricity generation.

Oxy-Coal Combustion

Only the Oxy Coal Combustion process is based upon equipment and systems that are already commercially available at the required scale. However, there are integration requirements, operating parameters and final designs that require verification at larger scale. Oxygen combustion and the major operational processes have been demonstrated at pilot scale and a new 300 MW commercial plant using this technology is being developed by B&W for the SaskPower Corporation to be located at Estevan, Saskatchewan.

In spite of the additional cost to concentrate a CO_2 stream for storage, recent studies show oxygen combustion to be competitive with the other capture technologies. Since this technology utilizes conventional equipment, it is likely to have a considerably lower deployment and operational risk, and has potential for retrofit to the existing fleet of conventional plants.

Additionally, recent studies by the U.S. Department of Energy indicate oxygen combustion will be the lowest cost solution for coal and that the incremental cost increases of electricity using oxy combustion is less than the increase associated with amine CO_2 scrubbing.

Oxygen combustion provides a means of replacing the nitrogen in air with CO_2 gas exiting the combustion chamber. By recirculating a portion of the combustion stream the oxy coal combustion plant effectively replaces the nitrogen in a conventional system with CO2 thereby inherently creating a concentrated CO_2 stream for permanent storage. The net effect is that the system looks and acts like a conventional power plant with which power plant operators are comfortable, but which is capable of near zero emissions given carbon storage. Additionally, by excluding air conveyed nitrogen from the combustion chamber there is a sharp reduction in nitrogen oxide emissions from this technology, which is likely to obviate the need for selective catalytic reduction facilities.

Although the properties of the flue gas differ from those with air firing due to the lack of nitrogen, it has been found that with the proper recycle ratio, an existing boiler can be converted to oxy coal combustion without changing heat transfer surfaces and only experiencing a small impact on fuel efficiency in the boiler island. For new units, optimized arrangements are being studied that offer some reduction in equipment size and improved performance.

The first generation of full-scale units is intended to require minimal change to the conventional power plant as reasonable to permit retrofit application and minimize risk. Advanced air separation technologies and optimization of the product gas specification and the cleanup/compression process are also expected to improve both performance and cost.

Radical Innovations

We see Oxy Coal technology as one of the potential carbon management solutions for the relatively near future. B&W is developing a portfolio of potential solutions, including some that are radically different from any that are currently approaching readiness for full scale testing. One of these approaches involves destruction of carbon dioxide, using naturally occurring enzymes to catalyze the reaction. While clearly still at the research stage, this approach may bear the potential for greatly reducing the costs for carbon dioxide reduction in the longer term.

Closing Comments

The first wave of near-zero emission coal plants will start operations around 2012. As industry learns from these early commercial deployments, we will make adjustments to improve efficiency and competitiveness. Technology development, economic and market incentives can accelerate the timeframe for implementing widespread carbon capture deployments on a commercial scale. This will only be successful if legislation does not favor one technology over another.

We are confident that our Oxy Coal Combustion technology can provide the most cost-effective solution for some power plants, while other technologies are better suited for others.

We are encouraged by indications that a consensus is building toward a market-based system for carbon management. A market-based system should encourage an efficient allocation of resources for reductions of carbon emissions both at new plants and, where tenable, at some existing plants. It is important to recognize that to significantly reduce our nation's CO2 emissions, capture of CO2 will have to occur at existing fossil-fired plants.

We ask that the legislation support the acceleration of resolving and expanding Research and Development associated with carbon storage. In addition there is a need for clear policies regarding legal ownership of and liability for the injected CO2, and concise communications to overcome local concerns with large annual injections at storage sites. We believe that unless the regulatory and technical obstacles to the long-term storage of carbon dioxide from electric power plants are resolved, these will become the limiting factors in reducing carbon emissions.

Thank you for the privilege to testify before the Subcommittee on these critically important matters.

Technical feasibility of rapid deployment of geological carbon sequestration

House Energy and Commerce Committee
Energy and Air Quality Sub-committee Hearing:
"Carbon Capture and Sequestration: An Overview"
Written Testimony

Dr. S. Julio Friedmann
Lawrence Livermore National Laboratory
March 6, 2007

Mr. Chairman, Representative Hastert, and members of the Committee: Thank you for inviting me to testify today on the technical aspects of carbon capture and sequestration. I am pleased to be here in my capacity as leader of the Carbon Management Program at the Lawrence Livermore National Laboratory to testify on this important technology pathway which could help continue to meet America's domestic energy needs while dramatically reducing the emission of greenhouse gases. Carbon capture and sequestration can be a vital element of a comprehensive energy strategy that includes efficiency gains, conservation, and carbon free energy supplies such as renewable or nuclear power. It can also support environmentally sound development of domestic transportation fuels including biofuels, coal-to-liquids, and hydrogen, and a smooth transition to a carbon-free energy infrastructure.

Carbon capture and sequestration (CCS) has two components. The first is the separation and concentration of CO_2 from point source flue gases, which are produced at power plants, refineries, ethanol plants, fertilizer plants, and other sources like cement factories. This step is needed to bring CO_2 concentrations up to 95 percent before the second step, sequestration. Geological carbon sequestration (GCS) or carbon storage, involves injection of CO_2 into porous rock formations deep below the surface. The goal is to keep CO_2 out of the atmosphere so as to avoid atmospheric warming and the consequences of climate change while allowing the continued use of fossil fuels for power generation and industrial purposes.

Over the past two years, much has been written on the subject of CCS. The Intergovernmental Panel on Climate Change (IPCC) 2005 special report includes a 135-page chapter on GCS. The MIT Report on the Future of Coal in a Carbon Constrained World, released next week, discusses geological sequestration in detail. Shortly, the National Petroleum Council will publish its 30 year strategy that includes a chapter on GCS. These documents and others listed at the end of this testimony serve as resources to those interested in learning more about the technical details that underlie my testimony.

Overview of Geological Carbon Sequestration

Basically, geological carbon sequestration involves compressing CO_2 to elevated pressures and injecting it into geological formations that are from 3,000 to 20,000 feet deep. The most promising reservoirs are *porous and permeable rock bodies*, generally at 1 km depth and pressures and temperatures where CO_2 would be in a supercritical phase in which it behaves like a very dense, liquid-like gas. These potential reservoirs include:

- *Saline formations*, which contain brine in their pore volumes, commonly of salinities greater than 10,000 ppm.
- *Depleted oil and gas fields* which have some combination of water and hydrocarbons in their pore volumes and a demonstrated seal. Injection of CO_2 into these reservoirs can stimulate enhanced oil recovery (EOR) or enhanced gas recovery and increase domestic fuel supply; substantial CO_2-EOR already occurs in the US with both natural and anthropogenic CO_2.
- *Deep coal seams*, often called unmineable coal seams, which comprise organic minerals with brines and gases in their pore and fracture volumes.

Once the CO_2 is injected into the subsurface, it will flow throughout the storage formation where it will remain trapped. This trapping will keep those greenhouse gases out of the atmosphere indefinitely. The IPCC issued a special report in 2005 on the topic of carbon sequestration, stating that if a site is chosen well and operated well, then it is highly likely (>90%) to store 99.9% of injected CO_2 in place for 100's of years, and likely to store 99% for 1000's of years.

The Earth's shallow crust is well suited to the indefinite trapping and storage of CO_2 because of its physical and chemical properties. This is because four different mechanisms trap CO_2 in the subsurface. To begin, CO_2 sequestration targets will have *physical barriers* to CO_2 migration out of the crust to the surface. These barriers will commonly take the form of impermeable layers (e.g., shales, evaporites) overlying the reservoir target and act immediately to limit CO_2 flow. At the pore scale, *capillary forces* will immobilize a substantial fraction of CO_2 as tiny, isolated bubbles trapped as a residual phase. Over a period of tens to hundreds of years, CO_2 in the formation will *dissolve* into other pore fluids, including hydrocarbon species (oil and gas) or brines, where the CO_2 cannot be released without active intervention. Over longer time scales (hundreds to thousands of years) the dissolved CO_2 may react with minerals in the rock volume to *precipitate* the CO_2 as new carbonate minerals. Finally, in the case of organic mineral frameworks such as coals, the CO_2 will physically *adsorb* onto the rock surface, sometimes displacing other gases (e.g., methane, nitrogen). These trapping mechanisms have been documented and observed in natural analogs (e.g., the natural CO_2 domes in Colorado) and laboratory experiments, and they have been simulated in integrated geological models. Although substantial work remains to characterize and quantify these mechanisms, they are sufficiently well understood today to trust estimates of the percentage of CO_2 stored over the timeframes discussed by the IPCC.

Because of their large storage potential and broad distribution, saline formations are likely sites for most geological sequestration. However, initial projects probably will occur in depleted oil and gas fields, accompanying EOR, due to the density and quality of existing subsurface data and the potential for economic return; the Weyburn EOR and storage project in Saskatchewan is one example. Availability of pore volumes in suitable formations for sequestration may be considered a natural resource. Areas that have this resource in abundance have a competitive advantage in a carbon constrained world compared to those that lack storage capacity.

At its heart, GCS is similar to oil and gas production (especially EOR), natural gas storage, hazardous waste disposal, and acid gas management. It is highly analogous to the injection of CO_2 for enhanced oil recovery, which has been done in the US for over 30 years. These activities use the same technologies as GCS, and their technical basis provides confidence in the viability of commercial GCS deployment. In addition, natural accumulations of CO_2 have demonstrably retained large CO_2 volumes for 10's to 100's of millions of years. This provides confidence in the possibility of long-term storage of CO_2 in suitable rock formations.

A key difference between GCS and applications mentioned above is that the GCS goal is to keep the CO_2 in the reservoir. This new application will have new requirements, such as a monitoring and verification (M&V) program. A site M&V program to support GCS should provide these services:

- to identify any early concerns or problems (as mentioned below) and protect public health and safety;
- to assign credits or offsets for commercial GCS, especially under a cap-and trade regime;
- to validate simulations and current understanding of sequestration science; and
- to guide any necessary mitigation efforts.

There are many technologies used in industry today that can monitor CO_2 in the subsurface and the surface, including time-lapse reflection seismic surveying, use of tracers, and electrical soundings. Some of these approaches have been tested in commercial and experimental projects. However, there has been little comprehensive application of these technologies to monitor CO_2 to date.

Several hazards could affect CCS operations at a site. These hazards, such as well failure or CO_2 seepage along faults, could lead to problems such as atmospheric release of CO_2 or groundwater contamination. Pre-existing wells present the largest risks as potential leakage paths, but leakage through wells is the simplest to detect and mitigate. Preliminary analyses through analog studies and simulation, which have been performed by industry, academia and national laboratories, suggest that the risks posed by these hazards are both very small and manageable. As such, carbon capture and sequestration can be safely and effectively deployed widely within the US. Key steps to avoiding hazards are careful site characterization before injection and appropriate M&V programs during injection.

The scale of commercial GCS

Today, the US emits annually 2 billion tons CO_2 from large point sources, and 25 percent of US CO_2 emissions come from coal power generation (~1.5 billion tons). To help you appreciate the scales involved, 1 billion tons is greater than the mass of all human beings on earth. Alternatively, the volumes of CO_2 at depth represented by this mass exceed current US oil and natural gas production combined. A single 1000 MW coal power plant will emit from 5 to 8 million tons CO_2 each year, roughly the same emissions as a 25,000 barrel/day coal-to-liquids plant. With sequestration in an appropriate geological formation, a 50 year injection program for one of these plants would accumulate in excess of 2 billion barrels of CO_2.It is the necessary scale of sequestration projects and enterprise that present challenges to deployment.

The good news is that it appears that the US has more than enough capacity to deploy CCS at large scale. Conservative estimates (including some I've published) are that the US has 2,200 billion tons capacity. Large sequestration resources occur in the mid-west, Texas, and the intermountain west, and substantial opportunities also exist in California, the Dakotas, Michigan, and offshore of the eastern US. The largest of these resources lie in saline formations and depleted oil and gas fields. While these published estimates are uncertain, it is likely that they substantially underestimate total US capacity. Said another way, we appear to have enough capacity to comfortably inject all of our current point source CO_2 emissions for more than 100 years, and are likely to be able to do so comfortably for more than 1000 years.

Commercial projects in carbon storage are underway elsewhere in the world. Three of them (Sleipner in Norway, In Salah in Algeria, and Weyburn in Canada) annually inject over 1 million tons of CO_2 from anthropogenic sources. Several more will come on line in 2008 in Norway and Australia, and nearly a dozen are on track world-wide for completion and injection before 2012. In the US, BP has announced a project in Carson California that will inject 4 million tons of CO_2 each year while producing 500 megawatts (MW) of zero-emission power. Xcel Energy has announced a project to generate 600 MW of zero-emission coal power using CCS. A few of these are enhanced oil recovery projects, which will produce additional liquid fuels. Most of these projects will inject into saline formations, which represent the largest potential CO_2 sinks in the US and the world. These activities demonstrate tremendous technical readiness in the US and the world for commercial deployment.

Potential climate abatement and cost

CCS has the potential to substantially reduce US and global greenhouse gas emissions. From a technical basis, that potential is only limited by the characteristics of the geology. Three conditions are important, sometimes called the ICE characteristics:

- I: sufficient *injectivity* to receive large volumes of CO_2 rapidly (up to several million tons CO_2/year for each project).
- C: sufficient *capacity* to accept large volumes of CO_2 (for some projects, in excess of 300 million tons over the project lifetime)
- E: *effectiveness* in trapping CO_2 for long time spans (100's to 1000's of years).

Based on these characteristics, it appears that both the US and world have abatement potential for CCS between 15 and 55 percent of global emissions reduction by 2050, based on current understandings of global geological options and energy supply infrastructure. The high reductions can be achieved through advanced technology options which connect the transportation sector to a decarbonized electric power sector that includes CCS (e.g., plug-in hybrid deployment, biofuels, or hydrogen). Importantly, this is a very attractive option for rapidly developing countries like China and India with large coal resources.

Most experts see CCS as a bridging technology. This means that it is actionable immediately and could be sustained for many years, allowing us to dramatically reduce greenhouse gas emissions while maintaining the economic benefits of fossil fuel power generation and making use of the current infrastructure. Most experts envision a subsequent future transition away from CCS as new carbon free technologies grow in the market place, including renewables, advanced fission and fusion power, and other developing technologies. CCS could be sustained in the US for a century serving as an affordable interim measure to buy time while an energy strategy and infrastructure is developed to support long-term needs.

Others testifying here today have discussed the costs of carbon capture and separation. By comparison, the costs of sequestration are much lower. For most US targets, the estimated cost of storage injection projects ranges from $1 to 12 per ton CO_2, but average cases range from $5 to 8 per ton CO_2. This is roughly 10% the total cost of capture and separation. The cost of monitoring and verification is much lower, with estimates from $0.25 to 1.00 per ton CO_2. The costs of assessment and site characterization are even less, estimated to be much less than $0.001 per ton CO_2.

Technical needs

I was asked to comment on what we know about carbon sequestration as an option for addressing climate change and what we don't know. I was also asked what work needs to be done to understand those things we don't know. To better bound the 15 to 55 percent estimate of potential greenhouse emission abatement through carbon sequestration, we need to increase the current understanding of global and national geological storage resources. Ultimately, GCS potential will depend on local geological conditions and energy infrastructure choices. Future energy infrastructure decisions (e.g., plant type and location) should be informed by understandings of storage resources. Assessment of this resource can be accomplished through careful and detailed geological studies and validated by a handful of large-scale demonstrations in representative geology. Those demonstrations should both confirm the safe and effective storage of CO_2 in the key formations and should provide the technical basis for future regulatory framework and operation protocols.

An assessment of geological storage resources should provide several key pieces of technical information:.

- A uniform, documented methodology that allows intercomparisons of geologic opportunities and accounts for the different trapping mechanisms.
- A capacity estimate for each region or state and for the nation as a whole.
- A relative ranking of potential sites by storage effectiveness, and their associated capacities.

- Rate information indicating the likely maximum sustainable injection rates for formations and regions.
- Data needed to develop economic models for GCS projects.

In short, a national capacity assessment would provide the same kinds of information that the national hydrocarbon assessments offer in mapping out the natural resources of the country with respect to this purpose. In this context, available pore volume to store CO_2 is such a resource.

