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CARBON CAPTURE AND STORAGE TECHNOLOGIES

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

TO

RECEIVE TESTIMONY ON THE CHALLENGES ASSOCIATED WITH RAPID DEPLOYMENT OF LARGE-SCALE CARBON CAPTURE AND STORAGE TECHNOLOGIES

BISMARCK, ND, MARCH 26, 2008

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CARBON CAPTURE AND STORAGE TECHNOLOGIES

WEDNESDAY, MARCH 26, 2008

U.S. SENATE,
SUBCOMMITTEE ON ENERGY,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Bismarck, North Dakota.

The subcommittee met, pursuant to notice, at 10:34 a.m., in the Missouri Room, Bismarck State College, Hon. Byron Dorgan presiding.

OPENING STATEMENT OF HON. BYRON L. DORGAN, U.S. SENATOR FROM NORTH DAKOTA

Senator DORGAN. I am going to call the hearing to order this morning. This is a hearing of the Senate Committee on Energy and Natural Resources, the Energy Subcommittee of that full committee.

The purpose today is an oversight hearing to receive testimony on the challenges associated with rapid deployment of large-scale carbon capture and storage technologies.

Let me give a brief opening statement and then turn to my colleague, Senator Tester from Montana, who is also a member of the Senate Energy Committee for an opening statement, after which we will take testimony from witnesses.

This is an interesting and challenging issue. Fifty percent of the electricity in this country comes from our coal resources. We are not going to see 5 or 10 or 20 years in the future a future in which coal is not used. We are going to continue to use our most abundant resource, that is coal. We have hundreds and hundreds of years of coal resources here in the Fort Union basin. The question is not whether we use coal. The question is how we use the coal.

We are now coming to a different and challenging intersection in public policy, and that intersection is not just about energy policy. It's also about climate change and legislation that affects climate change.

In June, the U.S. Senate will have on the floor of the Senate a climate change bill, the Warner-Lieberman bill. We will be debating that. At the same time that we discuss that, we also have to be mindful of the urgency of establishing targets and timetables for energy development that fit the needs of climate change, even as climate change has to have targets and timetables that fit the needs of this technology deployment that we are talking about today.

I chair this subcommittee, but I also chair the subcommittee on appropriations that funds the energy and water programs in our country. I have added in the past year $71 million above President Bush's budget for the issues of clean coal and carbon capture and enhanced oil recovery with carbon. I have done that because there is a real urgency to develop these pilot projects, to learn from them, and to determine what kinds of technologies will be deployable at commercial scale.

There are many issues attendant to the issue of carbon capture. I was touring last week a pilot project in Arizona where they are capturing CO_2 and using it to produce algae and then harvesting the algae for diesel fuel. It is a fascinating approach, because algae uses sunlight and consumes CO_2 in water to produce diesel fuel. It is one approach that might be used in commercial scale. They stopped the research on that 15 years ago. As chairman of the subcommittee last year, I put some money in to begin that research once again, and we have some pilot projects going on.

A company from Texas came to us and said they have two small pilot projects in which they are taking the flue gas from plants and chemically treating it, and it produces hydrogen. It produces baking soda and produces chloride. The CO_2 is stored in the baking soda and they simply landfill the baking soda. Would that not be interesting? Is that commercially deployable? I do not have any idea.

What we are doing is taking a look at pilot projects to do a lot of innovative, interesting things in capturing CO_2 and sequestering it or using it.

Now, some of the challenges are, what about the risks? For example, if you capture CO_2 and use it for enhanced oil recovery, you are sticking it underground. You enhance oil recovery. That is a benefit. So you have beneficial use of captured CO_2. You protect the air shed on the one hand and you enhance oil recovery on the other hand. But what are the risks of sequestering underground? Will it leak? Will it leach? If so, who has the liability for that?

All of these questions are questions that overhang the proposition that Senator Tester and I are interested in. What is commercially capable of being done to capture CO_2, sequester CO_2, and to unlock the opportunity for us to continue to use our vast coal resources without injuring our environment?

Montana and North Dakota are poised, I think, to become to two States in the Nation that can provide a significant boost to our country's energy development. We have vast coal deposits. We have oil and gas. We have the Bakken shale that straddles both States. We have a lot to offer our country. We have similar interests in trying to make sure that, as we move forward, we are not only leaders in the production of new energy, but we are leaders in the demonstration of new technologies of how to capture carbon, sequester carbon, use carbon in a beneficial way and, at the same time, protect the air and the environment in this country.

Senator Tester is a very valuable member of the Energy Committee, and it is just many ways coincidence that the two of us from these two States serve in this position right now at a time that is very, very important to be answering the energy questions

for the future. We want our States to be leaders, and that is the purpose of this hearing.

This is a regional hearing that encompasses the interests not just of our region, but of our Nation and also the world because when we develop new technologies, we want it to be offered to the rest of the world. But we are here especially because we are concerned about the interests of our region as well. We want to do things. We want to continue to do them, and we want to do them right.

So, Senator Tester, thank you for coming over this morning from Montana and being with me. Why do you not proceed, if you have an opening statement?

STATEMENT OF HON. JON TESTER, U.S. SENATOR FROM MONTANA

Senator TESTER. I do. I want to thank you very much, Senator Dorgan, for holding this hearing. I also want to thank you for your leadership in energy issues over the past many years.

It is very, very good to be here in North Dakota. It was a little over 100 years ago my great grandfather was tilling the soil about 200 miles east of here. So it is good to be back in the old country with you, Senator Dorgan. It is great to be here.

I want to introduce a couple folks, if I might, from Montana: Bonnie Lovelace, who will be on this first panel, who is Bureau Chief of Water Protection at the Montana Department of Environmental Quality. We have got Lee Spangler, sitting toward the back of the room, who will be on the next panel, Director of Big Sky Carbon Sequestration Partnership at Montana State University; and Gordon Criswell, who is the Environmental Manager at PPL Montana, which happens to be our biggest power supplier in Montana.