The Australian GEODISC program conducted such an assessment four years ago, and this information provided businesses and government with the information needed to make investment and policy decisions. That information has led to Australia's international leadership in GCS and buy-in from major industries such as coal mining and petroleum production. It also provided much information that entered into their regulatory framework, passed into law last month. GEODISC cost only $10 million and took only 3 years.

Because of the enormous scale required for commercial CCS operation, large projects are crucial to confirming our understanding of how CO_2 is trapped and stored, refining deployment operations, and demonstrating success. Smaller projects provide a partial learning platform; however, the key unresolved questions pertaining to commercial-scale injections can only be resolved at large scale. This is due to the hydrological, chemical, and mechanical response of the crust to changes in pressure and fluid composition from CO_2 injection. Many important responses only occur when thresholds are reached, and these will not be reached by small-scale injections. For example, the pressure build-up could cause mechanical failure of the caprock, faults, or wells only when their yield strength is exceeded. That cannot be tested with small-scale injections. Similarly, the rock heterogeneities that control flow in target reservoirs do not become apparent until large volumes are injected for long periods of time.

These issues could be resolved by a select number of large-scale experimental projects (on the order of 1 million tons CO_2/year injection) in target reservoirs of different characteristics that are instrumented, monitored, and analyzed to verify the practical reliability and implementation of sequestration. In addition, the technical results from such large-scale projects could inform the development of operational protocols and regulations. This would require an appropriate, integrated science and technology program to provide the needed analysis. Large experiments will provide the critical segue way to commercial operation and significant abatement of CO_2 in our atmosphere.

Summary

Opportunities for rapid deployment of GCS exist in the US. There is enough technical knowledge to select a safe and effective storage site, plan a large-scale injection, monitor CO_2, and remediate and mitigate any problems that might arise (e.g., well-bore leakage). This knowledge derives from over 100 years of groundwater resource work, oil and gas exploration and production, studies of geological analogs, natural gas storage site selection and operation, and hazardous waste disposal. A careful operator could begin work today at a commercial scale and confidently select and operate a site for 30 to 50 years.

National deployment of commercial CCS poses technical challenges and concerns due to the operational scale. An aggressive research, development, and deployment program could answer all the key technical questions within 10 years and could advise the formation of a legal and regulatory framework to protect the public without undue burden to industry.

Thank you again for the opportunity to present. I look forward to answering questions you might have, and to the real-time deployment of large-scale carbon management in the US.

Testimony of David G. Hawkins

Director, NRDC Climate Center

Thank you for the opportunity to testify today on the subject of carbon capture and sequestration. My name is David Hawkins. I am director of the Climate Center at the Natural Resources Defense Council (NRDC). NRDC is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1.2 million members and online activists nationwide, served from offices in New York, Washington, Los Angeles and San Francisco, Chicago and Beijing.

Today, the U.S. and other developed nations around the world run their economies largely with industrial sources powered by fossil fuel and those sources release billions of tons of carbon dioxide (CO_2) into the atmosphere every year. There is national and global interest today in capturing that CO_2 for disposal or sequestration to prevent its release to the atmosphere. To distinguish this industrial capture system from removal of atmospheric CO_2 by soils and vegetation, I will refer to the industrial system as carbon capture and disposal or CCD.

The interest in CCD stems from a few basic facts. We now recognize that CO_2 emissions from use of fossil fuel result in increased atmospheric concentrations of CO_2, which along with other so-called greenhouse gases, trap heat, leading to an increase in temperatures, regionally and globally. These increased temperatures alter the energy balance of the planet and thus our climate, which is simply nature's way of managing energy flows. Documented changes in climate today along with those forecasted for the next decades, are predicted to inflict large and growing damage to human health, economic well-being, and natural ecosystems.

Coal is the most abundant fossil fuel and is distributed broadly across the world. It has fueled the rise of industrial economies in Europe and the U.S. in the past two centuries and is fueling the rise of Asian economies today. Because of its abundance, coal is cheap and that makes it attractive to use in large quantities if we ignore the harm it causes. However, per unit of energy delivered, coal today is a bigger global warming polluter than any other fuel: double that of natural gas; 50 per cent more than oil; and, of course, enormously more polluting than renewable energy, energy efficiency, and, more controversially, nuclear power. To reduce coal's contribution to global warming, we must deploy and improve systems that will keep the carbon in coal out of the atmosphere, specifically systems that capture carbon dioxide (CO_2) from coal-fired power plants and other industrial sources for safe and effective disposal in geologic formations.

The Toll from Coal

Before turning to the status of CCD let me say a few words about coal use generally. The role of coal now and in the future is controversial due to the damages its production and use inflict today and skepticism that those damages can or will be reduced to a point where we should continue to rely on it as a mainstay of industrial economies. Coal is cheap and abundant compared to oil and natural gas. But the toll from coal as it is used today is enormous. From mining deaths and illness and devastated mountains and streams from practices like mountain top removal mining, to accidents at coal train crossings, to air emissions of acidic, toxic, and heat-trapping pollution from coal combustion, to water pollution from coal mining and combustion wastes, the conventional coal fuel cycle is among the most environmentally destructive activities on earth. Certain coal production processes are inherently harmful and while our society has the capacity to reduce many of today's damages, to date, we have not done so adequately nor have we committed to doing so. These failures have created well-justified opposition by many people to continued or increased dependence on coal to meet our energy needs.

Our progress of reducing harms from mining, transport, and use of coal has been frustratingly slow and an enormous amount remains to be done. Today mountain tops in Appalachia are destroyed to get at the coal underneath and rocks, soil, debris, and waste products are dumped into valleys and streams, destroying them as well. Waste impoundments loom above communities (including, in one particularly egregious case, above an elementary school) and thousands of miles of streams are polluted. In other areas surface mine reclamation is incomplete, inadequately performed and poorly supervised due to regulatory gaps and poorly funded regulatory agencies.

In the area of air pollution, although we have technologies to dramatically cut conventional pollutants from coal-fired power plants, in 2004 only one-third of U.S. coal capacity was equipped with scrubbers for sulfur dioxide control and even less capacity applied selective catalytic reduction (SCR) for nitrogen oxides control. And under the administration's so-called CAIR rule, even in 2020 nearly 30 per cent of coal capacity will still not employ scrubbers and nearly 45 per cent will lack SCR equipment. Moreover, because this administration has deliberately refused to require use of available highly effective control technologies for the brain poison mercury, we will suffer decades more of cumulative dumping of this toxin into the air at rates several times higher than is necessary or than faithful implementation of the Clean Air Act would achieve. Finally, there are no controls in place for CO_2, the global warming pollutant emitted by the more than 330,000 megawatts of coal-fired plants; nor are there any CO2 control requirements adopted today for old or new plants save in California.

Mr. Chairman and members of the committee, I know the environmental community is criticized in some quarters for our generally negative view regarding coal as an energy resource. But I would ask you to consider the reasons for this. Our community reacts to the facts on the ground and those facts are far from what they should be if coal is to play a role as a responsible part of the 21st century energy mix. Rather than simply decrying the attitudes of those who question whether using large amounts of coal can and will be carried out in a responsible manner, the coal industry in particular should support policies to correct today's abuses and then implement those reforms. Were the industry to do this, there would be real reasons for my community and other critics of coal to consider whether their positions should be reconsidered.

The Need for CCD

Turning to CCD, my organization supports rapid deployment of such capture and disposal systems for sources using coal. Such support is not a statement about how dependent the U.S. or the world should be on coal and for how long. Any significant additional use of coal that vents its CO2 to the air is fundamentally in conflict with the need to keep atmospheric concentrations of CO2 from rising to levels that will produce dangerous disruption of the climate system. Given that an immediate world-wide halt to coal use is not plausible, analysts and advocates with a broad range of views on coal's role should be able to agree that, if it is safe and effective, CCD should be rapidly deployed to minimize CO2 emissions from the coal that we do use.

Today coal use and climate protection are on a collision course. Without rapid deployment of CCD systems, that collision will occur quickly and with spectacularly bad results. The very attribute of coal that has made it so attractive—its abundance---magnifies the problem we face and requires us to act now, not a decade from now. Until now, coal's abundance has been an economic boon. But today, coal's abundance, absent corrective action, is more bane than boon.

Since the dawn of the industrial age, human use of coal has released about 150 billion metric tons of carbon into the atmosphere—about half the total carbon emissions due to fossil fuel use in human history. But that contribution is the tip of the carbon iceberg. Another 4 *trillion* metric tons of carbon are contained in the remaining global coal resources. That is a carbon pool nearly seven times greater than the amount in our pre-industrial atmosphere. Using that coal without capturing and disposing of its carbon means a climate catastrophe.

And the die is being cast for that catastrophe today, not decades from now. Decisions being made today in corporate board rooms, government ministries, and congressional hearing rooms are determining how the next coal-fired power plants will be designed and operated. Power plant investments are enormous in scale, more than $1 billion per plant, and plants built today will operate for 60 years or more. The International Energy Agency (IEA) forecasts that more than $5 trillion will be spent globally on new power plants in the next 25 years. Under IEA's forecasts, over 1800 gigawatts (GW) of new coal plants will be built between now and 2030—

capacity equivalent to 3000 large coal plants, or an average of ten new coal plants every month for the next quarter century. This new capacity amounts to 1.5 times the total of all the coal plants operating in the world today.

The astounding fact is that under IEA's forecast, 7 out of every 10 coal plants that will be operating in 2030 don't exist today. That fact presents a huge opportunity—many of these coal plants will not need to be built if we invest more in efficiency; additional numbers of these coal plants can be replaced with clean, renewable alternative power sources; and for the remainder, we can build them to capture their CO_2, instead of building them the way our grandfathers built them.

If we decide to do it, the world could build and operate new coal plants so that their CO_2 is returned to the ground rather than polluting the atmosphere. But we are losing that opportunity with every month of delay—10 coal plants were built the old-fashioned way last month somewhere in the world and 10 more old-style plants will be built this month, and the next and the next. Worse still, with current policies in place, none of the 3000 new plants projected by IEA are likely to capture their CO_2.

Each new coal plant that is built carries with it a huge stream of CO_2 emissions that will likely flow for the life of the plant—60 years or more. Suggestions that such plants might be equipped with CO_2 capture devices later in life might come true but there is little reason to count on it. As I will discuss further in a moment, while commercial technologies exist for pre-combustion capture from gasification-based power plants, most new plants are not using gasification designs and the few that are, are not incorporating capture systems. Installing capture equipment at these new plants after the fact is implausible for traditional coal plant designs and expensive for gasification processes.

If all 3000 of the next wave of coal plants are built with no CO_2 controls, their lifetime emissions will impose an enormous pollution lien on our children and grandchildren. Over a projected 60-year life these plants would likely emit 750 billion tons of CO_2, a total, from just 25 years of investment decisions, that is 30% greater than the total CO_2 emissions from all previous human use of coal. Once emitted, this CO_2 pollution load remains in the atmosphere for centuries. Half of the CO_2 emitted during World War I remains in the atmosphere today.

In short, we face an onrushing train of new coal plants with impacts that must be diverted without delay. What can the U.S. do to help? The U.S. is forecasted to build nearly 300 of these coal plants, according to reports and forecasts published by the U.S. EIA. By taking action ourselves, we can speed the deployment of CO_2 capture here at home and set an example of leadership. That leadership will bring us economic rewards in the new business opportunities it creates here and abroad and it will speed engagement by critical countries like China and India.

To date our efforts have been limited to funding research, development, and limited demonstrations. Such funding can help in this effort if it is wisely invested. But government subsidies--which are what we are talking about--cannot substitute for the driver that a real market for low-carbon goods and services provides. That market will be created only when requirements to limit CO_2 emissions are adopted. This year in Congress serious attention is finally being directed to enactment of such measures and we welcome your announcement that you intend to play a leadership role in this effort.

Key Questions about CCD

I started studying CCD in detail ten years ago and the questions I had then are those asked today by people new to the subject. Do reliable systems exist to capture CO_2 from power plants and other industrial sources? Where can we put CO_2 after we have captured it? Will the CO_2 stay where we put it or will it leak? How much disposal capacity is there? Are CCD systems "affordable"? To answer these questions, the Intergovernmental Panel on Climate Change (IPCC) decided four years ago to prepare a special report on the subject. That report was issued in September, 2005 as the IPCC Special Report on Carbon Dioxide Capture and Storage. I was privileged to serve as a review editor for the report's chapter on geologic storage of CO_2.

CO_2 Capture

The IPCC special report groups capture or separation of CO_2 from industrial gases into four categories: post-combustion; pre-combustion; oxyfuel combustion; and industrial separation. I will say a few words about the basics and status of each of these approaches. In a conventional pulverized coal power plant, the coal is combusted using normal air at atmospheric pressures. This combustion process produces a large volume of exhaust gas that contains CO_2 in large amounts but in low concentrations and low pressures. Commercial post-combustion systems exist to capture CO_2 from such exhaust gases using chemical "stripping" compounds and they have been applied to very small portions of flue gases (tens of thousands of tons from plants that emit several million tons of CO_2 annually) from a few coal-fired power plants in the U.S. that

sell the captured CO_2 to the food and beverage industry. However, industry analysts state that today's systems, based on publicly available information, involve much higher costs and energy penalties than the principal demonstrated alternative, pre-combustion capture.
New and potentially less expensive post-combustion concepts have been evaluated in laboratory tests and some, like ammonia-based capture systems, are scheduled for small pilot-scale tests in the next few years. Under normal industrial development scenarios, if successful such pilot tests would be followed by larger demonstration tests and then by commercial-scale tests. These and other approaches should continue to be explored. However, unless accelerated by a combination of policies, subsidies, and willingness to take increased technical risks, such a development program could take one or two decades before post-combustion systems would be accepted for broad commercial application.

Pre-combustion capture is applied to coal conversion processes that gasify coal rather than combust it in air. In the oxygen-blown gasification process coal is heated under pressure with a mixture of pure oxygen, producing an energy-rich gas stream consisting mostly of hydrogen and carbon monoxide. Coal gasification is widely used in industrial processes, such as ammonia and fertilizer production around the world. Hundreds of such industrial gasifiers are in operation today. In power generation applications as practiced today this "syngas" stream is cleaned of impurities and then burned in a combustion turbine to make electricity in a process known as Integrated Gasification Combined Cycle or IGCC. In the power generation business, IGCC is a relatively recent development—about two decades old and is still not widely deployed. There are two IGCC power-only plants operating in the U.S. today and about 14 commercial IGCC plants are operating, with most of the capacity in Europe. In early years of operation for power applications a number of IGCC projects encountered availability problems but those issues appear to be resolved today, with Tampa Electric Company reporting that its IGCC plant in Florida is the most dispatched and most economic unit in its generating system.

Commercially demonstrated systems for pre-combustion capture from the coal gasification process involve treating the syngas to form a mixture of hydrogen and CO_2 and then separating the CO_2, primarily through the use of solvents. These same techniques are used in industrial plants to separate CO_2 from natural gas and to make chemicals such as ammonia out of gasified coal. However, because CO_2 can be released to the air in unlimited amounts under today's laws, except in niche applications, even plants that separate CO_2 do not capture it; rather they release it to the atmosphere. Notable exceptions include the Dakota Gasification Company plant in Beulah, North Dakota, which captures and pipelines more than one million tons of CO_2 per year from its lignite gasification plant to an oil field in Saskatchewan, and ExxonMobil's Shute Creek natural gas processing plant in Wyoming, which strips CO_2 from sour gas and pipelines several million tons per year to oil fields in Colorado and Wyoming.

Today's pre-combustion capture approach is not applicable to the installed base of conventional pulverized coal in the U.S. and elsewhere. However, it is ready today for use with IGCC power plants. The oil giant BP has announced an IGCC project with pre-combustion CO_2 capture at its refinery in Carson, California. When operational the project will gasify petroleum coke, a solid fuel that resembles coal more than petroleum to make electricity for sale to the grid. The captured CO_2 will be sold to an oil field operator in California to enhance oil recovery. The principal obstacle for broad application of pre-combustion capture to new power plants is not technical, it is economic: under today's laws it is cheaper to release CO_2 to the air rather than capturing it. Enacting laws to limit CO_2 can change this situation, as I discuss later.

While pre-combustion capture from IGCC plants is the approach that is ready today for commercial application, it is not the only method for CO_2 capture that may emerge if laws creating a market for CO_2 capture are adopted. I have previously mentioned post-combustion techniques now being explored. Another approach, known as oxyfuel combustion, is also in the early stages of research and development. In the oxyfuel process, coal is burned in oxygen rather than air and the exhaust gases are recycled to build up CO_2 concentrations to a point where separation at reasonable cost and energy penalties may be feasible. Small scale pilot studies for oxyfuel processes have been announced. As with post-combustion processes, absent an accelerated effort to leapfrog the normal commercialization process, it could be one or two decades before such systems might begin to be deployed broadly in commercial application.

Given, the massive amount of new coal capacity scheduled for construction in the next two decades, we cannot afford to wait until we see if these alternative capture systems prove out, nor do we need to. Coal plants in the design process today can employ proven IGCC and pre-combustion capture systems to reduce their CO_2 emissions by about 90 percent. Adoption of policies that set a CO_2 performance standard now for such new plants will not anoint IGCC as the technological winner since alternative approaches can be employed when they are ready. If the alternatives prove superior to IGCC and pre-combustion capture, the market will reward them accordingly. As I will discuss later, adoption of CO_2 performance standards is a critical step to improve today's capture methods and to stimulate development of competing systems.

I would like to say a few words about so-called "capture-ready" or "capture-capable" coal plants. I will admit that some years ago I was under the impression that some technologies like IGCC, initially built without capture equipment could be properly called "capture-ready." However, the implications of the rapid build-out of new coal plants for global warming and many conversations with engineers since then have educated me to a different view. An IGCC unit built without capture equipment can be equipped later with such equipment and at much lower cost than attempting to retrofit a conventional pulverized coal plant with today's demonstrated post-combustion systems. However, the costs and engineering reconfigurations of such an approach are substantial. More importantly, we need to begin capturing CO_2 from new coal plants without delay in order to keep global warming from becoming a potentially runaway problem. Given the pace of new coal investments in the U.S. and globally, we simply do not have the time to build a coal plant today and think about capturing its CO_2 down the road.

Implementation of the Energy Policy Act of 2005 approach to this topic needs a review in my opinion. The Act provides significant subsidies for coal plants that do not actually capture their CO_2 but rather merely have carbon "capture capability." While the Act limits this term to plants using gasification processes, it is not being implemented in a manner that provides a meaningful substantive difference between an ordinary IGCC unit and one that genuinely has been designed with early integration of CO_2 capture in mind. Further, in its FY2008 budget request, the administration seeks appropriations allowing it to provide $9 billion in loan guarantees under Title XVII of the Act, including as much as $4 billion in loans for "carbon sequestration optimized coal power plants." The administration request does not define a "carbon sequestration optimized" coal power plant and it could mean almost anything, including, according to some industry representatives, a plant that simply leaves physical space for an unidentified black box. If that makes a power plant "capture-ready" Mr. Chairman, then my driveway is "Ferrari-ready." We should not be investing today in coal plants at more than a billion dollars apiece with nothing more than a hope that some kind of capture system will turn up. We would not get on a plane to a destination if the pilot told us there was no landing site but options were being researched.

Geologic Disposal

We have a significant experience base for injecting large amounts of CO_2 into geologic formations. For several decades oil field operators have received high pressure CO_2 for injection into fields to enhance oil recovery, delivered by pipelines spanning as much as several hundred miles. Today in the U.S. a total of more than 35 million tons of CO_2 are injected annually in more than 70 projects. (Unfortunately, due to the lack of any controls on CO_2 emissions, about 80 per cent of that CO_2 is sources from natural CO_2 formations rather than captured from industrial sources. Historians will marvel that we persisted so long in pulling CO_2 out of holes in the ground in order to move it hundreds of miles and stick in back in holes at the same time we were recognizing the harm being caused by emissions of the same molecule from nearby large industrial sources.) In addition to this enhanced oil recovery experience, there are several other large injection projects in operation or announced. The longest running of these, the Sleipner project, began in 1996.

But the largest of these projects injects on the order of one million tons per year of CO_2, while a single large coal power plant can produce about five million tons per year. And of course, our experience with man-made injection projects does not extend for the thousand year or more period that we would need to keep CO_2 in place underground for it to be effective in helping to avoid dangerous global warming. Accordingly, the public and interested members of the environmental, industry and policy communities rightly ask whether we can carry out a large scale injection program safely and assure that the injected CO_2 will stay where we put it.

Julio Friedmann's testimony addresses these questions at length and with much greater authority that I can supply so I will simply summarize the findings of the IPCC on these issues. In its 2005 report the IPCC concluded the following with respect to the question of whether we can safely carry out carbon injection operations on the required scale:

"With appropriate site selection based on available subsurface information, a monitoring programme to detect problems, a regulatory system and the appropriate use of remediation methods to stop or control CO2 releases if they arise, the local health, safety and environment risks of geological storage would be comparable to the risks of current activities such as natural gas storage, EOR and deep underground disposal of acid gas."

The knowledge exists to fulfill all of the conditions the IPCC identifies as needed to assure safety. While EPA has authority regulate large scale CO_2 injection projects its current underground injection control regulations are not designed to require the appropriate showings for permitting a facility intended for long-term retention of large amounts of CO_2. With adequate resources applied, EPA should be able to make the necessary revisions to its rules in two to three years. We urge this Committee to act to require EPA to undertake this effort this year.

Do we have a basis today for concluding that injected CO_2 will stay in place for the long periods required to prevent its contributing to global warming? The IPCC report concluded that we do, stating:

"Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years."

Despite this conclusion by recognized experts there is still reason to ask what are the implications of imperfect execution of large scale injection projects, especially in the early years before we have amassed more experience? Is this reason enough to delay application of CO_2 capture systems to new power plants until we gain such experience from an initial round of multi-million ton "demonstration" projects? To sketch an answer to this question, my colleague Stefan Bachu, a geologist with the Alberta Energy and Utilities Board, and I wrote a paper for the Eighth International Conference on Greenhouse Gas Control Technologies in June 2006. The obvious and fundamental point we made is that without CO_2 capture, new coal plants built during any "delay and research" period will put 100 per cent of their CO_2 into the air and may do so for their operating life if they were "grandfathered" from retrofit requirements. Those releases need to be compared to hypothetical leaks from early injection sites.

Our conclusions were that even with extreme, unrealistically high hypothetical leakage rates from early injection sites (10% per year), a long period to leak detection (5 years) and a prolonged period to correct the leak (1 year), a policy that delayed installation of CO_2 capture at new coal plants to await further research would result in cumulative CO_2 releases twenty times greater than from the hypothetical faulty injection sites, if power plants built during the research period were "grandfathered" from retrofit requirements. If this wave of new coal plants were all required to retrofit CO_2 capture by no later than 2030, the cumulative emissions would still be four times greater than under the no delay scenario. I believe that any objective assessment will conclude that allowing new coal plants to be built without CO_2 capture equipment on the ground that we need more large scale injection experience will always result in significantly greater CO_2 releases than starting CO_2 capture without delay for new coal plants now being designed.

The IPCC also made estimates about global storage capacity for CO_2 in geologic formations. It concluded as follows:

"Available evidence suggests that, worldwide, it is likely that there is a technical potential of at least about 2,000 GtCO2 (545 GtC) of storage capacity in geological formations. There could be a much larger potential for geological storage in saline formations, but the upper limit estimates are uncertain due to lack of information and an agreed methodology."

Current CO_2 emissions from the world's power plants are about 10 Gt (billion metric tons) per year, so the IPCC estimate indicates 200 years of capacity if power plant emissions did not increase and 100 years capacity if annual emissions doubled.

Policy Actions to Speed CCD

As I stated earlier, research and development funding is useful but it cannot substitute for the incentive that a genuine commercial market for CO_2 capture and disposal systems will provide to the private sector. The amounts of capital that the private sector can spend to optimize CCD methods will almost certainly always dwarf what Congress will provide with taxpayer dollars. To mobilize those private sector dollars, Congress needs a stimulus more compelling than the offer of modest handouts for research. Congress has a model that works: intelligently designed policies to limit emissions cause firms to spend money finding better and less expensive ways to prevent or capture emissions.

Where a technology is already competitive with other emission control techniques, for example, sulfur dioxide scrubbers, a cap and trade program like that enacted by Congress in 1990, can result in more rapid deployment, improvements in performance, and reductions in costs. Today's scrubbers are much more effective and much less costly than those built in the 1980s. However, a CO_2 cap and trade program by itself may not result in deployment of CCD systems as rapidly as we need. Many new coal plant design decisions are being made literally today. Depending on the pace of required reductions under a global warming bill, a firm may decide to build a conventional coal plant and purchase credits from the cap and trade market rather than applying CCD systems to the plant. While this may appear to be economically rational in the short term, it is likely to lead to higher costs of CO_2 control in the mid and longer term if substantial amounts of new conventional coal construction leads to ballooning demand for CO_2 credits. Recall that in the late 1990's and the first few years of this century, individual firms thought it made economic sense to build large numbers of new gas-fired power plants. The problem is too many of them had the same idea and the resulting increase in demand for natural gas increased both the price and volatility of natural gas to the point where many of these investments are idle today.

Moreover, delaying the start of CCD until a cap and trade system price is high enough to produce these investments delays the broad demonstration of the technology that the U.S. and other countries will need if we continue substantial use of coal as seem likely. The more affordable CCD becomes, the more widespread its use will be throughout the world, including in rapidly growing economies like China and India. But the learning and cost reductions for CCD that are desirable will come only from the experience gained by building and operating the initial commercial plants. The longer we wait to ramp up this experience, the longer we will wait to see CCD deployed here and in countries like China.

Accordingly, we believe the best policy package is a hybrid program that combines the breadth and flexibility of a cap and trade program with well-designed performance measures focused on key technologies like CCD. One such performance measure is a CO_2 emissions standard that applies to new power investments. California enacted such a measure in SB1368 last year. It requires new investments for sale of power in California to meet a performance standard that is achievable by coal with a moderate amount of CO_2 capture.

Another approach is a low-carbon generation obligation for coal-based power. Similar in concept to a renewable performance standard, the low-carbon generation obligation requires an initially small fraction of sales from coal-based power to meet a CO_2 performance standard that is achievable with CCD. The required fraction of sales would increase gradually over time and the obligation would be tradable. Thus, a coal-based generating firm could meet the requirement by building a plant with CCD, by purchasing power generated by another source that meets the standard, or by purchasing credits from those who build such plants. This approach has the advantage of speeding the deployment of CCD while avoiding the "first mover penalty." Instead of causing the first builder of a commercial coal plant with CCD to bear all of the incremental costs, the tradable low-carbon generation obligation would spread those costs over the entire coal-based generation system. The builder of the first unit would achieve far more hours of low-carbon generation than required and would sell the credits to other firms that needed credits to comply. These credit sales would finance the incremental costs of these early units. This approach provides the coal-based power industry with the experience with a technology that it knows is needed to reconcile coal use and climate protection and does it without sticker shock. A bill introduced in the other body, S. 309, contains such a provision. It begins with a requirement that one-half of one per cent of coal-based power sales must meet the low-carbon performance standard starting in 2015 and the required percentage increases over time according to a statutory minimum schedule that can be increased in specified amounts by additional regulatory action.

A word about costs is in order. With today's off the shelf systems, estimates are that the production cost of electricity at a coal plant with CCD could be as much as 40% higher than at a conventional plant that emits its CO_2. But the impact on average electricity prices of introducing CCD now will be very much smaller due to several factors. First, power production costs represent about 60% of the price you and I pay for electricity; the rest comes from transmission and distribution costs. Second, coal-based power represents just over half of U.S. power consumption. Third, and most important, even if we start now, CCD would be applied to only a small fraction of U.S. coal capacity for some time. Thus, with the trading approach I have outlined, the incremental costs on the units equipped with CCD would be spread over the entire coal -based power sector or possibly across all fossil capacity depending on the choices made by Congress. Based on CCD costs available in 2005 we estimate that a low-carbon generation obligation large enough to cover all forecasted new U.S. coal capacity through 2020 could be implemented for about a two per cent increase in average U.S. retail electricity rates.

Conclusions

To sum up, since we will almost certainly continue using large amounts of coal in the U.S. and globally in the coming decades, it is imperative that we act now to deploy CCD systems. Commercially demonstrated CO_2 capture systems exist today and competing systems are being researched. Improvements in current systems and emergence of new approaches will be accelerated by requirements to limit CO_2 emissions. Geologic disposal of large amounts of CO_2 is viable and we know enough today to conclude that it can be done safely and effectively. EPA must act without delay to revise its regulations to provide the necessary framework for efficient permitting, monitoring and operational practices for large scale permanent CO_2 repositories.

Finally CCD is an important strategy to reduce CO_2 emissions from fossil fuel use but it is not the basis for a climate protection program by itself. Increased reliance on low-carbon energy resources is the key to protecting the climate. The lowest carbon resource of all is smarter use of energy; energy efficiency investments will be the backbone of any sensible climate protection strategy. Renewable energy will need to assume a much greater role than it does today. With today's use of solar, wind and biomass energy, we tap only a tiny fraction of the energy the sun provides every day. There is enormous potential to expand our reliance on these resources.
We have no time to lose to begin cutting global warming emissions. Fortunately, we have technologies ready for use today that can get us started.

Mr. Chairman, that completes my testimony, I will be happy to take any questions you or other committee members may have.

Statement of
Edward Lowe, General Manager
Gasification Market Development, GE Energy
Before the United States House of Representatives
Energy and Commerce Committee
Subcommittee on Energy and Air Quality
March 6, 2007

Good morning, Mr. Chairman and Members of the Committee. I am Edward Lowe, General Manager for Gasification Market Development at GE Energy. GE appreciates the invitation to participate at this hearing.

GE is a worldwide supplier of advanced power generation technologies that include steam turbines, environmental services and IGCC for coal. Coal is our country's most abundant fossil fuel resource and an important component of the fuel mix necessary for the security and reliability of our nation's electrical power generation Climate change marks a fundamental paradigm shift that will require that we use coal in a different manner for it to be environmentally and economically acceptable. The approaches as to how coal can continue to be a significant part of our energy mix in an economical and environmentally acceptable manner with cleaner coal technology is the focus of my testimony.

Today, the installed coal power base in the United States is dominated by pulverized coal combustion, or PC (Figure 1). The widespread deployment of pulverized coal began in the early 1920's. Since then, steam temperatures, pressures and efficiencies have increased but the basic technology is unchanged. Finely ground coal is mixed with air, burned and heat is extracted from the combustion products to boil water and produce steam that is used in a steam turbine. Pollutants, such as sulfur particulates and mercury are carried as combustion product in a large volume of flue gas. The major physical change that you would see between the early and today's plants is the addition of "end-of-pipe" emission control equipment such as scrubbers to capture sulfur, catalytic reactors to reduce NOx, and precipitators or fabric filters to capture particulates. This control equipment can be larger than the original boiler and a major portion of the plant cost. The approach of merely adding additional boxes to the treatment train as regulations develop continues today with examples being mercury and concepts for achieving carbon capture.

An alternative demonstrated technology for coal power generation is integrated gasification combined cycle, or IGCC (Figure 1). IGCC is fundamentally different than combustion-based PC. The coal-to-power process begins with gasification – a partial oxidation process -- that turns the coal into a natural gas-like fuel called synthesis gas (also known as syngas) primarily consisting of carbon monoxide and hydrogen. Syngas initially contains pollutants such as sulfur, particulate and metals; however, with IGCC these pollutants can be removed pre-combustion, which eliminates the need for adding large, post-combustion treatment boxes. Since syngas is 1/100th of the volume from combustion, pollutants are concentrated and can be more economically and efficiently captured and removed than with post-combustion cleanup. Low volume and high concentration also have beneficial implications for carbon capture which will be discussed later. The cleaned gas is then converted to power in an advanced gas turbine combined cycle plant.