This topic is very, very important for both of our States, and we do share some of the same reserves in the lignite formation as well as some oil formations, the Bakken shale, Williston Basin.

Montana is the sixth largest producer of coal in this country. It has the biggest reserves, about 120 billion tons. Coal, as Senator Dorgan said, is going to be a part of our energy future for a long time to come. So we have got to figure out ways that we can burn it in a way that does not put us out of business as people.

So this hearing is important on those lines.

There seems to be a perfect storm brewing. If you take a look at the climate change legislation that we are going to be taking up in the Senate here in June, along with the efforts to capture carbon because of CO_2 impacts on the environment, along with ways to enhance our oil recovery in the oil fields, this really can be a win-win-win situation. But we need more research. We need more technology. We need everybody at the table. We need to figure out ways we can do things and do them right.

As we move forth in this country, we have tremendous challenges as far as our energy portfolio into the future, and it does include renewables, but it also includes coal. How we develop the technology that revolves around carbon capture and transportation and storage is going to determine how successful we are economically as a country.

This is a worldwide problem, and I refer back to when the President of France was giving a statement to the joint session of Con-

gress about a year ago and said when it comes to climate change, the world is waiting for the United States to lead. The Inspector General said the same thing of the United Nations, said we are waiting for the United States to step up to the plate.

We can do it. It is going to take a public-private partnership to get it done, but hopefully with the leadership of Senator Dorgan and the folks that are on these panels here today and the rest of the people in Congress; we can come up with some common sense solutions to a worldwide problem.

So with that, thank you, Senator Dorgan, for bringing everyone here together today, and I look forward to the testimony.

Senator DORGAN. Senator Tester, thank you very much.

I want to introduce the first panel. We have Tim Spisak, who is the Fluids Manager Division Chief from the U.S. Department of the Interior in Washington, DC. We have Scott Klara, the Director of the Office of Coal and Power R&D, National Energy Technology Laboratory in Pittsburgh, Pennsylvania; and Bonnie Lovelace, the Chief of the Water Protection Bureau of the Montana Department of Environmental Quality.

I would say to you and to all the witnesses that your entire statement will be made a part of the record, the permanent record, and we would ask that you summarize your statement. Mr. Spisak, we will ask you to go first.

STATEMENT OF TIM SPISAK, DIVISION CHIEF, FLUID MINERALS, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR

Mr. SPISAK. Good morning, Mr. Chairman and Senator Tester. Thank you for the opportunity to present BLM's views on carbon capture and storage.

The challenges of addressing carbon dioxide accumulation in the atmosphere are significant. Fossil fuel usage, a major source of CO_2 emissions to the atmosphere, will continue in both industrialized and developing nations. Therefore, within a number of Federal and State agencies, a variety of strategies are being investigated to reduce emissions and remove CO_2 from the atmosphere. These strategies include the capture and long-term storage of CO_2 by injection into geologic formations.

As we discuss the various aspects of carbon sequestration, we should also consider the potential benefits associated with the resource. CO_2 is a leasable commodity under the Mineral Leasing Act. The BLM currently collects revenues derived from the sale of carbon dioxide produced in connection with oil production on public lands. In 2007, the sale of CO_2 generated over $23 million in royalty revenue in the States of Colorado, New Mexico, and Wyoming.

The BLM currently approves the injection of CO_2 into existing oil fields to increase oil production. The benefits derived from carbon injection are not limited to enhanced oil recovery, though. Carbon injection in oil-bearing formations yields valuable data that will inform efforts to capture and sequester carbon dioxide effectively in geologic formations found on public lands.

Public Law 110–140, the Energy Independence and Security Act of 2007, which the President signed into law this past December, includes provisions on carbon capture and storage that the Depart-

ment is working to implement. In fiscal year 2008, the Department will begin developing a methodology to conduct a national assessment of CO_2 storage capacity in oil and gas reservoirs and saline formations. An independent panel of experts and stakeholder organizations will be convened to provide a technical review of the methodology.

The Act includes provisions on carbon capture and storage that the BLM is implementing. Section 713 of the Act directs the BLM to maintain records on, and an inventory of, the quantity of carbon dioxide storage within Federal mineral leaseholds. The BLM will coordinate with the Minerals Management Service on changes that may be required to the oil and gas operations report that is used to collect production and injection data on Federal mineral estates.

In addition, section 714 of that Act directs the Department to develop a framework for geological sequestration of carbon dioxide on public land and to report back to the committee by December 2008. This effort, coordinated among several agencies within the Department, will result in recommendations for: criteria for identifying candidate geological sequestrationsites in several specific types of geological settings; a proposed regulatory framework for leasing of public land or of an interest in public land for long-term sequestration; ensuring any geological carbon sequestration activities on public land provide for public review and protect the quality of the natural and cultural resources; additional legislation that may be required to ensure that public land management and leasing laws are adequate to accommodate the long-term geological sequestration of carbon dioxide; and additional legislation that may be required for issuing rights-of-way for CO_2 pipelines on public land.

The report will also address legal and regulatory issues in split estate situations.

It is clear that addressing the challenge of reducing atmospheric CO_2 and understanding the effect of global climate change is a complex issue with many interrelated components. The assessment activities called for in the Act should ultimately increase the information base upon which decisionmakers will rely as they deal with these issues.

In addition to addressing the challenges presented by carbon dioxide, we should also, again, recognize that this commodity provides continuing opportunities for future knowledge and use. Our experience demonstrates that there is a demand and a value to this resource.

The Bureau now stands ready to assist Congress as it examines the challenges and opportunities presented by carbon sequestration. I thank you for this opportunity to present this testimony, and I am prepared to answer any questions that you may have.

[The prepared statement of Mr. Spisak follows:]

PREPARED STATEMENT OF TIM SPISAK, DIVISION CHIEF, FLUID MINERALS, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR

INTRODUCTION

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to be here today in Bismarck, North Dakota, to discuss large scale carbon capture and storage technologies. My testimony today will address the Bureau of Land Management's (BLM) perspective on carbon capture and storage as it relates to on-going

and future work of the BLM, particularly with respect to implementation of Sections 713 and 714 of the Energy Independence and Security Act of 2007 (EISA).