With its pre-combustion cleanup, gasification can be considered as a coal refining process. Compared to current state-of-the-art PC plants, IGCC can produce emissions of sulfur dioxide and nitrogen oxides that are dramatically lower. Compared to an average of recent PC permits and permit applications (Figure 2), an IGCC plant would produce 90% lower SOx, 77% lower NOx and 33% lower particulate matter. IGCC is highly effective at mercury removal and can achieve 90% or higher removal independent of coal type. IGCC consumes 30% less water than PC technology and produces useful byproduct such as elemental sulfur or sulfuric acid for beneficial industrial use such as fertilizer production and vitreous slag for construction use.

So you may ask, if IGCC is so much better, what has been holding up its deployment? A key factor is technology maturity. Compared to 80-90 years of PC experience, the first commercial US coal IGCC plants came into operation 10 years ago through the DOE Clean Coal program. These projects have validated IGCC for coal-to-power. Due to a low variable cost of production, one of these plants--the TECO Polk IGCC plant—is the first TECO plant to dispatch in its fleet, which includes larger PC plants. Owners of both of the early IGCC plants – Duke and TECO – are now pursuing new IGCC projects as recipients of investment tax credit certification under the 2005 Energy Act.

A second key reason is high initial capital cost, although IGCC is beginning to move down the experience/cost curve. Experience provides a flow of design improvements necessary to reduce cost. Design margins incorporated in first-of-a-kind plants can be reduced. Engineering can be re-used and schedules reduced. Recently, inflation has accelerated in basic materials and construction costs to impact all coal projects, both PC and IGCC. For example, the Chemical Engineering Plant Cost Index increased by 29% from 2001 to 2006. IGCC carries larger contingencies due to perceived risk and lack of experience in construction and startup. Today we estimate that the first large-scale commercial IGCC plants to have a 20%-25% premium over PC. As IGCC is deployed, that premium will be reduced to where we believe this gap will be reduced to 10% or less. Savings will be achieved by 1) avoiding one-of-a-kind designs to reduce design and engineering cost and provide a baseline for improvement, 2) optimizing gasification and power generation technology integration, 3) improving design through operating experience, and 4) reducing costs by building a supply chain with greater volume and standard components.

However, with carbon capture and sequestration, we believe pulverized coal will bear a cost premium over IGCC. Carbon capture in an IGCC plant will be performed pre-combustion versus post combustion as would be done in a pulverized coal plant. Pre-combustion capture provides the same fundamental advantages it has with capturing other pollutants -- small volume, high pressure, and high concentration.

In terms of readiness, IGCC is ready for carbon capture today. All of the key processes and equipment required for carbon capture in IGCC have been demonstrated in chemical and refinery applications. The process is flexible and can be configured for a wide range of carbon capture levels. An IGCC plant configured for pre-combustion carbon capture from coal consists of the following four steps:

1. Gasification conversion of coal to syngas. GE gasification technology has 14 units operating on coal and pet coke solid fuels.

2. A chemical process (shift) that reacts carbon monoxide with water to form CO2 and hydrogen. There are 25 units in operation that are using the shift process with GE gasification technology.

3. The CO2 is scrubbed from the syngas using an appropriate solvent and separated into a concentrated stream. The remaining syngas is primarily hydrogen. There are 25 units in operation today that are using scrubbing to produce hydrogen from GE gasification in the chemical industry.

4. The hydrogen is then converted to power in a combined cycle gas turbine. Hydrogen is an acceptable and proven fuel for gas turbines. The capability to use hydrogen fuel has been proven in 22 GE gas turbines operating today with hydrogen content between 50% to 95% -- representative of the range expected from a coal IGCC plant with carbon capture. GE is also providing commercial bids today for hydrogen fueled gas turbines.

All of the key components of low carbon power with IGCC have been proven in large-scale commercial operation and are ready to be integrated into a total IGCC carbon capture power plant. Lessons learned will be drawn from GE's base of over 3GW of global GE IGCC experience and much of this involved with integration of IGCC into refineries (Figure 2). An example of how these pieces are being combined into a commercial IGCC plant with carbon capture is the hydrogen-to-power project that GE is designing with BP and Edison Mission Energy for a refinery at Carson California. In addition to capturing CO2 that will be used for enhanced oil recovery and hydrogen power with 90% carbon capture, this plant will achieve criteria emissions at or better than a natural gas fired turbine and at a fraction of those achievable with a PC using state-of-the-art air quality control equipment. IGCC is also providing a highly beneficial use for petroleum coke – a refinery byproduct.

A key advantage of IGCC with carbon capture that should not be overlooked is the production of hydrogen. IGCC plants that are configured for carbon capture represent a ready hydrogen source that can serve as the catalyst for a hydrogen economy. This cannot be done with a pulverized coal plant. Although the initial primary use will be for power generation, deployment of IGCC with carbon capture and hydrogen generation can serve as both a catalyst and backbone for a hydrogen economy. An IGCC plant that cycles through a turndown of power at night will be able to utilize the gasification plant to generate commercial hydrogen. The net result is that coal can become the source of ultra-clean fuel for transportation or other embodiments of a hydrogen economy and a broadened range of economic and societal environmental benefit from coal. This is in addition to the generation of useful byproducts such as sulfur or sulfuric acid for chemicals and construction material that IGCC provides.

PC plants are currently limited to post-combustion carbon capture. Other approaches such as oxycombustion are just entering early demonstrations and far from being proven. If configured with carbon capture using current commercial technology, a PC plant would be equipped with an additional CO2 scrubber. A physical difference with IGCC would be the larger size of the scrubber required to treat a 100-fold higher flue gas volume than IGCC syngas and at a 5-fold lower flue gas CO2 concentration than IGCC syngas. As referenced in the DOE NETL 2006 Cost and Performance Analysis of Fossil Energy Plants, scrubbing and solvent regeneration requires a large amount of power – approximately 28% of total PC plant output versus approximately 12% for an IGCC plant. The additional capital cost for carbon capture will also be significant - approximately 70%-75% for PC versus 25-30% for an IGCC plant. The net impact is a significant increase in the cost of electricity of approximately 65% for a PC plant versus approximately 25% for an IGCC plant.

Given these costs, and exclusive of a value for CO2 that can be derived from enhanced oil recovery (EOR), which is also a proven technology, there is currently no economic or market motivation to drive implementation or development of carbon capture. If low carbon power from coal is to be deployed, implementation will require policy that establishes a market price for carbon.

Another barrier to deployment is that the US does not have a carbon capture and sequestration regulatory regime. We believe that CO2 sequestration and storage can be done effectively and safely and you will hear about that from another panelist. With respect to transport, currently in the US, there are approximately 3500 miles of CO2 pipelines already in place and 28 MT/year of CO2 injected for EOR recovering more than 55 MM barrels of oil per year. The DOE estimates that there are approximately 550 reservoirs in the U.S. where CO2 could be used for EOR. The use of CO2 for EOR in these reservoirs could result in an increased recovery of nearly 89 billion barrels of oil. Key demonstrations of carbon sequestration are planned by the Regional Carbon Sequestration Partnerships and supported by DOE. GE is working with our customers to fully understand and integrate the requirements that will be placed on CO2 for EOR, deep well or aquifer sequestration and their impact on plant design and tradeoffs.

In the area of carbon capture, technology decisions cannot be divorced from policy decisions. Clear policy is needed as an effective catalyst for new technology development, deployment and improvement. Fortunately, we have positive examples of how this can be done.

- Turbine advancements that increased efficiency from 40% to 60% with a concurrent reduction in NOx emissions by a 8-fold was driven by the Clean Air Act, financial support from the DOE and our own investment.

- Federal Production Tax Credits coupled with state Renewable Portfolio Standards provided the pivotal support to grow a wind energy industry that did not exist 15 years ago to installation of 2,500MW of wind energy and a total installed wind capacity of 12,000MW in the US in 2006. With continued clear policy and support, new global wind energy is expected to maintain an average 13% CAGR until 2030.

These are the kinds of success stories that we should all want for cleaner and low carbon coal power generation. Favorable federal policy for cleaner coal can take the form of clarity of regulatory policy, incentives, and removal of barriers. These are needed to send a message to the marketplace. Early movers need to be rewarded. Long-term liability issues for carbon sequestration need be resolved. Market mechanisms that will define a value for carbon are needed.

Policy options that GE recommends for consideration are

- Expanding the current investment tax credits authorized and funded under the Energy Policy Act of 2005 to offset the current 20% to 25% CAPEX premium of IGCC.
- Incentives or extra credits for early movers with carbon capture
- CO_2 allocations for new low carbon plants
- Low carbon portfolio standard with trading among utilities for low carbon credits
- Carbon capture requirements for new coal power plants phased in over time starting with carbon capture ready, then equivalent to best in class NGCC, and finally with Best Available Control Technology
- EOR and saline aquifer carbon storage demonstration projects
  - Government issued site selection criteria & monitoring requirements
  - De minimis leakage and liabilities for leakage must be addressed

With respect to demonstration projects, IGCC with carbon capture can serve as a CO2 source for large-scale sequestration demonstrations. This should be a deliberate and careful phased approach both in terms of the capture level and the scale of sequestration. As an example, IGCC is capable of modest (3%-10%) carbon capture with a small impact to cost and efficiency. At 10% capture, a

600MW IGCC plant will generate approximately 400,000 tons/year of CO2 for sequestration or enhanced oil recovery. Government funding for intermediate scale demonstrations would serve to validate the approach, increase confidence, understanding and experience of integrating carbon capture with sequestration and the base for moving to higher levels of capture. Legislation should encourage and reward those who undertake such demonstrations with credit for their early action.

Finally, I would like to thank you and your colleagues the Congress for recognizing the vital role of cleaner coal the 2005 Energy Policy Act. IGCC was a significant beneficiary. Three coal IGCC projects and a petroleum coke hydrogen-to-power IGCC project were awarded investment tax credits. These projects will provide initial experience that is vital to begin closing the cost gap and moving IGCC into wide commercial acceptance and as a platform that brings coal to readiness for a carbon-constrained environment.

Thank you for your attention and I look forward to your questions.

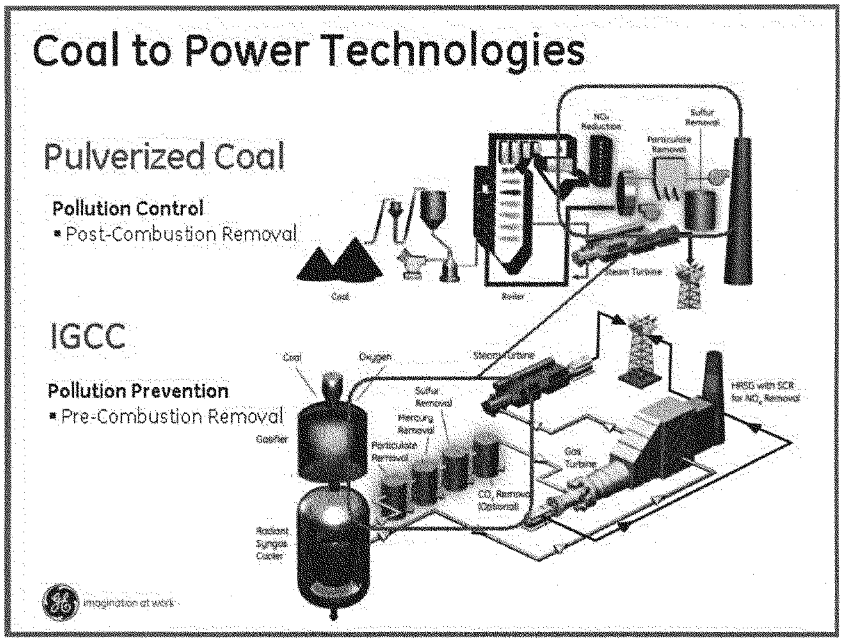


Figure 1

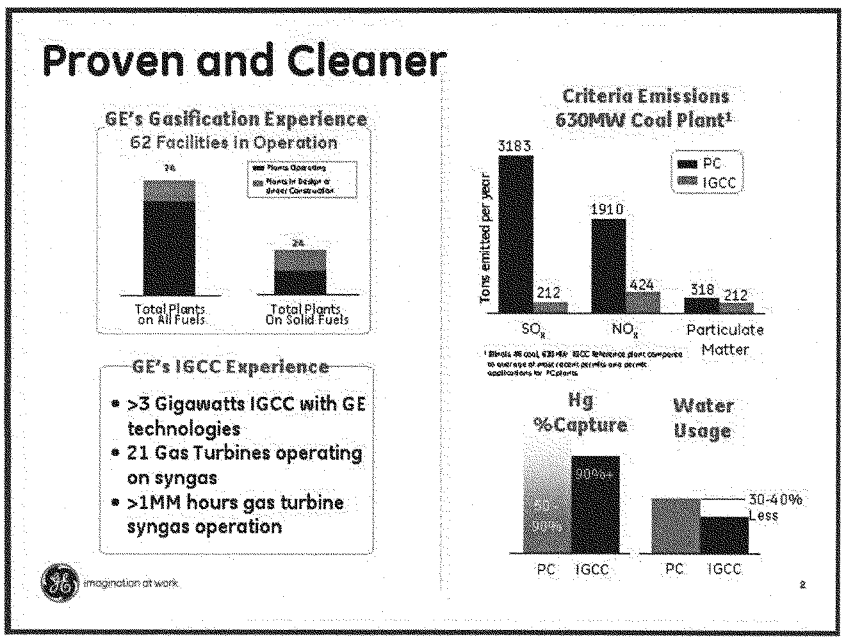


Figure 2

Government Policy/Incentives to Accelerate Cleaner Coal

- **Expand the current investment tax credits authorized and funded under the Energy Policy Act of 2005 to offset the current 20% to 25% CAPEX premium of IGCC**
- **CO_2 allocations for new low carbon plants**
- **Low carbon portfolio standard with trading among utilities for low carbon credits**
- **Carbon capture requirements for new coal power plants phased in over time...**
  - *Start with carbon-capture ready*
  - *Next - equivalent to Best-in-Class NGCC*
  - *Finally - Best Available Control Technology*
- **EOR and saline aquifer carbon storage demonstration projects**
  - *Gov't issued site selection criteria & monitoring requirements*
  - *De minimis leakage and liabilities for leakage must be addressed*

imagination at work

Figure 3

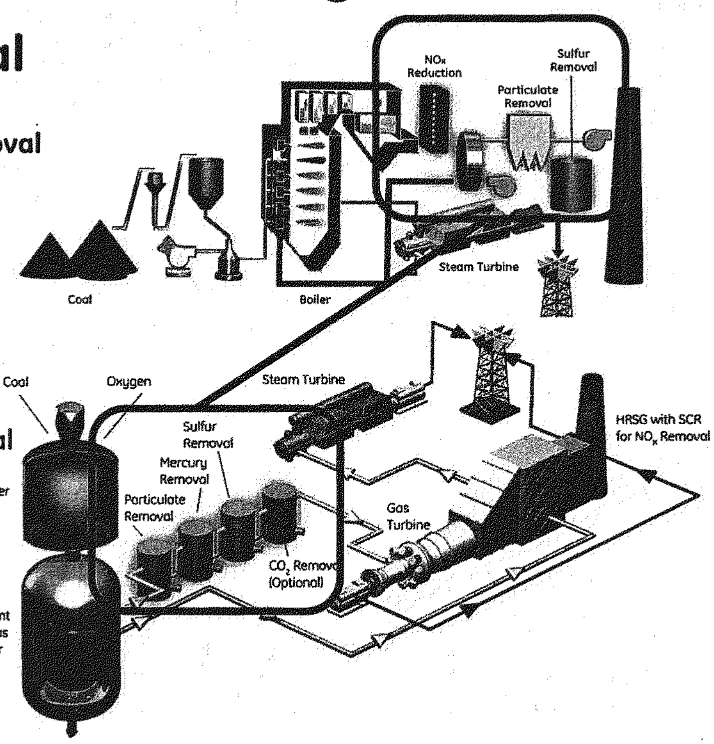
Coal to Power Technologies

Pulverized Coal

Pollution Control
- Post-Combustion Removal

IGCC

Pollution Prevention
- Pre-Combustion Removal



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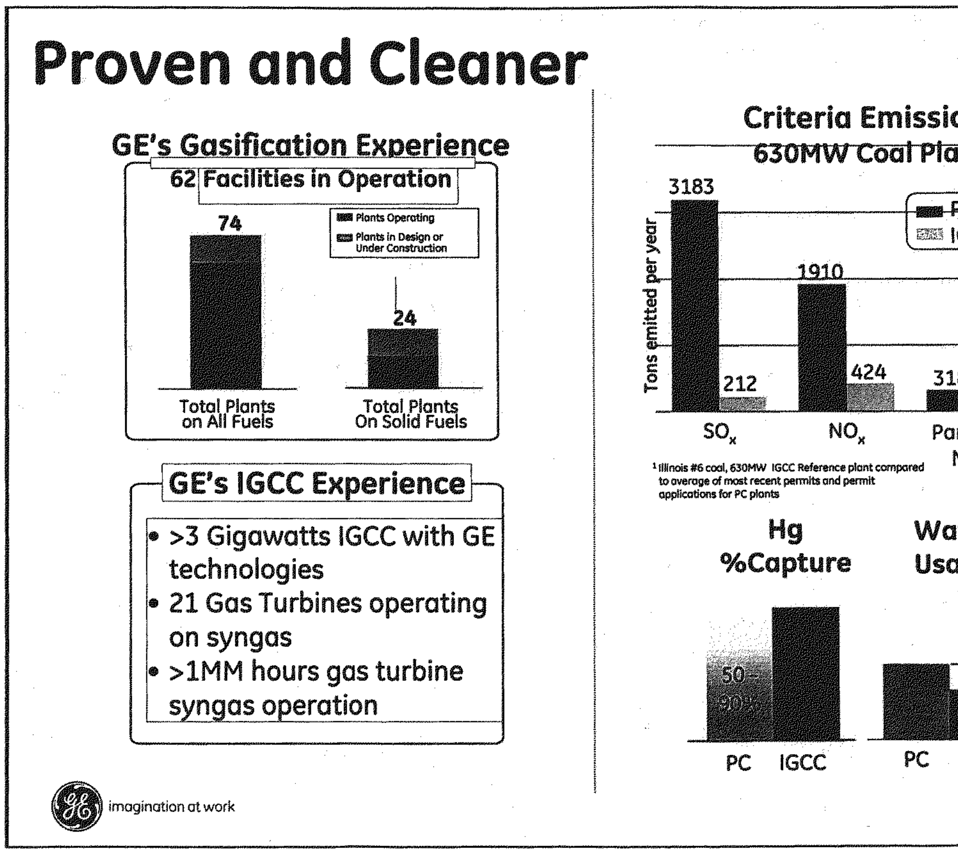