The challenges of addressing carbon dioxide accumulation in the atmosphere are significant. Fossil fuel usage, a major source of carbon dioxide emissions to the atmosphere, will continue for the foreseeable future in both industrialized and developing nations. Therefore, a variety of strategies are being investigated to reduce emissions and remove carbon dioxide from the atmosphere. Such strategies include the facilitated sequestration of carbon for the capture and storage of carbon dioxide through terrestrial sequestration using soils and trees, or by injection into geologic formations.

Carbon injection techniques also have useful practical applications in processes known as enhanced oil recovery (EOR), which currently takes place on some public lands managed by the BLM. These processes often allow the recovery of additional energy resources from older oil and gas fields. Carbon dioxide is a leasable commodity under the Mineral Leasing Act of 1920. The BLM currently collects revenues in the form of royalties derived from the sale of carbon dioxide produced in connection with oil and gas production on public lands. In 2007, for example, the sale of carbon dioxide generated over $23 million in royalty revenue in the states of Colorado, New Mexico, and Wyoming.

In addition to enhancing oil recovery, EOR's utilization of carbon injection may yield valuable data that will inform efforts to capture and sequester carbon dioxide effectively in geologic formations found on public lands. A critical issue for evaluation of storage capacity is the integrity and effectiveness of these formations for sealing carbon dioxide underground, thereby preventing its release into the atmosphere.

GEOLOGIC STORAGE OF CARBON

The current atmospheric carbon dioxide concentration is approximately 380 parts per million volume and rising at a rate of approximately 2 parts per million volume annually, according to the most recent information from the Intergovernmental Panel on Climate Change (IPCC). The 2005 IPCC Special Report on Carbon Dioxide Capture and Storage concluded that in emissions reductions scenarios striving to stabilize global atmospheric carbon dioxide concentrations at targets ranging from 450 to 750 parts per million volume, the global storage capacity of geologic formations may be able to accommodate most of the captured carbon dioxide. How much of this carbon dioxide storage capacity would be economically feasible (assuming some price on carbon), however, is not known. Also, geologic storage capacity may vary widely on a regional and national scale. A more refined understanding of geologic storage capacity is needed to address these knowledge gaps.

Geological storage of carbon dioxide in porous and permeable rocks involves injection of carbon dioxide into a subsurface rock unit and displacement of the fluid or formation water that initially occupied the pore space. This principle operates in all types of potential geological storage formations such as oil and gas fields, deep saline water-bearing formations, or coal beds. Most of the potential carbon dioxide storage capacity in the U.S. is in deep saline formations.

ONGOING EFFORTS

The EISA includes provisions on carbon capture and storage that the BLM is implementing. Section 713 of EISA directs the BLM to maintain records on, and an inventory of, the quantity of carbon dioxide stored within Federal mineral leaseholds. The BLM is reviewing its current data collection structures and methods, including commercially available data, and will determine how this new data collection requirement can be incorporated into existing systems. The BLM will coordinate with the Minerals Management Service on changes that may be required to the Oil and Gas Operations Report that is used to collect production and injection data on Federal mineral estate. We do not anticipate any obstacles with collecting the additional information at this time.

Section 714 of the EISA directs the Secretary of the Interior to submit a report containing a recommended framework for geological sequestration on public land to this Committee, as well as to the House Committee on Natural Resources, by December 2008.

This effort, coordinated among several agencies within the Department of the Interior, is anticipated to result in recommendations relating to:

- criteria for identifying candidate geological sequestration sites in several specific types of geological settings;
- a proposed regulatory framework for the leasing of public land or of an interest in public land for the long-term geological sequestration of carbon dioxide;

- a procedure for ensuring any geological carbon sequestration activities on public land provide for public review and protect the quality of natural and cultural resources;
- if appropriate, additional legislation that may be required to ensure that public land management and leasing laws are adequate to accommodate the long-term geological sequestration of carbon dioxide; and
- if appropriate, additional legislation that may be required to clarify the appropriate framework for issuing rights-of-way for carbon dioxide pipelines on public land.

The report will also describe the status of Federal leasehold or Federal mineral estate liability issues related to the release of carbon dioxide stored underground in public land, including any relevant experience from enhanced oil recovery using carbon dioxide on public lands.

In addition, the report will identify issues specific to the issuance of pipeline rights-of-way on public land and legal and regulatory issues specific to carbon dioxide sequestration on land in cases in which title to mineral resources is held by the United States, but title to the surface estate is not.

This effort will be undertaken in coordination with the Environmental Protection Agency, the Department of Energy, and other appropriate agencies.

CONCLUSION

It is clear that addressing the challenge of reducing atmospheric carbon dioxide and understanding the effect of global climate change is a complex issue with many interrelated components. The assessment activities called for in EISA should ultimately increase the information base upon which decision makers will rely as they deal with these issues. In addition to addressing the challenges presented by carbon dioxide, we should also recognize that this commodity presents certain opportunities for future knowledge and use. As a leasable commodity, our experience demonstrates that there is a demand and a value attributable to this resource. As we examine undeveloped oil and gas reservoirs, we should consider the potential benefits of accessible sequestered carbon dioxide. It is clear that the discussion on this subject will continue and the BLM stands ready to assist Congress as it examines these challenges and opportunities. Thank you for the opportunity to present this testimony. I am pleased to answer questions you and other Members of the subcommittee might have.

Senator DORGAN. Mr. Spisak, thank you very much. I should have mentioned that Mr. Spisak has 23 years of government service with the U.S. Bureau of Mines, including service as a petroleum engineer and supervisory petroleum engineer, masters in business administration, bachelors in petroleum and natural gas engineering from Penn State. We appreciate your being here.

Next, we will hear from Scott Klara. He is currently the Director for the Strategic Center for Coal at the National Energy Technology Laboratory. Mr. Klara is responsible for overseeing the Department's $500 million per year coal research and development program that consists of several hundred projects related to technology areas such as coal gasification, carbon sequestration, fuel cells, advanced turbines, coal liquids, and so on. He has over 20 years of experience in engineering and management. Mr. Klara, thank you for being with us. You may proceed.

STATEMENT OF SCOTT M. KLARA, DIRECTOR, NATIONAL ENERGY TECHNOLOGY LABORATORY, DEPARTMENT OF ENERGY, PITTSBURGH, PA

Mr. KLARA. Thank you, and I am pleased to be here. I appreciate the opportunity to provide comments and testimony on the Department of Energy's development of carbon capture and storage technologies as a potential solution to mitigate greenhouse gases. Throughout these remarks, I will refer to carbon capture and storage as CCS.

As you are well aware, fossil fuels will play a critical role in the Nation's future energy strategy. CCS is a key pathway that the Department of Energy is pursuing to ensure the continued use of fossil fuels in a possible carbon-constrained world. We are working with the brightest minds in the country through research and development with government-industry-academic partnerships that are focused on developing the knowledge base and technologies to overcome the issues associated with wide-scale deployment.

The sequestration program specifically is addressing the key challenges that confront the wide-scale deployment of CCS technologies through research on cost effective capture technologies; monitoring, mitigation, and verification technologies to ensure permanent storage; permitting issues, liability issues, public outreach and infrastructure needs.

The program has been performing sequestration field tests for many years where we are drilling wells and potential storage locations and injecting small quantities of carbon dioxide to validate the potential of these locations.

Substantial progress has also occurred in the area of monitoring, mitigation, and verification, with the development and refinement of technologies to better understand storage stability, permanence, and the characteristics of CO_2 migration.

Research has also focused on the development of technology options that dramatically lower the cost of capturing carbon dioxide at fossil fuel power plants. This research is exploring a wide range of approaches. Some examples would include membranes, oxy-combustion concepts, solid sorbents, CO_2 hydrates, and advanced gas/liquid scrubbing technologies. These efforts cover not only improvements to state-of-the-art technologies but also the development of revolutionary concepts. Some of these, for example, are metal organic frameworks, ionic liquids, and enzyme-based systems.

A key centerpiece for the program is the regional carbon sequestration partnerships. Two of those will be represented in the next panel.

Geographic differences in fossil fuel use and potential storage sites throughout the country dictate regional approaches in addressing CCS.

The seven partnerships represent more than 350 unique organizations in 41 States, 3 Indian nations, and 4 Canadian provinces. Each partnership is focused on a specific region that has similar characteristics related to carbon capture and storage opportunities. Together these partnerships form a network of capability, knowledge, and infrastructure to enable carbon sequestration technology to play a major role in a national strategy to mitigate greenhouse gas emissions.

Collectively, the partnerships represent regions encompassing 97 percent of CO_2 emissions from coal, 97 percent of industrial CO_2 emissions, and 96 percent of the total land mass of the United States, and essentially all geologic storage potential opportunities throughout the country.

The partnerships have identified the most promising opportunities for carbon sequestration in their regions and are performing widespread multiple geologic and terrestrial field tests, more than 25 in total.

The partnerships are also addressing key infrastructure issues related to permitting, pore space ownership, site access, liability, public outreach, and education.

Over the course of these projects, the Department and the partnerships will jointly develop best practice manuals on topics such as site characterization, site construction, operations, monitoring, mitigation, closure, long-term stewardship, and all the issues you might imagine associated with putting commercial-scale projects on the ground. These manuals will serve as guidelines for a future geologic sequestration industry in their regions and help transfer the lessons learned from the Department's programs to all regional stakeholders.

In summary, the Department's sequestration program is playing a key role in ensuring that CCS technologies will be available. The United States should continue to share leadership in technology development future deployment. This leadership could bring economic rewards in new business opportunities it creates here and abroad and provide important leverage to help speed engagement by developing countries like China and India.

I applaud the efforts of this committee for taking the leadership role in this very important issue. I would be happy to engage in further discussions after the testimony. Thank you, Mr. Chairman.

[The prepared statement of Mr. Klara follows:]

PREPARED STATEMENT OF SCOTT M. KLARA, DIRECTOR, NATIONAL ENERGY TECHNOLOGY LABORATORY, DEPARTMENT OF ENERGY, PITTSBURGH, PA

Thank you, Mr. Chairman and Members of the Committee. I appreciate this opportunity to provide testimony on the Department of Energy's (DOE's) development of Carbon Capture and Storage (CCS) technologies as a potential solution to mitigate greenhouse gas emissions.

Fossil fuels will play an important role in the Nation's future energy strategy. In a scenario of a future carbon-constrained world, successfully developing technologies to mitigate the release of carbon dioxide (CO_2) into the atmosphere will permit the continued use of fossil fuels. Economic growth has been shown to be tied to energy availability and consumption. However, we are striving to reduce the energy intensity of the economy, which would help decouple economic growth and energy availability and consumption. To retain coal, and to a lesser extent natural gas, as viable energy sources, CCS technologies must play a central role. CCS is a key pathway that DOE is pursuing to make the continued use of fossil fuels practical in a possible carbon-constrained future.

DOE is taking a leadership role in the development of carbon capture and storage technologies. Through its Carbon Sequestration Program, which is managed within the Office of Fossil Energy and implemented by the National Energy Technology Laboratory (NETL), DOE is developing both the core and supporting technologies through which CCS is expected to become an effective and economically viable option for reducing CO_2 emissions. We are working with the brightest minds in the country through research and development (R&D) with Government-industry-academic partnerships that are focused on developing the knowledge base and technologies to overcome potential barriers to the widespread deployment of carbon capture and storage technologies.

The Carbon Sequestration Program is addressing the key challenges that confront the wide-scale deployment of capture and storage technologies through research on cost-effective capture technologies; monitoring, mitigation, and verification technologies to ensure permanent storage; permitting issues; liability issues; public outreach; and infrastructure needs. As an example, today's commercially available capture and storage technologies will add approximately 80% to the cost of electricity for a new pulverized coal plant, and about 35% to the cost of electricity for a new

advanced gasification-based plant.[1] The Program is aggressively pursuing developments to reduce these costs to less than a 10% increase in the cost of electricity for new gasification-based energy plants, and less than a 30% increase in the cost of electricity for pulverized coal energy plants (the 30% goal for pulverized coal energy plants is tentative and under development).