Proven and Cleaner
GE's Gasification Experience
62 Facilities in Operation
Plants Operating
Plants in Design or Under Construction
74
24
Total Plants on All Fuels
Total Plants On Solid Fuels
GE's IGCC Experience
• >3 Gigawatts IGCC with GE technologies
• 21 Gas Turbines operating on syngas
• >1MM hours gas turbine syngas operation
Criteria Emissions
630MW Coal Plant[1]
PC
IGCC
Tons emitted per year
3183
212
1910
424
318
212
SOx
NOx
Particulate Matter
[1] Illinois #6 coal, 630MW IGCC Reference plant compared to average of most recent permits and permit applications for PC plants
Hg %Capture
50-90%
PC
IGCC
Water Usage
30% Less
PC
IGCC
imagination at work

3/6/07

HOUSE SUBCOMMITTEE ON ENERGY AND AIR QUALITY

STATEMENT OF MARK SCHOENFIELD

Carbon capture and sequestration require technologies that can effectively and efficiently perform, and we are here to talk about a solution which also keeps our power plants running and consumers able to have affordable power.

I am the Senior Vice-President for Operations and General Counsel of Jupiter Oxygen, a small privately held Illinois company which has developed and pioneered a revolutionary technology that makes it both practical and cost effective for electric power plants to capture CO2, because it reduces fossil fuel usage and concentrates the CO2 for capture. Unlike most clean coal technologies being developed, Jupiter's patented process can be either designed into new plants or used to retrofit existing plants. The ability to retrofit the existing 600 coal-fired electric power plants is very important to the elimination of CO2 emissions for climate change, and for NOx, S0x and particulate emissions, as well as mercury pollution in the United States.

Natural gas power plants also emit CO2. Jupiter's technology can also be used on gas fired electric power plants, which results in virtually no emissions levels for NOx, while also being able to capture CO2. Thus, our technology is now emerging as one of the most promising environmental control technologies for use in both coal and gas-fired electric power plants.

The Jupiter oxy-fuel combustion technology uses pure oxygen as the combustion agent, instead of air which contains nitrogen. The resulting exhaust contains almost no NO_x and concentrates CO2 for efficient capture. Because air is not used, CO2 does not need to be separated from nitrogen before being compressed, which reduces the cost of capture.

Experimenting and developing the patented oxy-fuel process began in the mid-1990's as a way to cut fuel costs and lower emissions at Jupiter Aluminum, an aluminum recycling and manufacturing business and a patent licensee. Jupiter's technology has been in use at the aluminum plant since 1997, Even without CO2 capture, the technology results in less fuel being used, so there is CO2 avoidance because 70% less CO2 is produced now at that aluminum recycling and manufacturing plant than before.

Since 2001, Jupiter has taken its technology from industrial furnaces to fossil fuel steam boilers and electric power plant test applications. In 2002, the company tested its oxy-fuel technology in a steam boiler using oxygen instead of air, and firing with both natural gas and coal.

In November, 2004, Jupiter combined its oxy-fuel technology with the Integrated Pollutant Removal (IPR) technology developed by the National Energy Technology Laboratory of the US Department of Energy. Jupiter technology enables the IPR system to work efficiently, and test results showed that the combined hybrid system made it both practical and cost effective to capture the CO2.

This means that coal supplies can be used in an environmentally friendly way, now and in the future. The use of these clean, efficient, and innovative combustion and CO2 capture technology processes with coal can provide both improved energy independence and security for the U.S., a stable energy supply to support economic growth, and, at the same time, provide truly capture ready power plants fully equipped for C02 capture, which will only need to have a C02 pipeline hooked up. Moreover, the fuel reduction means that, even before CO2 capture is fully implemented, less CO2 is being produced so there is immediate CO2 avoidance.

And the good news for consumers is that not only can Jupiter's Oxy-fuel technology with the DOE IPR system eliminate greenhouse gas emissions from power plants, it can do so at a cost that will not affect them financially. In fact, the fuel savings and increased power plant efficiencies give Jupiter's technology a clear cost advantage over other clean coal technologies, especially coal gasification. From what we have seen, each of these cost figures is lower than

than alternative clean coal technologies to produce the same results. Plus our technology is ready now, and does not require things still to be invented.

One key problem is that utilities and others are reluctant to use this approach despite our successful tests until R&D testing is done in an operating unit on the grid. We have started a project for the world's first oxy-fuel clean coal retrofit of an operating electric power plant. Because this is a first-of-its kind in the world project, continued federal funding is essential.

Section 1407 of 2005 Energy Bill authorized $100,000,000 a year for three years for this type of undiluted, high flame temperature oxy-fuel technology. To date, the DOE has yet to move forward to obtain that funding. In fact, the Administration's last three budgets have had no funding for oxy-fuel technology nor have they had any funding for retrofitting the existing coal-fueled power plants or natural gas power plants in the United States, even though there is wide spread congressional support for both.

We need members of this committee to push the DOE and the Administration to support oxy-fuel technology and our retrofit project with the Ohio Air Quality Development Authority, including for use of the DOE NETL's own IPR technology and our planned work with the NETL. And we need your support in Congress in helping us obtain the funding necessary to move forward with this vital and important retrofit project.

There is no reason to wait to solve the reported climate change problems associated with coal and natural gas burning electric power plants. We can do so now with federal support.

And so, in conclusion, the United States can have an effective approach to clean coal technology today. We can do so at a reasonable price both for the generators and the consumers. There is no reason to wait thirty years or even twenty years. We can safely use coal to power the economy of our great country today, and to use natural gas as well, without adding to climate change or air pollution. Oxy-fuel technology combined with the IPR system developed by the United States in the DOE's own lab is the economical and safe answer to capturing CO2.

The Jupiter oxy-fuel/DOE IPR technology combination can make the United States the world leader in Clean Coal Technology, and end the problem of emissions of Green House Gases and other harmful emission such as mercury from electric power plants.

Statement of Thomas D. Shope
Principal Deputy Assistant Secretary
for Fossil Energy
Subcommittee on Energy and Air Quality
Committee on Energy and Commerce
U.S. House of Representatives

March 6, 2007

Mr. Chairman, Members of the Committee, it's a pleasure for me to appear before you today to discuss the general subject of carbon sequestration.

The availability of affordable energy is an important component of economic growth. The use of fossil fuels, however, can result in the release of emissions with potential impacts on the environment. Of growing significance are emissions of carbon dioxide (CO_2) which contribute to global climate change.

Balancing the economic value of fossil fuels with the environmental concerns associated with fossil fuel use is a difficult challenge. Carbon capture and storage technologies provide a key strategy for reconciling energy and environmental concerns. By capturing CO_2 before it is emitted to the atmosphere and then storing it in underground geologic formations, the use of fossil fuels in power generation can be largely decoupled from growth in atmospheric concentrations of CO2 emissions.

On a global scale, carbon capture and storage technologies have the potential to be a cost-effective option for overall climate change mitigation and increase flexibility in reducing greenhouse gas emissions. Furthermore, a particularly beneficial aspect of certain carbon dioxide capture and storage (CCS) technologies is that the majority of their component parts – carbon capture, transportation and storage– rely on commercially available technologies, enhancing the availability of CCS technologies as viable mitigation options.

The Global Energy Technology Strategy Program (GTSP), a public and private sector research collaboration, has identified near-term, medium-term and long-term benefits associated with carbon capture. In the near term, carbon capture and sequestration technologies will allow the growth of a modern industrial economy – including electricity generation – to chart a viable path forward into a carbon-constrained world. In the medium term, carbon capture and sequestration technologies will facilitate a smoother transition of the global economy to a low greenhouse gas (GHG) emissions future. In the long term, carbon capture and sequestration will make valuable commodities like electricity and hydrogen with low associated GHG emissions cheaper than they would be if such technologies were not available.

The U.S. Department of Energy (DOE) is taking a leadership role in the development of carbon capture and storage technologies. The coal program supports DOEs mission to promote America's energy security through reliable, clean, and affordable energy by developing the technological capability to dramatically reduce pollutant emissions from coal fired power plants and dramatically reduce carbon emissions to achieve near zero atmospheric emissions. Through its Carbon Sequestration Program – managed within DOE's Office of Fossil Energy and implemented by the National Energy Technology Laboratory (NETL) – DOE is developing technologies through which CCS will become an effective and economically viable option for reducing CO_2 emissions. The Carbon Sequestration Program works in concert with other programs within the Office of Fossil Energy that are developing technologies integral to coal-fueled power generation with carbon capture: Advanced Integrated Gasification Combined Cycle, Advanced Turbines, Fuels, Fuel Cells, and Advanced Research. If successful, this research and development could enable carbon control technologies to help overcome the various technical, economic and potential public acceptance barriers currently limiting widespread commercial applications, including cost-effective CO_2 capture, long-term stability (permanence) of CO_2 in underground formations, monitoring and verification, integration with power generation systems, and public acceptance.

The overall goal of the Carbon Sequestration Program is to develop, by 2012, fossil fuel power generation systems viable for commercial deployment that achieve 90 percent CO_2 capture with 99 percent storage permanence at less than a 10 percent increase in the cost of energy services. Reaching this goal requires an integrated research, development, and demonstration program linking fundamental advances in CCS to practical advances in technologies amenable to extended commercial use. The technologies developed in this Program will also serve as fundamental components of the

FutureGen project, which will be the first power plant in the world to integrate permanent CCS with coal-to-energy conversion and hydrogen production.

The year 2007 marks the 10-year anniversary of the DOE Carbon Sequestration Program that was launched in 1997 as a small-scale research effort to ascertain the technical viability of carbon capture and storage. During that time, the Carbon Sequestration Program has grown into a multi-faceted research, development, and demonstration program that aims to provide the means by which fossil fuels can continue to be used for power generation in a carbon-constrained world. The first 10 years have significantly advanced the knowledge base pertaining to CCS. Much work remains, however, to enable the large-scale implementation and commercialization of this technology. In particular, large field tests are required to validate and improve model predictions of scientific behavior of injected carbon dioxide at scale, demonstrate the engineering and scientific processes for successfully implementing and validating long-term storage of sequestered carbon, and achieve cost-effective integration with power plant systems for capture. Looking forward, it is also important to recognize carbon sequestration as more than just an end-of-process emissions control technology. Carbon sequestration represents a useful element in the entire energy supply picture because it could help provide the means to allow fossil fuels to continue to be used for power generation in a carbon-constrained world, and has application in some cases to facilitating greater recovery of domestic oil, natural gas, and coal bed methane.

Program Overview

The DOE Carbon Sequestration Program (Program) leverages applied research with field demonstrations to assess the technical and economic viability of carbon capture and storage as a greenhouse gas mitigation option. Successful carbon capture and storage technology development and deployment could help provide the means by which fossil fuels can continue to be used for power generation in a carbon-constrained world.

Program Highlights and Accomplishments

Since its inception 10 years ago, the Program has been moving carbon sequestration technology forward to enable its cost-effective use in meeting potential future GHG emissions reduction requirements. Through its technological successes, the Program has played a central role in helping advance international acceptance of carbon sequestration as a leading mitigation option for reducing GHG emissions into the atmosphere. Major Program accomplishments over its 10-year life include:

1. ***Characterization and Validation Efforts Within the Regional Carbon Sequestration Partnership Program.*** The ongoing characterization and validation work by the Regional Carbon Sequestration Partnerships (RCSPs) is laying the groundwork for a future in which large-scale deployment of carbon capture and storage technologies is possible.

2. ***CO_2 Capture Cost Reduction.*** DOE-funded research in CO_2 capture has led to identifying technologies and pathways to reduce costs for CO_2 capture. The Program has conducted research into solvent, sorbent, membrane, and oxy-combustion systems that, if successfully deployed, could capture greater than 90 percent of the flue gas CO_2 at a significant cost reduction when compared to state-of-the-art amine based capture systems. Through the research and system analysis over the past years, potential cost reductions of 30-45% have been identified for the capture of CO_2.

3. ***CO_2 Storage.*** Program efforts in geologic and terrestrial CO_2 storage have led to a far better understanding of the sequestration potential of various storage sites.

4. ***Monitoring, Mitigation, and Verification (MM&V).*** Field projects have demonstrated the ability to "map" CO_2 injected into an underground formation at a much higher resolution than previously anticipated, and confirmed the ability of tracers to track CO_2 migration through a formation which will be an important tool for verifying that the carbon dioxide has remained sequestered. DOE-sponsored research has also led to the development of a novel tool to obtain geochemical samples of water and gas at *in situ* pressure.

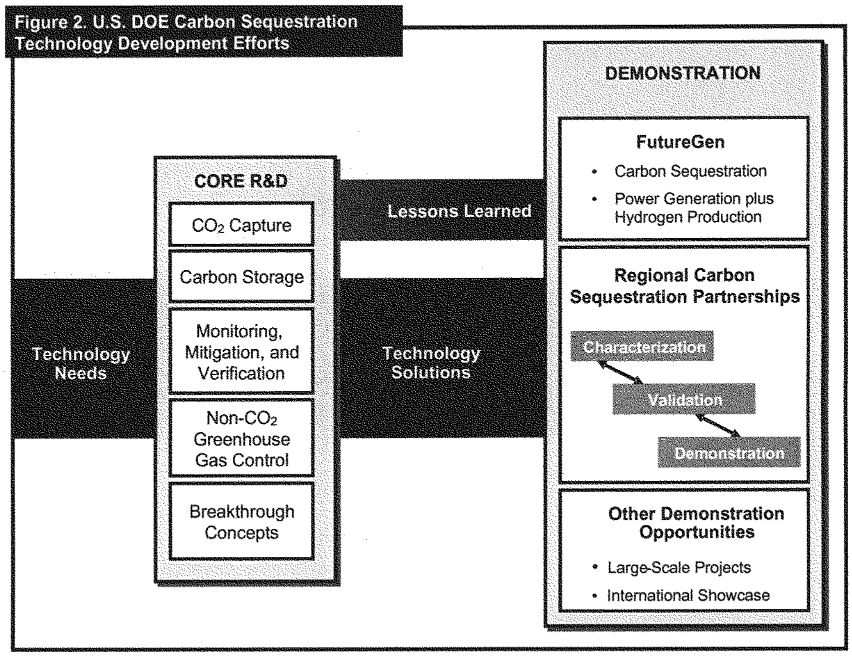
5. ***Carbon Sequestration Atlas.*** **The *2006 Carbon Sequestration Atlas of the United States and Canada*,** developed by the National Energy Technology Laboratory (NETL), the RCSPs, and the National Carbon Sequestration Database and Geographical

Information System (NATCARB), contains information on CO_2 emissions point sources, geologic formations with sequestration potential, and terrestrial ecosystems with potential for enhanced carbon uptake – all referenced to their geographic location to enable matching sources and sequestration sties. An interactive version of the Atlas is available through the NATCARB website (www.natcarb.org).