The Carbon Sequestration Program encompasses several key elements: Core R&D, Technology Validation, and Infrastructure Development. The Core R&D Program continues to make great strides toward meeting future technology needs. The Program has been performing CCS field tests for many years, drilling wells in potential storage locations and injecting small quantities of CO_2 to validate the potential of key storage locations throughout the country. Substantial progress has occurred in the area of monitoring, mitigation, and verification with the development and refinement of technologies to better understand storage stability, permanence, and the characteristics of CO_2 migration.

Research is also focused on developing technology options that dramatically lower the cost of capturing CO_2 from fossil fuel energy plants. The research in this area can be categorized into three pathways: post-combustion, pre-combustion, and oxy-combustion. Post-combustion refers to capturing CO_2 from the stack gas after a fuel has been combusted in air. Pre-combustion refers to a process where a hydrocarbon fuel is gasified to form a mixture of hydrogen and carbon dioxide, and CO_2 is captured from the synthesis gas before it is combusted. Oxy-combustion is an approach where a hydrocarbon fuel is combusted in pure or nearly pure oxygen rather than air and produces a mixture of CO_2 and water that can easily be separated to produce pure CO_2. This research is exploring a wide range of approaches: membranes; oxy-combustion concepts; solid sorbents; CO_2 hydrates; and advanced gas/liquid scrubbing technologies. These efforts cover not only improvements to state-of-the-art technologies but also development of several revolutionary concepts, such as metal organic frameworks, ionic liquids, and enzyme-based systems.

A key centerpiece for the Program is the field program, which is being implemented through the Regional Carbon Sequestration Partnerships. The technologies, processes, and scientific knowledge necessary for carbon capture and storage depend in part on patterns of fossil fuel use and geology, which can vary between geographic regions of the United States, and even within regions. The Program is testing geologic storage in several different geologies in different regions of the country in order to build experience that will allow broad application of carbon capture and storage. The Regional Partnerships are teams comprised of state agencies, universities, and private companies with the goal of developing the knowledge base and infrastructure for the wide-scale deployment of carbon capture and storage technologies. The seven Partnerships represent more than 350 unique organizations in 41 States, 3 Indian Nations, and 4 Canadian Provinces. It is important to note that the cost share for the Regional Partnerships is about 40% (including in-kind contributions of CO_2, a major program cost), which indicates significant industry and other partner interest in the success of this program.

Collectively, the seven Regional Carbon Sequestration Partnerships represent regions encompassing 97% of coal-fired CO_2 emissions, 97% of industrial CO_2 emissions, 96% of the total landmass, and essentially all of the geologic storage sites in the country that can potentially be available for carbon sequestration. The field test program is structured with a three-phase approach.

The first phase, called the Characterization Phase, was initiated in 2003 and focused on characterizing regional opportunities for carbon capture and storage, and identifying regional CO_2 sources and storage formations. The Characterization Phase was completed in 2005 and led into the current Validation Phase.

The Validation Phase focuses on field tests to validate the efficacy of carbon sequestration technologies in a variety of geologic storage sites throughout the country. Using the extensive data and information gathered during the Characterization Phase, we identified the most promising opportunities for carbon sequestration in their regions and are performing widespread, multiple geologic field tests an—more than 25 field tests in total. We are also addressing key infrastructure issues related to permitting, space ownership, site access, liability, public outreach, and education. It is important to note that small-scale CO_2 injection is already occurring at several sites throughout the country and in Canada. Our close cooperation with the Environmental Protection Agency (EPA) and other Federal and State agencies has led to favorable permitting decisions for these projects. We continue to work closely with

[1] Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity, U.S. Department of Energy/National Energy Technology Laboratory, DOE/NETL-2007/1281, Final Report, May 2007.

EPA and others in developing CCS regulations, which will provide additional certainty regarding CCS project siting and development.

The third phase, the Demonstration Phase, of the Partnerships was initiated in fiscal year 2008. This phase is focused on conducting large-scale injection tests in representative geologies to demonstrate that CO_2 capture, transportation, injection, and storage can be accomplished at a scale equivalent to future commercial deployments. The geologic structures to be tested during these large-volume sequestration tests will likely serve as the candidate sites for initial deployment of future commercial applications of carbon capture and storage technologies. DOE is developing a peer-reviewed plan to be completed this spring that will identify the scientific and engineering test parameters to guide design and selection of large-scale tests. Items to be addressed include: rate of injection, duration of injection, and number and phasing of tests.

Over the course of these field projects, DOE, with support from the Regional Carbon Sequestration Partnerships, will develop Best Practice Manuals on topics such as site characterization, site construction, operations, monitoring, mitigation, closure, and long-term stewardship. These Manuals, which will be developed in conjunction with DOE's Office of Science, will serve as guidelines for a future geologic sequestration industry, including regional considerations, and help to transfer the lessons learned from DOE's Program to all stakeholders.

DOE recognizes the importance of developing the talent base in engineering, science, trades, law, and government. These disciplines will be necessary for a future sequestration industry. Partners such as industry, universities, and government see the need to train students and professionals in carbon capture and storage. DOE research and field projects can serve as the foundation for training grounds, future text books, and case studies that will educate the future workforce for carbon capture and storage deployment.

Of particular note relative to Program accomplishments, the Sequestration Program has produced the world's first CO_2 source/sink database—the "National Carbon Sequestration Database and Geographical Information System (NATCARB)." NATCARB provides a graphical user interface on the internet that allows users to search regions of the country for CO_2 sources and geologic storage locations. NATCARB is constantly updated with emerging information through databases that are maintained by the Regional Partnerships, as well as databases from the Environmental Protection Agency and the United States Geological Survey. NATCARB is available "free of charge" on the internet and is now receiving over 600 unique users per month from across the world.

The Sequestration Program has created a national methodology to assess the capacity for CO_2 storage in the United States and Canada. A National Atlas (another world first) was generated using NATCARB. The "2006 Carbon Sequestration Atlas of the United States and Canada" shows the aggregate CO_2 storage capacity for geologic formations in the United States and parts of Canada to be estimated at over 3,500 billion tons, enough capacity to store more than 600 years of the United States total CO_2 emissions at current annual generation rates. The Atlas, along with these storage estimates, will be updated every few years as emerging new information is incorporated into the NATCARB database.

In summary, CCS will likely play an important role in mitigating CO_2 emissions under potential future stabilization scenarios. The Department's Sequestration Program is playing a key role in ensuring that carbon capture and storage technology will be available. The United States should continue to show leadership in technology development and future deployment. This leadership could bring economic rewards in the new business opportunities it creates here and abroad, and through the Carbon Sequestration Leadership Forum and other organizations, it will provide important leverage to help speed engagement by critical developing countries like China and India. I applaud the efforts of this Committee for taking a leadership role in this very important issue.

Mr. Chairman, members of the Committee, this completes my statement. I would be happy to answer any questions you may have.

Senator DORGAN. Mr. Klara, thank you very much.

Next, we will hear from Bonnie Lovelace, the Chief of Water Protection Bureau at the Department of Environmental Quality in Montana. She has managed the subdivision, reviewed it as part of the Water Protection Bureau. Prior to managing that, she worked 12 years in the coal mining regulation program serving as bureau

chief for 9 years. A B.S. in geology, mathematics, and M.S. in geology.

Ms. Lovelace, you may proceed.

STATEMENT OF BONNIE LOVELACE, CHIEF, WATER PROTECTION BUREAU, MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

Ms. LOVELACE. Thank you, Mr. Chairman and Senator Tester. I appreciate the opportunity for the State of Montana to be here today.

I need to talk to you a little bit today about what a robust regulatory program might look like. Montana's legislature is real busy right now with an interim committee studying carbon sequestration. We have heard from industry. We have heard from the agency now, and we are taking a hard look at it. I do not know at this point whether there will be any legislation resulting from that effort, but we are certainly getting an education, and I appreciate the fact that you are too.

We are concerned about the pollution risks of carbon sequestration. Industry has indicated that if they take carbon out of the flue gas, they can take about 90 percent of the pollution out of there. The pollution that is there is whatever is going up the stack. So whatever kind of industry that is, if it is a power plant, it is what is in the coal. If it is an incinerator, it is whatever is being incinerated. So those are the pollutants we are concerned about.

The 10 percent that they cannot get is what would go into the ground. We are concerned about leakage to the surface. We are concerned about pollution of groundwater, and we are concerned about the interaction of those chemicals with the geology itself. Certain pH levels can mobilize metals and that is a broad range, and the actual pollutants themselves can mobilize metals and other pollutants, break it down in the geology, if you will, and mobilize those pollutants.

So what we would be asking for would be a robust regulatory scheme that would cover those things, and I would like to describe a little bit what that might be.

We think all of the pollutants that are being injected need to be identified. An analysis of the site and how it would interact with those pollutants would be important. We would like to have proper definition of the extent of the area for those analyses. A line on a map that says you are injecting here may not be enough. What is happening underground may be bigger than that.

We would like to see stringent requirements for injection well construction, and of course, that is an engineering aspect.

We would like to see engineering and testing of all the wells and the distribution network.

We would like to see long-term monitoring; assurances of some financial responsibility, assurances that they will have the ability to manage the site properly; site safety requirements and perhaps bonding; well closure plans. Then after the wells are closed how the site in post-closure is going to be operated and managed and fully maintained.

Public participation has to be an important part of any regulatory scheme, and then the ongoing liabilities. I appreciate your

comments on that, Senator Dorgan. Clearly what they are, and we support that entirely and that those all be looked at. Of course, any regulatory scheme has enforcement provisions and should.

The State of Montana has looked at the IRGCC proposed regulations, and a lot of these pieces are missing from those. They acknowledge that they were not trying to do all of that, but we would want to see that.

The EPA is writing regulations under the Safe Drinking Water Act and possibly a new class—we are not sure yet, but a possible new class of underground injection control. We certainly would want to look at that in the State of Montana. However, when we obtained our Class II authority through the EPA that took a good 10 years. We cannot do things that slowly. So we would certainly like any help that we get, if that is going to happen on an expedited process and freedom for the States to move more quickly with that, more quickly as history has shown.

In Montana, we have a Water Quality Act and then we have the oil and gas regulation. They intermix in this case. When you are talking about enhanced oil recovery, then we are going to have one regulatory scheme. If enhanced oil recovery is over and it can't be used, when we are talking about putting carbon sequestration into our groundwater, that is a different setting; and so different laws will come into play. I guess my point there is that we are operating under our existing laws. They may need to be changed and States may need time to do that and consider those possibilities.

The liabilities, obviously, have three main parts: when they are operating and putting it in the ground, the storage period, and then what if they take it out in the future. So we need to cover all of those aspects.

We need help with startup programs and funding. Montana has a fee program and will not have anybody to charge fees here to start a program. It would have to be existing to do that.

Then finally, it was addressed earlier, the split estate issue. Montana does have a lot of split estates, where they have a lot of checkerboard patterned land. We think the pores will be owned by the surface owners. This has never been tested in court. But how that would interact with mineral owners in the future will be, I think, resolved by the courts and we do not have any good answers.

[The prepared statement of Ms. Lovelace follows:]

PREPARED STATEMENT OF BONNIE LOVELACE, CHIEF, WATER PROTECTION BUREAU, MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

The State of Montana greatly appreciates the leadership the Committee has quickly taken to inform themselves of the issues surrounding carbon capture and storage. There can be no question that energy needs combined with climate change and general environmental impacts are causing us to take a close look at opportunities to conduct our business differently than we have in the past. Carbon capture and storage are at the forefront of methods being considered for handling the pollutants affecting our environment.