6. ***Systems Analysis.*** The NETLs Office of Systems, Analysis, and Planning (OSAP) conducts innovative assessments of CO_2 capture and separations processes. OSAPs work in this area has increased our understanding of the issues surrounding integration of CO_2 capture systems with different fuel conversion systems, thereby leading to the potential to significantly reduce costs.

DOEs Carbon Sequestration Program Structure

The Carbon Sequestration Program contains two main elements: *Core R&D* and *Demonstration*. The following figure shows how these elements are linked. The Core R&D element converts recognized technology needs in several focus areas into technology solutions that can then be demonstrated in the field. Lessons learned from the field tests are fed to the Core R&D element to guide future research and development.



Core R&D involves laboratory and pilot-scale research aimed at developing new technologies and new systems for GHG mitigation. The Core R&D portfolio includes technology development projects cost-shared with industry; research grants; and research conducted through NETLs OSAP and The Office of Research and Development (ORD). This effort encompasses five focus areas: CO_2 capture; carbon storage; monitoring, mitigation and verification; non-CO_2 greenhouse gas control; and breakthrough concepts.

The largest components of the Program's Demonstration element are the seven Regional Carbon Sequestration Partnerships Programs. The seven RCSPs are examining regional differences in geology, land practices, ecosystem management, and industrial activity that may affect the deployment of carbon sequestration technologies. Activities conducted in the seven RCSPs will provide the knowledge needed to help advance carbon sequestration as a viable GHG mitigation option across the U.S. and Canada.

The Carbon Sequestration Program also supports development of technologies for FutureGen, a key DOE project aimed at building a highly efficient and technologically sophisticated power plant that can produce both hydrogen and electricity while capturing and sequestering CO_2 emissions. FutureGen will serve as a full-scale demonstration of carbon sequestration technologies, thereby providing a venue for evaluating technologies emerging from Core R&D efforts.

The Carbon Sequestration Program includes several supporting mechanisms performing systems analyses and economic modeling of potential new CO_2 capture processes to identify issues with their integration into full-scale power plants. For example the Program also participates in cross-cutting studies to model future national energy scenarios incorporating carbon capture and storage. Finally, the Program collaborates extensively with other U.S. Government agencies, especially the Environmental Protection Agency, and works with the international carbon capture and storage community through its membership in organizations such as the Carbon Sequestration Leadership Forum (CSLF) to promote the international development of improved cost-effective technologies for CCS.

Challenges

Carbon sequestration technologies encompass two main CO_2 reduction pathways, both of which have a role in mitigating potential climate change. The CO_2 can either be captured at the point where it is produced (point source) or it can be removed from the air. For geologic sequestration systems focused on capture from point sources, the captured CO_2 is permanently stored underground; for terrestrial sequestration systems focused on removing CO_2 from the air, the CO_2 is absorbed by plants or soils.

Capturing the CO_2 from industrial operations is currently an expensive process. There are three capture technology areas — pre-combustion, post-combustion, or oxycombustion. All of these technologies require a series of energy-intensive process steps involving heating and cooling, pressure changes, operation of separation or absorption equipment, purifying the product, storing the product, and then transporting it. In the case of power generation using current capture technologies, the energy needed to capture and separate the CO_2 and regenerate the absorbent currently increases the energy required by 20 percent or more and leads to a substantial increase in the cost of electricity. The result of these operations is a net increase in the cost of electricity or other products from the plant and a decrease in net energy efficiency. The challenge is to develop effective carbon capture technologies that minimize these costs.

The Carbon Sequestration Program is designed to develop the technology base that will enable carbon sequestration to become a viable GHG mitigation option. Important to any such technology road mapping effort is the recognition and identification of challenges that hinder commercialization. Various technical, economic and social challenges currently prevent carbon sequestration from becoming a widely used technology. The Carbon Sequestration Program is addressing these challenges through applied research, proof-of-concept technology evaluation, pilot-scale testing, large-scale demonstration, stakeholder involvement, and public outreach.

Cost-Effective Capture

For geologic sequestration applications in which the CO_2 is stored underground, there are three main cost components: capture, transport and storage (which encompasses injection and monitoring). The cost of capture is typically several times greater than the cost of transport and storage. In today's economic and regulatory environment, carbon capture technologies could increase electricity production costs by 60-100 percent at existing power plants and by 20-55 percent at new advanced coal-fired power plants using Integrated Gasification Combined Cycle (IGCC) technology or supercritical coal plants.

While industrial CO_2 separation processes are commercially available, they have not been deployed at the scale required for large power plant applications, and their application could significantly increase electricity production costs. Improvements to existing CO_2 capture processes, therefore, as well as the development of alternative capture technologies, are important in reducing the costs incurred for carbon sequestration.

Technology Development Efforts – CO_2 Capture

Carbon sequestration begins with the separation and capture of CO_2 from power plant process or flue gas and other point sources. At present, this process is both costly and energy intensive; CO_2 capture accounts for the majority of the cost of the CO_2 sequestration system. Therefore, R&D goals within the Program's CO_2 Capture focus area are aimed at improving the efficiency and reducing the costs of capturing CO_2 emissions from coal-fired power generating plants.

The Program currently funds a large number of laboratory-scale and pilot-scale research projects involving solvents, sorbents, membranes, and oxygen combustion systems (oxy-combustion). Efforts are focused on systems for capturing CO_2 from coal-fired power plants since they are the largest centralized sources of CO_2, although the technologies developed will be applicable to natural-gas-fired power plants and industrial CO_2 sources as well.

- *Capture Technology Approaches*

Depending on the process or power plant application in question, there are three main approaches to capturing the CO_2 generated from a primary fossil fuel – post-combustion, pre-combustion, and oxycombustion. The following sub-sections will elaborate on the three different capture approaches.

- *Post-Combustion Systems*

Post-combustion systems separate CO_2 from the flue gases produced by the combustion of the primary fuel in air. The flue gases, if controlled, would exit the power station into the surrounding atmosphere. These systems normally use a liquid solvent to capture the small fraction of CO_2 present in a flue gas stream in which the main constituent is nitrogen (which comes from air used in the combustion process).

Pulverized coal (PC) plants, which are 99 percent of all coal-fired power plants in the United States, burn coal in air to produce steam. CO_2 is contained in the flue gas at a concentration of 10-15 percent. This is a challenging application for CO_2 capture because:

- The low pressure and dilute concentration dictate a high volume of gas to be treated.
- Trace impurities in the flue gas tend to reduce the effectiveness of the CO_2 adsorbing processes.
- Compressing captured CO_2 from atmospheric pressure to pipeline pressure (1,200 - 2,000 pounds per square inch [psi]) uses a lot of energy and thus represents a large parasitic load.

The CO_2 concentration in flue gas from a coal-fired IGCC turbine is about 9 percent and from a natural gas-fired turbine about 4 percent. The flue gas in these systems approaches ambient pressure, and thus the CO_2 partial pressure of the gas is low, indicating that a very large volume of gas needs to be treated.

For a modern PC power plant or a natural gas combined cycle (NGCC) power plant, current post-combustion capture systems would typically employ an organic solvent such as monoethanolamine (MEA). Aqueous amines are the state-of-the-art technology for CO_2 capture for PC power plants. Analysis conducted at the NETL shows that CO_2 capture and compression using amines raises the cost of electricity from a newly-built supercritical PC power plant by about 85 percent, from 4.9 cents/kWh to 9.0 cents/kWh. The goal for advanced CO_2 capture applied to PC systems is that CO_2 capture and compression added to a newly constructed PC power plant increases the cost of electricity by no more than 20 percent, compared with a no-capture case.

- *Pre-Combustion Systems*

Pre-combustion systems process the primary fuel in a reactor with steam and air or oxygen to produce a mixture consisting mainly of carbon monoxide and hydrogen ('synthesis gas') at high pressure. This is the technology used in IGCC plants. Additional hydrogen, together with CO_2, is produced by reacting carbon monoxide with steam in a second reactor (a 'shift reactor'). The resulting mixture of hydrogen and CO_2 can then be separated into a CO_2 gas stream, and a stream of hydrogen. If the CO_2 is stored, the hydrogen is a carbon-free energy carrier that can be combusted to generate power and/or heat. Although the initial fuel conversion steps are more elaborate and costly than in post-combustion systems, the high concentrations of

CO_2 produced by the shift reactor and the high pressures often encountered in these applications are more favorable for CO_2 separation. The advantage of this type of system is the higher CO_2 concentration (partial pressure), and thus the lower volume of gas to be handled resulting in smaller equipment sizes and lower capital costs. Energy penalties and costs for CO_2 sequestration in a pre-combustion setting are significantly less compared with that from a pulverized coal combustion plant. Pre-combustion would be used at power plants that employ IGCC technology.

The state-of-the-art for CO_2 capture from an IGCC power plant is glycol-based Selexol sorbent. Analysis conducted at the NETL shows that CO_2 capture and compression using Selexol raises the cost of electricity from a newly built IGCC power plant by 25 percent, from 5.5 cents/kWh to 6.5 cents/kWh. The goal for advanced CO_2 capture and sequestration systems applied to an IGCC is to raise the production cost of electricity by no more than 10 percent. The goal for IGCC is more stringent than for PC because the conditions for CO_2 capture are more favorable in an IGCC plant.

- *Oxycombustion Systems*

Oxycombustion systems use oxygen instead of air for combustion of the primary fuel to produce a flue gas that is mainly water vapor and CO_2. This results in a flue gas with high CO_2 concentrations (greater than 80 percent by volume) and some excess O_2. The water vapor is then removed by cooling and compressing the gas stream. Oxycombustion requires the upstream separation of oxygen from air, with a purity of 95–99 percent oxygen assumed in most current designs. Further treatment of the flue gas may be needed to remove air pollutants and noncondensed gases (such as nitrogen) from the flue gas before the CO_2 is sent to storage.

- *Collaboration*

The Carbon Capture Program collaborates with other Federal Government agencies, state and local agencies, non-governmental organizations, private industry, and international organizations, as appropriate, in areas of relevance to the program. These collaborative efforts play an important role in the continued development and success of the program. For example, collaborations with these potential partners could help leverage R&D funding dollars, expand the portfolio of technologies, address key technical and economic barriers, or identify new areas of research emphasis.

- *Specific Accomplishments within Carbon Capture Portion of Program*

The Carbon Capture Program has played a vital role in the overall Carbon Sequestration Program during the past decade, with several successes. A sampling of some of the successful developments and interactions of the Program are:

- Sorbent Achieves 99 Percent CO_2 Removal: Laboratory experiments by NETL researchers have demonstrated that a NETL-developed regenerable sorbent can remove 99 percent of the CO_2 in a simulated coal combustion flue gas. Additional research will test the sorbent in bench-scale reactors and evaluate the feasibility of preparing the sorbent for large-scale units.

- Integrating Carbon Capture with Oxygen-fired Circulating Fluidized Bed Technology: Test results at a 2.9 MW project performer site show that no significant roadblocks are foreseen for integrating the carbon capture component to oxygen-fired circulating fluidized bed technologies that are being developed.

- Separation of Hydrogen from Carbon Dioxide: A project team has investigated the use of CO_2 hydrates as a way to capture CO_2. The process has shown potential to reduce the energy requirement for CO_2 capture and the capability to capture greater than 75 percent of the CO_2.

Program's Demonstration - Regional Carbon Sequestration Partnerships Program

As mentioned in the previous discussion of the program structure, the largest component of the Program's Demonstration element is the Regional Carbon Sequestration Partnerships Program. Seven Regional Carbon Sequestration Partnerships are examining regional differences in geology, land practices, ecosystem management, and industrial activity that affect the deployment of carbon sequestration technologies. Activities conducted in this Program will help provide the knowledge needed to make CCS a viable GHG mitigation option both domestically and internationally.

Carbon Sequestration Leadership Forum (CSLF)

The Carbon Sequestration Leadership Forum is a voluntary climate initiative of developed and developing nations that account for about 75 percent of all manmade carbon dioxide emissions. The CSLF was established in 2003 and focuses on development of carbon capture and storage technologies as a means of accomplishing long-term stabilization of greenhouse gas levels in the atmosphere. The goal is to improve carbon capture and storage technologies through coordinated research and development with international partners and private industry. This could include promoting the appropriate technical, political, and regulatory environments for the development of such technology.

The CSLF is currently comprised of 22 members, including 21 countries and the European Commission. Members engage in coordinated and cooperative technology development aimed at enabling the early and on-going reduction of the carbon dioxide which constitutes more than 60 percent of such emissions - the product of electric generation and other heavy industrial activity.

Regional Carbon Sequestration Partnerships Background

Geographic differences in fossil fuel use and potential sequestration storage sites across the U.S. must be evaluated in addressing CO_2 sequestration. DOE has created a network of seven RCSPs to help develop the technology, infrastructure, and regulations to implement CO_2 sequestration in different regions and geologic formations within the Nation. Underlying this regional partnership approach is the belief that local organizations and citizens will contribute expertise, experience, and perspectives that more accurately represent the concerns and desires of a given region, thereby resulting in the development and application of technologies better suited to that region.

Collectively, the seven RCSPs represent regions encompassing 97 percent of coal-fired CO_2 emissions, 97 percent of industrial CO_2 emissions, 97 percent of the total land mass, and essentially all the geologic sequestration sites in the U.S. potentially available for carbon sequestration. The RCSPs are evaluating numerous sequestration approaches to assess which approaches are best suited for specific regions of the country and are helping develop a framework to validate and demonstrate the most promising carbon sequestration technologies.

CO_2 injection into different geologic formations, including depleted oil and natural gas fields, unmineable coal seams, saline formations, shale, and basalt formations -- has evolved as the highest priority for near term deployment in a carbon constrained world. Among the seven RCSP regions, geologic storage sites differ in their lithology as well as their locations relative to CO_2 emission sources and pipelines. Some regions have an abundance of different types of geologic formations, while opportunities in other regions are dominated by a specific formation type.

The process of sequestering carbon dioxide involves identifying sources that produce CO_2 and identifying storage sites where the CO_2 can be safely and permanently stored. Based on data assembled for the *2006 Carbon Sequestration Atlas of the United States and Canada*, the aggregate CO_2 sink capacity is estimated to hold several hundred years of total domestic U.S. emissions.

The RCSP Program was initiated in September 2003 through an open solicitation process that required a minimum 20 percent cost share from the prospective awardees. The RCSP Program is implemented in three phases:

- Phase I – Characterization (FY2004 – FY2005)
- Phase II – Validation (FY2006 – FY2009)
- Phase III – Demonstration (FY2008 – FY2017)

As a whole, the seven RCSPs have provided more than 31 percent in cost sharing through the first two phases. Even though the RCSP Program is being implemented in three phases, it should be viewed as an integrated whole, with many of the goals and objectives transitioning from one phase to the next. Accomplishments and results from the Characterization Phase have helped to refine goals and activities in the Validation Phase, and results from the Validation Phase are expected to enhance the Demonstration Phase.

The RCSP Program encourages and requires open information sharing among its members. DOE and the RCSPs sponsor both general workshops and more focused technology area working group meetings to facilitate information exchange. During these meetings, the most effective approaches to problem solving become apparent and are quickly adopted, thus strengthening the overall RCSP Program. Although each RCSP has its own objectives and field tests, cooperation has been a hallmark of the Program to date. These workshops and working group activities were initiated during the Characterization Phase, have continued into the Validation Phase, and will likely be an important aspect of the Demonstration Phase as well.