THE ISSUES

Montana has embarked upon some study of the issues surrounding possible capture and storage of carbon dioxide. Our legislature during the last legislative session considered but did not pass legislation establishing a regulatory scheme for capture and storage. In the interim between legislative sessions a legislative committee is studying capture and storage and the myriad of issues involved with its practice.

Parts and pieces of the practice of putting carbon dioxide in the ground are well known. The oil industry has successfully used pressurized carbon dioxide for enhanced oil recovery for many years. However, we also know that if, on a large scale, we capture flue gas, pressurize it and put it in the ground, the oil industry cannot use all that would be produced. We know that designing and building the infrastructure for moving the pressurized carbon dioxide is possible and, in fact, there is a history of success.

I would like to address what we do not know and what should be included in a robust regulatory scheme if we begin to capture flue gas from carbon dioxide emitters and put it in the ground.

Carbon dioxide becomes problematic when we take it in a polluted form, pressurize it and try to store it in the ground where it may move where we don't want it, mix with water or mobilize metals.

In Montana, fly ash from burned coal has been found to contain a number of pollutants including Boron, Selenium, Arsenic, Mercury, Sodium, Potassium, Magnesium, Sulfate, Calcium, Chloride and radioactive material. If we add cement plants to the group of facilities capturing emissions for sequestration, then we add more pollutants to the mix. The possible pollutants increases as types of processes are added to the universe of those capturing the emissions. The best numbers we have heard regarding cleaning the pollutants from the flue gas is about 90%. That leaves 10% of the pollutants that could be in the liquid put under ground. Once underground, the carbon dioxide and companion pollutants may: 1) work their way to the surface where pressure loss will return it to a gaseous and deadly state, 2) may move with groundwater as a pollution plume, and 3) may interact with the geologic body and mobilize more pollutants. In the best of circumstances, the polluted carbon dioxide will stay put in the location chosen for it.

A REGULATORY SCHEME

The best scenario for sequestration would be to select proper sites that will hold the carbon dioxide in the chosen location, use only those types of sites, engineer the injection facility to the best controls and to monitor over the long run to be sure the carbon dioxide stays in place. A proper regulatory program would include permitting requirements to cover:

- Identification of all pollutants in the injected substance
- Site characterization to include analysis of substance volumes injected, buoyancy analysis, viscosity factors, corrosivity analysis, and permanency factors related to geology
- Proper definition of the extent of the area to review and monitor
- Stringent requirements for injection well construction
- Engineering testing of the well and distribution network
- Monitoring
- Assurances of financial responsibility of the sequestration operator/owner
- Site safety requirements and bonding
- Well closure plans and requirements
- Post closure plans and requirements
- Public participation, including environmental analysis preparation
- Clear definition of ongoing liabilities for managing and maintaining the site.
- Enforcement provisions

The EPA is drafting a set of rules under the Safe Drinking Water Act Underground Injection Control program. If these rules go forward, the program needs to be delegable to states whether or not the other elements of Underground Injection Control are delegated. The delegation process needs to be rapid and separate from the historically slow processes. Federal agencies that are working on carbon sequestration need to make a major effort to share information about technologies, analysis methods and new developments.

Under Montana's current law and regulations governing discharges to groundwater, carbon sequestration could take two roads. First, if the sequestration is for enhanced oil recovery, the Underground Injection Control, Class II program would regulate its use. This program is delegated to the Department of Natural Resources and Conservation and such operations are exempt from the Montana Water Quality Act permit requirements. If the sequestration is for storage, but not enhanced oil recovery, the Montana Water Quality Act would prevail as the regulatory framework. The Water Quality Act includes authority for discharges to groundwater. Two main factors would drive the regulatory framework. The actual discharge of pollutants would require a groundwater permit which would be written for meeting groundwater standards. Also, a nondegradation policy would apply which ratchets

down the pollutant amounts allowed to be discharged. The actual values of allowable pollutants would depend on the quality of the receiving water. Many of the items listed above describing a robust regulatory program are lacking authority in the Montana Water Quality Act.

Risks to the public health and safety and the environment from sequestration operations include chemical interactions that may occur in the ground, movement of pollutant plumes, and leakage of the carbon dioxide from the storage site to either groundwaters or to the surface. Seismically active areas would pose a serious risk to storage site leakage potential.

LIABILITIES

Liabilities and any regulatory approach to them will be to some degree dependent upon the view of whether or not sequestered carbon dioxide is a pollutant or a commodity. This is a time oriented determination if while being injected for storage it is a pollutant, but after injection is complete it becomes a commodity (or in some cases, vice versa). Potentially responsible parties include storage site landowners, injectors, operators, transporters, generators, lenders or contractors. A regulatory program needs to clearly define and delineate liabilities with respect to portions of the operation, storage period and, if used, the withdrawal of the carbon dioxide for use in the future.

FUNDING

Further, if carbon capture and storage practices are of true importance, the federal government needs to assist states with financing to start up and manage proper programs. The Underground Injection Control programs have historically had only minimal support. Even if states developed fee programs for permitting and maintaining storage facilities, resources are needed to begin the programs before there is anyone to charge fees.

AUTHORITIES

Each state has its own statutes regulating water quality. Those statutes would define the circumstances in which delegation of a federal program could move forward. Some states are moving forward with legislation and rulemaking to establish a program for carbon sequestration. Montana is studying the possibilities, but has not completed any specific legal framework. Montana would evaluate the eventual EPA program established under the Safe Drinking Water Act Underground Injection Control program to determine whether or not to seek delegation.

SPLIT ESTATES

Mineral ownership issues have yet to be resolved in many locations. Questions of who owns the pore space into which carbon could be injected has yet to be determined. Where the mineral and surface estates are separately owned, the solution to ownership and responsibilities is likely to be resolved in the courts unless communitization agreements are established ahead of development. A dispute could occur if a location has been developed for gas, some is left in the body, but is not currently being mined, then the site is wanted for sequestration. A significant amount of cooperation will be needed to resolve these kinds of issues.