Characterization Phase

The Characterization Phase, completed in 2005, focused on characterizing regional opportunities for CCS, identifying regional CO_2 sources, and identifying priority opportunities for field tests. Each RCSP developed decision support systems that house regional geologic data on CO_2 storage sites and information on CO_2 sources to complete source-sink matching models. Each RCSP also researched project tools necessary to model and measure the fate and spread of CO_2 after injection. Combined with public outreach and education programs conducted by the

RCSPs during the Characterization Phase, these activities indicate that CCS is a viable option to mitigate CO_2 emissions. In preparation of the Validation and Demonstration Phases, the RCSPs gathered data necessary to prepare and conduct geologic field tests, and succeed in the following key accomplishments:

- Established a national network of companies and professionals working to advance sequestration technology so that it is viable for commercial deployment. The RCSPs brought an enormous amount of capability and experience together to work on the challenge of infrastructure development. Together with DOE, the RCSPs secured the active participation of more than 500 individuals representing more than 300 industrial companies, engineering firms, state agencies, non-governmental organizations, and other supporting organizations.

- Raised awareness and support for carbon sequestration as a GHG mitigation option. Each RCSP developed creative and innovative approaches to outreach and education. Articles about sequestration have appeared in local newspapers, documentaries have been shown on public television, and RCSP leaders have made appearances on local television programs. All seven RCSPs developed websites that describe their activities and several RCSPs experimented with innovative, internet-based outreach efforts, including a modified chat room for fielding questions about sequestration and town hall style meetings.

- Advanced understanding of permitting requirements for future carbon sequestration projects. To comply with public and regulatory requirements of multiple federal and state programs responsible for addressing possible safety and environmental risks, carbon sequestration projects will likely require specific permits. Working in collaboration with the Interstate Oil and Gas Compact Commission (IOGCC) and the U.S. Environmental Protection Agency, the RCSPs are assessing requirements and procedures for permitting future commercial sequestration deployments. Specifically, DOE and EPA meet on a quarterly basis at a high management level to ensure that Agency efforts are coordinated and communicated to each other effectively. Both DOE and the RCSPs were involved with providing comments for EPA's first Underground Injection Control program guidance related to permitting initial pilot projects as experimental technology wells, giving regulatory agencies enhanced flexibility in expediting these projects.

- Identified priority opportunities for sequestration field tests. The RCSPs identified, within their Regions, high priority opportunities for selected field tests during the Validation Phase.

- Established a series of protocols for project implementation, accounting, and contracts. RCSP activities in this area focused on the development of accounting protocols and support for state or national GHG accounting registries.

Validation Phase

The Validation Phase, initiated in October 2005, focuses on field tests to validate the efficacy of carbon sequestration technologies in a variety of geologic and terrestrial storage sites throughout the U.S. Using the extensive data and information gathered during the Characterization Phase, the seven RCSPs identified the most promising opportunities for carbon sequestration in their Regions and commenced geologic field tests. In addition, the RCSPs are verifying regional CO_2 sequestration capacities, satisfying project permitting requirements, and conducting public outreach and education activities.

The field tests conducted during the Validation Phase address the following goals:

- Validate and refine current CO_2 formation models for various geologic sequestration sites;
- Collect physical data to confirm capacity and injectivity estimates made during the Characterization Phase;
- Demonstrate the effectiveness of Monitoring, Mitigation and Verification (MM&V) technologies to measure CO_2 movement in the formations and confirm the integrity of the seals;
- Develop guidelines for well completion, operations, and abandonment to maximize storage potential and mitigate potential leakage; and
- Develop strategies that can be used to optimize the storage capacity for various sink types.

To achieve these primary Validation Phase goals, each RCSP has established supporting goals and planned actions. Many of these supporting goals and actions were created as a logical continuation of goals completed and/or specific accomplishments attained during the Characterization Phase. For example, initial data collected on CO_2 point sources and potential sequestration sites will be updated during the Validation Phase as additional data and analytical procedures become available. In addition, a common economic modeling approach for CO_2 capture will be developed during the Validation Phase and beyond. It will be based on preliminary economic models of available and emerging capture technologies created during the Characterization Phase. Storage capacity estimates for saline formations will be re-calculated in the Validation Phase and beyond using a common methodology developed by the RCSPs during the Characterization Phase; and instrumentation evaluated and tested during the Characterization Phase to follow CO_2 injection, plume migration, and storage permanence will be field-tested in the Validation Phase.

As I previously mentioned, the U.S. Department of Energy (DOE) is taking a leadership role in the development of CCS technologies. The challenges being addressed through research and development within the Carbon Sequestration Program will allow carbon sequestration to become an effective and economically viable option for reducing CO_2 emissions. Successful research and development will enable carbon mitigation technologies to overcome the various technical, economic and social barriers currently limiting widespread commercial applications, including barriers to cost-effective CO_2 capture, long-term stability (permanence) of CO_2 in underground formations, monitoring and verification, integration with power generation systems, and, most important, that of public acceptance.

Mr. Chairman, and members of the Committee, this completes my prepared statement. I would be happy to answer any questions you may have at this time.

HANCE SCARBOROUGH WRIGHT WOODWARD & WEISBART

A Registered Limited Liability Partnership
ATTORNEYS AND COUNSELORS AT LAW

JAY B. STEWART
E-MAIL: jstewart@hswww.com

111 CONGRESS AVENUE
SUITE 500
AUSTIN, TEXAS 78701
(512) 479-8888
(512) 482-6891 (FACSIMILE)

OTHER LOCATIONS:
DALLAS (NORTH), TEXAS
DOWNTOWN DALLAS, TEXAS
WASHINGTON, D.C.

March 2, 2007

THE TEXAS EXPERIENCE

I. Regulatory Oversight of Subsurface Injection Activities in Texas

It is the policy of the State of Texas: (a) to maintain the quality of fresh water in the state to the extent consistent with the public health and welfare and the operation of existing industries, taking into consideration the economic development of the state; (b) to prevent underground injection that may pollute fresh water; and (c) to require the use of all reasonable methods to implement this policy.[1] The Texas Legislature assigned responsibility for regulating underground injection activities to the Railroad Commission of Texas ("RRC") and the Texas Commission on Environmental Quality ("TCEQ"). As a result of implementing and refining specific agency programs and standards in accordance with the intent of the Texas Legislature, the RRC and TCEQ have created an unparalleled regulatory framework for underground injection activities.

A. The Railroad Commission of Texas

The RRC is the state agency with specific oversight over the injection of substances for the extraction of minerals.[2] It has been active in the regulation of underground injection activities for more than fifty years.[3] On April 23, 1982, the RRC's Underground Injection Control ("UIC") program was approved by the U.S. Environmental Protection Agency as meeting the federal safe drinking water requirements established by the federal Safe Drinking Water Act of 1974.[4] The Environmental Services Section of the RRC (formerly the Underground Injection Control Section) oversees the permitting and regulation of certain types of injection wells, including: (a) injection wells used to dispose of oil and gas waste, including salt water and other produced fluids, wastes associated with the underground storage of hydrocarbons, and wastes

[1] TEX. WATER CODE CH. 27 (Texas Injection Well Act).
[2] The Railroad Commission of Texas was established in 1891 and has broad authority over oil and gas exploration and production in Texas. As the oldest regulatory agency in Texas and one of the oldest of its kind in the nation, the Railroad Commission has regulatory divisions that oversee the Texas oil and gas industry, gas utilities, pipeline safety, safety in the liquefied petroleum gas industry, and the surface mining of coal.
[3] The first RRC-permitted injection well was permitted on April 4, 1936.
[4] The Safe Drinking Act of 1974 is codified in 42 U.S.C.§300f et. seq.

arising out of, or incidental to, the operation of gasoline plants, natural gas processing plants, and pressure maintenance or repressuring plants[5]; (b) underground hydrocarbon storage wells[6]; (c) brine mining injection wells[7]; and (d) injection wells used to enhance recovery of oil and gas.[8] Thus, the RRC has direct oversight over the injection of water and carbon dioxide ("CO_2") for enhanced oil recovery operations in Texas.

CO_2 injection in Texas began in 1973 on the Sacroc Unit. This was the first CO_2 injection project in the world. Currently, CO_2 injection occurs on 294 leases in Texas. RRC-permitted CO_2 injection wells are currently authorized to inject a total of 64,900,000 MCF *per day*. During the latest RRC reporting cycle, 5,835 wells reported injection of CO_2.[9] It is estimated that 25 million metric tons per year are injected on an annual basis, with most of that in Texas Permian Basin. It is estimated that more than 55 million barrels of annual crude oil production resulted from these enhance recovery efforts.[10]

The RRC first approved underground gas storage in depleted reservoirs in 1949. The RRC has approved a total of 38 projects for gas storage in depleted reservoirs.[11] Of the 38 approved gas storage projects, 14 are currently active. Of the active projects, the oldest was approved in 1952.

B. The Texas Commission on Environmental Quality

The TCEQ regulates underground injection activities that are not associated with the exploration and production of oil and gas. A few examples of injection wells regulated by the TCEQ are: (a) wells that inject municipal, industrial, or hazardous wastes into a layer that is below the lowermost underground source of drinking water; (b) wells that inject fluids to extract uranium or sulfur and to get rid of waste byproducts from the mining operation; (c) wells that inject hazardous waste above an underground source of drinking water; and (d) any well or similar apparatus that releases a liquid or liquids into or above an underground source of drinking water.[12]

C. Underground Injection Application Review Process in Texas

In accordance with their jurisdictions defined above, the RRC and TCEQ have rigorous review procedures for proposed injection activities. The RRC and TCEQ application review processes ensure that appropriate license conditions for the specific activity are in place to protect human health and the environment. Once a completed license application for a certain type of injection activity is submitted to either the RRC or TCEQ, it will undergo a technical review by agency

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[5] *See* TEX. WATER CODE CH. 27.
[6] *See* TEX. NAT. RES. CODE §91.201 et. seq.
[7] *See* TEX. WATER CODE CH. 27.
[8] *See* TEX. NAT. RES. CODE §91.101.
[9] These active wells are part of the 9,999 wells that still have current RRC permits that allow CO_2 injection.
[10] *Carbon Capture and Storage: A Regulatory Framework for States*, p. 30; Interstate Oil and Gas Compact Commission 2005.
[11] This excludes gas cycling and pressure maintenance projects.
[12] *See* TEX. WATER CODE CH. 27.

experts who routinely judge the available technologies for injection and geologic evaluation.[13] The applicant must demonstrate to the agency experts that the radius or cone of influence (plume) that the injected material will form in the target formation(s). The pressures of the injection and of the injection formation must be shown to be compatible with what is being injected and permanently stored. The mechanical integrity of the wells must be demonstrated. An "area of review" analysis must be provided and studied to ensure that all wells or other potential pathways are located, investigated and plugged if necessary. Only after a thorough engineering and geologic review is completed will a license be granted.

II. Limitations to Liability during Captured CO_2 Operations

The proposal of carbon sequestration has raised legal questions with protecting the host site owner or operator from liability for the remote possibility of claims for damages to another's personal or real property resulting from the injection of CO_2 into the subsurface strata. As discussed below, Texas case law and statutory law offers adequate protections to the host site owner or operator upon injection of the CO_2 into the subsurface strata.

A. Texas Case Law

Existing case law protects the operator from exposure to liability if the captured CO_2 operations are conducted in accordance with state-issued permits and applicable regulations. The Supreme Court of Texas has held that subsurface injection operations approved by a state agency insulates the operator from liability under the theory of trespass because "the operator lacks the necessary intent" to physically invade another's subsurface or minerals.[14] Further, state agency approval of the injection operations will likely minimize any liability in a cause of action brought under the theory of private nuisance, which requires a finding of a substantial and unreasonable interference with another's use of his or her property.[15] A state court would likely find that no nuisance exists because the interference, if any, is not unreasonable due to the fact that the state authorized the CO_2 injection operations.

Under Texas case law, it is highly unlikely that a court would find any strict liability in a products liability cause of action for damages resulting from the injection of CO_2 into the subsurface strata. The injection process is not an abnormally dangerous activity because it does

[13] RRC evaluates underground injection permit applications under its jurisdiction in accordance with Title 16, Texas Administrative Code ("TAC"), Chapter 3 (Oil and Gas Division). TCEQ evaluates underground injection permit applications under its jurisdiction in accordance with 30 T.A.C. Chapter 331 (Underground Injection Control).

[14] *See Railroad Comm'n v. Manziel*, 361 S.W.2d 560 (Tex. 1962) (Court indicated that it is unlikely that a plaintiff who is objecting to secondary recovery in the oil and gas industry or analogous operations authorized by the Railroad Commission can recover in trespass); *also see Z.A.O, Inc. v. Yarbrough*, 50 S.W.3d 531, 543 (Tex. App.—El Paso, 2001) (Court held that a private cause of action for trespass could not be maintained because the state agency with regulatory jurisdiction determined that the level of contaminants at the site did not exceed the standards established by state law).

[15] *Z.A.O., Inc.*, 50 S.W.3d at 542 ("In Texas, nuisance involves a condition which substantially interferes with the use and enjoyment of land by causing unreasonable discomfort or annoyance to persons of ordinary sensibilities attempting to use and enjoy it.").

not pose a high risk of injury to persons or property, and such activity has been commonly undertaken by the energy industry in this state for decades.[16] Further, CO_2 by itself is not an abnormally dangerous or defective product. It is a chemical compound naturally found in the earth's atmosphere with many beneficial and safe uses.

As a result of the existing case law in Texas, it is highly unlikely that a court would find a clean coal project operator to be negligent if the operator was conducting operations and activities in accordance with its permits and applicable regulations.

B. Texas House Bill 149

Responding to the specific issues presented as part of the FutureGen effort, Texas passed House Bill 149 into law during the 3rd Called Session of the 79th Legislature (2006). HB 149 transfers ownership of the generated CO_2 from the FutureGen Alliance to the State of Texas. Specifically, once the extraction or "capture" of the CO_2 byproduct from the clean coal electrical generation process occurs, by law, the Railroad Commission of Texas ("Commission") acquires the right, title and interest to the captured CO_2.

Transfer of ownership of the captured CO_2 to the Commission is significant for long-term liability concerns. If injection is performed in accordance with its state permits and regulations, the operator's conduct will be concluded regarding the permanent sequestration of the CO_2. Possible claims for damages from unanticipated migration, upset or release would be caused by the State's property, not the property of the operator. Although the Commission would assume legal responsibility for these claims, the Commission is protected under Texas law from liability under the principles of governmental sovereign immunity.

Because the state and its political subdivisions enjoy complete sovereign immunity at common law, a plaintiff must establish both a waiver of immunity from suit and liability pursuant to a Constitutional or statutory provision in order to successfully pursue to judgment a tort claim against the Commission for its acts or omissions involving the captured CO_2.[17] The Texas Tort Claims Act ("TTCA") does provide an ***extremely limited*** waiver of sovereign immunity for certain torts.[18] Waiver of immunity is provided in situations where personal injury is caused by a condition or use of tangible personal or real property if the government unit would, were it a private person, be liable to the claimant under Texas law.[19] The TTCA does not waive immunity

[16] *See Hicks v. Humble Oil*, 970 S.W.2d 90 (Tex. App.—Houston [14th Dist.], 1998, pet denied) (Texas courts "have rejected the doctrine of abnormally dangerous activities as a basis for strict liability.").
[17] *See Tex. Parks & Wildlife Dep't v. Davis*, 988 S.W.2d 370, 372 (Tex. App.—Austin 1999, pet. filed); *see also Tex. Nat. Res. Cons. Comm. v. IT-Davy*, 74 S.W.3d 849, 854 (Tex. 2002) (Concerning contracts with the state, the Texas Supreme Court has expressly recognized that immunity allows governmental entities to breach their contracts and rely upon immunity to preclude suit when it is determined that the contract no longer serves the best interest of the entity).
[18] *See Univ. of Texas Med. Branch v. York*, 871 S.W.2d 175, 177 (Tex. 1994).
[19] *See Medrano v. City of Pearsall*, 989 S.W.2d 141, 144 (Tex. App.—San Antonio, 1999, no pet.).

for claims arising out of an intentional tort. Further, immunity is not waived for property damage caused by a condition or use of governmental real property.[20]

TTCA places significant limitations on the ability of a plaintiff to recover damages against a governmental unit of the state. Money damages for governmental liability are limited under the TTCA. Most importantly, a judgment in a suit under TTCA may be enforced only in the same manner and to the same extent as other judgments against the governmental unit are enforceable as provided by law, unless the governmental unit has liability or indemnity insurance protection, in which case the holder of the judgment may collect the judgment, to the extent of the insurer's liability, as provided in the insurance or indemnity contract or policy or as otherwise provided by law.[21]

In sum, an owner or operator of a clean coal project in Texas will be protected from liability once the CO_2 is captured (and title is transferred to the State of Texas). Likewise, there is a very low probability that a plaintiff will succeed in recovering damages from the State of Texas as the result of an act or omission involving the captured CO_2. Given the established legal protections applicable to these circumstances, Texas is a viable and practical location for hosting a clean coal project.

Respectfully submitted,

Jay B. Stewart

[20] Tex. Civ. Prac. & Rem. Code Ann §101.057.
[21] Tex. Civ. Prac. & Rem. Code Ann. §101.107(a).

HANCE SCARBOROUGH WRIGHT
WOODWARD & WEISBART

A Registered Limited Liability Partnership
ATTORNEYS AND COUNSELORS AT LAW

JAY B. STEWART
E-MAIL: jstewart@hswww.com

111 CONGRESS AVENUE
SUITE 500
AUSTIN, TEXAS 78701
(512) 479-8888
(512) 482-6891 (FACSIMILE)

OTHER LOCATIONS:
DALLAS (NORTH), TEXAS
DOWNTOWN DALLAS, TEXAS
WASHINGTON, D.C.

March 2, 2007

The Honorable John D. Dingell, Chairman
The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce
2125 Rayburn House Office Building
Washington, D.C. 20515

Re: Carbon Sequestration: Submission of testimony regarding the Texas Experience. Subcommittee on Energy and Air Quality hearing on "Carbon Capture and Sequestration: An Overview" – March 6, 2007.

Dear Chairman Dingell, Ranking Member Barton and Members of the Committee:

Thank you for the opportunity to discuss with you today the State of Texas' experience with legal issues regarding the injection and storage of carbon dioxide. For the record, my name is Jay B. Stewart. I am an attorney who practices regulatory law in Austin, Texas. As part of my practice, I represent entities and individuals before the Railroad Commission of Texas ("RRC") and the Texas Commission on Environmental Quality ("TCEQ") regarding oil and gas and injection activities. I have also been retained to work with the FutureGen Texas team regarding the State's efforts to site a clean coal project in Texas. I come before you today to discuss the Texas Experience with CO_2 injection and the existing and prospective regulatory framework necessary to ensure successful and secure geologic sequestration of CO_2.

Evaluating and licensing CO_2 injection in Texas has a regulatory track record that spans back more than 30 years. The prolific Permian Basin in West Texas began utilizing CO_2 injection as a recovery technology in 1973. Once the traditional extraction of oil and gas has exhausted itself, secondary and tertiary recovery technologies are used to extract the vast remaining reserves. Recent data indicates that up to 70 licensed enhance oil recovery projects utilizing CO_2 were operational in the Permian Basin of West Texas alone. Over 5,800 wells have reported injection of CO_2 with a total injection of 25 million metric tons per year. It is estimated that more than 55 million barrels of annual crude oil production resulted from these enhance recovery efforts. With more than 30 years of history of using CO_2 for oil recovery, these operations have a safety record of no major accidents.

From a legal, regulatory and engineering standpoint, CO_2 injection into geologic formations for productive use is nothing new in Texas. A developed regulatory framework exists to evaluate and judge each and every project. The Railroad Commission of Texas regulates injection of water and CO_2 for enhanced oil recovery operations. It also has decades of evaluating and regulating the common practice of brine and oil and gas waste injection into geologic formations, insuring that those formations are not productive of oil and gas and that they do not contain useable groundwater. The Texas Commission on Environmental Quality regulates injection of non-hazardous waste, hazardous waste and experimental wells. Both these agencies have experienced staff that routinely judge the available technologies for injection and geologic evaluation. It is only after these experts have approved an injection project that a project license is allowed to proceed.

Acknowledging the experience in oil and gas and geologic evaluation of both the state's regulators and industry, Texas courts have consistently developed case law that clearly delineate the liability of the actors and neighbors of these projects. Evaluation of legal liability rests primarily in the common law. Liability for negligence or malfeasance in the construction and operation of a facility utilized for capture and injection of CO_2 would rest in traditional tort law causes of action. There is no liability forgiveness for bad actors that operate negligently.

Legal challenges to the activity of injection, however, have been thoroughly adjudicated in Texas and those causes of action are limited under the common law. Actions for trespass, nuisance and negligence are severely limited in Texas so long as the operator has a valid license from the state agency and that operator has acted in accordance with the license and applicable regulations. Texas has adjudicated the public policy implications of injection activities within its borders, and has consistently ruled with the state agencies charged with enforcing those requirements.

I have discussed the legal treatment of liability in Texas as to the practice of injection of CO_2 and its use under existing regulatory frameworks. Carbon sequestration intended to be permanent adds a significant new component to the legal analysis. Liability for the unlikely possibilities of release or migration of sequestered CO_2 that could occur well beyond the time frames that are occasioned by operations in Texas should be evaluated.

Proper geologic and technical considerations are the first requirements to avoid possible liability for long-term events. Carbon sequestration into proven, confined geologic formations is paramount. Proposed storage of CO_2 in depleted oil and gas formations, deep saline formations, salt caverns and unminable coalbeds all have containment and absorption characteristics that minimize the possibilities of any release or migration. Before a license is granted, the operator must prove to the agency experts the radius of influence or plume that the injected material will form in the injection formation. The pressures of the injection and of the injection formation must be shown to be compatible with what is being injected and permanently stored. Thorough evaluation and study of the injection proposal and target formation is the first and foremost check on potential future liability of permanent geologic storage of carbon.

As with any good legal analysis, the lawyer must then ask the question "But what if…?" In Texas, we answered this question by passing into law a transfer of ownership of the CO_2 from the FutureGen facility to the State of Texas. Acknowledging the goal of permanence of carbon sequestration, the permanence of the State is the only entity that can provide the necessary notice and monitoring beyond what one could expect in a private entity's lifespan. The State is protected by the principals of sovereign immunity while it cares for the injected CO_2 that is, by state law, its property and responsibility.

Oil and gas producing states have significant regulatory frameworks for geologic evaluation and approval of injection technologies. Texas' 100-year plus experience of oil and gas exploration and production in almost every corner of the state provides significant data points to predict where and to what extent appropriate geologic formations exist for carbon sequestration. Texas law regarding mineral exploration and extraction has likewise matured along side the technology and realities of an energy hungry nation. Application of Texas' experienced body of law, and of new modifications that have been added to ensure long term care of sequestered carbon, makes Texas an ideal candidate for carbon sequestration analysis and operation.

I have attached a legal brief discussing in more detail my testimony regarding applicable Texas law. I ask that the brief be added to the record as part of my testimony.

Thank you, and I am available for any questions.

Respectfully submitted,

Jay B. Stewart

enclosure

TESTIMONY OF

WILLIAM L. WEHRUM
ACTING ASSISTANT ADMINISTRATOR
OFFICE OF AIR AND RADIATION

BENJAMIN H. GRUMBLES
ASSISTANT ADMINISTRATOR
OFFICE OF WATER

U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
COMMITTEE ON ENERGY AND COMMERCE
UNITED STATES HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON ENERGY AND AIR QUALITY

March 6, 2007

Good morning, Chairman Boucher and members of the Subcommittee. Thank you for the opportunity to testify on behalf of the Environmental Protection Agency (EPA or Agency). My name is Bill Wehrum and I am the Acting Assistant Administrator for EPA's Office of Air and Radiation. With me this morning is Benjamin Grumbles, EPA's Assistant Administrator for the Office of Water. We both would be pleased to answer any questions the Subcommittee may have with respect to capture and geologic storage of carbon dioxide from power plants, the subject of this hearing.

As you know, the President and this Administration are firmly committed to taking sensible action on climate change. The Administration's policy is science-based, encourages research breakthroughs that lead to technological innovation, and harnesses the power of markets to commercially deploy those technologies.

As my colleague from Department of Energy (DOE) explained, the Administration is actively investigating the prospects for carbon dioxide capture from power plants and other industrial sources and long-term storage in geologic formations. Our testimony today will focus on EPA's role in ensuring that carbon capture and storage is developed and deployed in a manner that safeguards the environment. We are focusing our efforts on two fronts: (1) partnering with public and private stakeholders to develop an understanding of the environmental aspects of carbon capture and storage that must be addressed for the necessary technologies to become a viable strategy for reducing greenhouse gases; and (2) ensuring carbon dioxide storage is conducted in a manner that protects underground sources of drinking water, as required by the Safe Drinking Water Act. Before discussing each of these EPA efforts in turn, I would like to briefly discuss the role of coal in our nation's energy future.

I. ROLE OF COAL AND CARBON CAPTURE TECHNOLOGIES

Coal is an essential fuel to achieve energy security and increase economic prosperity in the United States. Currently, about 50 percent of electricity in the United States is generated from coal, and at current rates of consumption, U.S. coal reserves are large enough to meet our energy needs for more than 200 years. To achieve our goal of energy security, coal must to continue to play a major role in the generation of electricity in this country. Carbon dioxide capture and storage can potentially make a significant contribution to reducing greenhouse gas emissions from coal-fired electricity generation, while allowing continued use of our ample coal reserves.

To address the potential environmental impact of coal-fired power plants, EPA, DOE, and others are exploring technological innovations that would allow coal to be burned more efficiently and with fewer emissions. Recognizing the importance of advanced coal technology, EPA is already working to ensure that these new technologies are deployed in an environmentally responsible manner.

II. ADVANCED COAL TECHNOLOGY

EPA is examining how we can facilitate the use of advanced coal technologies through research and the efforts of a recently-convened work group of private and public stakeholders. Through our efforts, we are gaining a better understanding of how the use of carbon dioxide capture technologies could impact existing power plants and affect the siting, engineering, and design of new ones.

At the recommendation of the Clean Air Act Advisory Committee, EPA established the Advanced Coal Technology Work Group in January 2007 to discuss and identify the potential barriers and opportunities to create incentives under the Clean Air Act for the development and deployment of advanced coal technologies and specifically geologic sequestration. The Work Group includes participants from electric utilities, coal companies, equipment manufacturers and pollution control providers, States and Tribes, public utility commissions, environmental and public health organizations, academia, and Federal agencies such as DOE and the Department of Defense.

The Work Group is developing a set of shared recommendations that could be undertaken by various stakeholders (e.g., EPA, DOE, DOD, States, Tribes, utilities, public utility commissions, equipment providers, and environmental and health organizations) to accelerate the development and use of advanced coal technologies. In its work to date, the Work Group has discussed a wide range of issues associated with the commercial use of advanced coal technologies. We believe that an approach involving a shared set of actions to address some of these issues will provide the greatest opportunity to advance the technology most quickly.

With respect to carbon dioxide capture and storage, key issues identified by the Work Group include: (1) the availability and cost of capture technologies for new and existing pulverized coal and integrated gasification combined cycle power plants and how to encourage "first mover" projects that capture and store carbon dioxide; (2) regulatory and other measures to accelerate the pace of carbon capture and storage; (3) the siting of power plants, including the availability and location of pipeline capacity to transport carbon dioxide to a suitable geologic formation for long-term geologic storage; (4) monitoring and verification to ensure the storage of carbon dioxide is effective; (5) liability concerns associated with carbon capture and storage; (6) legal issues involving property rights implicated by long-term storage; (7) public education and outreach; and (8) the development of the expertise needed to capture carbon dioxide from power plants and store it in suitable geologic formations. These issues will be explored more fully in coming months. The Work Group plans to issue an interim report in June 2007, with the final report planned for January 2008.

As a result of the Work Group's discussions, we are developing an understanding of the different aspects of carbon dioxide capture and storage that need to be examined and addressed if geologic carbon dioxide storage is to become a viable strategy for reducing greenhouse gases on a large commercial scale. Addressing these issues will require an integrated approach that focuses on providing incentives and reducing barriers (e.g., economic, legal) for "first mover" projects and in the process paves the way for the ability to store carbon dioxide in geologic formations in the future.

In further support of advanced coal technology, EPA is contributing to existing research to advance carbon dioxide capture technology. The Research Triangle Institute (RTI) was recently awarded a three-year, $4 million cooperative agreement from DOE to continue the development of a carbon dioxide capture technology that is based on an inexpensive, dry, reusable sorbent. The technology has been in development at RTI for the past five years and is designed to reduce carbon dioxide emissions at coal-fired power plants, as well as natural gas plants, cement plants, and petroleum refineries. RTI is currently working with EPA's Office of Research and Development (ORD) to further develop the technology at the bench-scale and will continue to work with ORD, as well as several other companies and organizations, to demonstrate the technology at ORD's pilot-scale Multipollutant Combustion Research Facility at the Research Triangle Park, NC campus.

III. GEOLOGIC CARBON DIOXIDE STORAGE

Another focus of the Agency is the development of risk management strategies to ensure that carbon dioxide injection and long-term geologic storage are conducted in an environmentally responsible manner. After realizing the potential future importance of this technology, the Office of Air and Radiation and the Office of Water began working together on this issue. We determined that the underground injection of carbon dioxide is subject to the Underground Injection Control (UIC) Program of the Safe Drinking Water Act (SDWA), which regulates injection activities to protect current and future sources of drinking water. In carrying out our responsibilities under the Safe Drinking Water Act, EPA's goal is to ensure protective, effective storage of carbon dioxide injection in suitable geologic formations.

EPA has more than 30 years of experience overseeing the UIC Program. Under this program, EPA works closely with States to ensure that underground injection is conducted in a manner that protects ground water and drinking water. There is a significant amount of expertise and experience in transporting and injecting carbon dioxide, particularly in the oil and gas sector. Annually, billions of gallons of fluids are injected via wells which are authorized under State and Federal Underground Injection Control Programs. Approximately 35 million tons of carbon dioxide are injected annually and, in the Southwest United States, there is an extensive infrastructure to transport and inject carbon dioxide for enhanced oil and gas recovery. Although the knowledge gained from these activities is extremely useful, we do not have experience in integrated carbon dioxide capture and storage technologies on a commercial scale for coal-fired power plants. Developing this expertise is essential to ensuring the potential utility of carbon dioxide capture and storage technology.

DOE's research efforts to integrate and demonstrate carbon dioxide capture and storage will go a long way toward reducing costs and providing the data needed for EPA and States to develop appropriate risk management strategies. My DOE colleague's testimony lays out the Department's plans to develop this critical technology. In the next year or so, DOE, acting through its Regional Partnerships, will implement many field tests of carbon dioxide injection throughout the country in a variety of geologic settings. DOE will also conduct a smaller number of larger tests and ultimately include commercial-scale projects such as FutureGen, a $1 billion project to create the world's first zero-emissions fossil fuel plant, and other industry sponsored efforts.

To support these policies, EPA has developed UIC permitting guidance that recommends treatment of injection wells associated with research and development projects as "experimental technology" wells, which are covered under our existing regulations. Our goal is to provide guidance that facilitates permits while encouraging environmentally responsible injection activities. Another goal of the guidance is to promote information exchange between project proponents and regulators, which will eventually support the development of a long-term management strategy for future geologic carbon dioxide storage projects and answer public questions about the emerging technology. The guidance recommends a workable UIC permitting approach for the next several years while more data are gathered to determine the most appropriate management framework for large-scale commercial deployment of geologic carbon dioxide storage.

IV. CONCLUSION

EPA understands that making environmentally responsible use of the nation's large reserves of coal is important for public health, the environment, economic growth, and energy security. We are committed to working with DOE and our other public and private partners to accelerate the important work underway to realize the significant potential of carbon dioxide capture and geologic storage of coal-fired power plant emissions.