Members of the Committee, I appreciate the invitation to offer testimony on this important issue. Thank you for working hard on this significant issue. Close attention to these developments is necessary to guarantee that our nation's water supply is protected in a clean state and to maintain the progress we have made in cleaning up contaminated sites. After decades of significant water quality work, it would be a national embarrassment to be creating new Superfund sites today simply by not developing a robust regulatory program to manage carbon sequestration.

Senator DORGAN. Ms. Lovelace, thank you very much.

A couple of questions. Mr. Spisak, when we had recent testimony by Assistant Secretary Allred from the Department of the Interior, he indicated that they are interested in a large-scale carbon capture and storage project on public lands.

Do you know what the status of that is? Has there been follow-up on that between the Department of the Interior and the Department of Energy?

Mr. SPISAK. Yes. Actually the Farnum Dome in Utah, which is part of the southwest regional partnership with DOE—and I am sure Scott will be able to talk to you a little bit more about that—but there were some questions—you know, it is a project that DOE is overseeing, and it is primarily on Federal lands with a little bit of State land. We were made aware of it here not too long ago, and there was a question about whether royalties would be due at the time that the CO_2 was produced. It was going to be produced and then reinjected into a different zone. There was some question about whether royalties would be due at that point.

We got engaged and we figured out what we need to do is to unitize the zone that they will be injecting the gas back into, and that will allows us to, in effect, keep it within the unit which would not trigger royalty payments. As I understand, the royalties over the life of this project would be about $4 million. If the commodity was not being sold yet, in deference of trying to get the technology developed and through this project, we felt, by unitizing it, it has not really left the property and would defer any royalty payments until after the project, when it might be produced at that time.

So, by figuring out that roadblock, it looks like we are able to keep the project moving forward and working with DOE.

Senator DORGAN. Mr. Klara, what kind of focus exists on this issue of carbon capture? You have about a half billion dollars to do a lot of things with. Are you starting to provide some focus, or are you just broadcasting seeds out there and hoping something grows?

Mr. KLARA. Absolutely, we are providing focus. I think years ago, at the start of any new initiative—this sequestration program was started in 1997—that it does start out—there is a bit of a shotgun blast looking for research ideas. Now the research ideas are starting to get very focused, and we have very stringent goals within the program, anywhere from years 2012 to 2020. Those goals all have significant metrics on the cost of technology, how much permanence could be assured, et cetera.

So definitely, we have a very focused program to try to obtain and reach these goals, and we track those on a yearly basis. So, indeed, I think the program is very focused as it currently stands.

Senator DORGAN. When will you finish the next technology road map?

Mr. KLARA. On an annual basis, we put out a sequestration technology road map. The purpose of that is several-fold. One purpose is to just update on the developments that have accrued in the past year. The other is to reevaluate tracking toward the milestone goals in the 2012 to 2020 timeframe where we have different markers and to update status of progress toward that.

We would anticipate that probably toward the end of the summer this year we will have our next road map available. The last one was from May of last year.

Senator DORGAN. Is it your assessment that we are making great progress with the expenditure of this money? We are spending a lot of money in pursuit of these projects, and we need to spend more. But are we making progress?

Mr. KLARA. I believe we are. I think if you look at the track record of initiatives that we have in the Department—and more importantly, the people that are performing the initiatives—you

heard of just one small example that Tim mentioned about taking one of the projects and putting it on public land and the uses associated with getting across all the issues and hurdles needed to put that project in place.

We also have a portfolio capture technologies, all that have been going from a pilot scale up to commercial demonstration. Some of the ones you mentioned, for example, the algae project, a key project within our portfolio, thanks in large part to the appropriations language. The baking soda project we have been looking and analyzing that. Those are key examples of where right now I would estimate that there could be maybe upwards of 20 key capture projects that are in various stages of development that we believe could be ready in the 2012, 2015, 2020 timeframe for commercialization.

I think it is important to note, too, that capture technologies exist now, but they are expensive. So what we are trying to do within the program is try to get the cost of capture to some reasonable levels where wide-scale deployment could make the most sense.

Senator DORGAN. Ms. Lovelace, is the current EPA rulemaking efforts—is it an approach that will address most of the shortcomings you describe?

Ms. LOVELACE. Senator Dorgan, I believe that they will address most of them.

A real question that we will be left with that effort is whether or not the States have the authorities to do all of those items. Most of the States' water quality statutes do not have the authorities to look forward with a lot of that.

Senator DORGAN. Senator Tester.

Senator TESTER. Thank you, Senator Dorgan.

You might as well just keep the mike, Bonnie, and we will go from there.

You listed several components to an overall regulatory scheme. In your view, do you see these components—analysis of the site, long-term monitoring assurances—the list goes on and on and on. Do you see this as being a Federal issue or a State issue? Do you think that regulations should come out of the Feds or the State? I am just asking your opinion.

Ms. LOVELACE. I think it would be a good idea, if we are going to do this and do it well, that we do it consistently. So some Federal guidance would certainly be useful. But I don't think that the States should be operating these programs and have the ability as a Federal program to be delegated, as many of our programs are today.

Senator TESTER. I do not know where you are from the State legislature standpoint, but the split estate issue is always a big issue, and this for a different reason. Does the Department have an opinion as to whether the CO_2 belongs to the mineral owner or the landowner?

Ms. LOVELACE. No, they do not. We believe very strongly that this will get resolved in the courts because it has not been tested. Here is an example. If someone were to be out there taking a gas out of—as a mineral, you know, out of the site, and now along comes carbon sequestration. There may still be some gas in there,

and they might like to go get it some day. Now, all of a sudden, somebody wants to sequestering that site, there is the problem. We would still have the mineral ownership, but the pores above it may be owned by the surface owner, and that is going to be where the rub is going to come. That is where the courts are probably going to come into play.

Now, I want you to understand, Senator Tester, that the Department of Environmental Quality in Montana does not oversee this kind of thing. So I am speaking from experience, but I do not regulate this.

Senator TESTER. Does anybody?

Ms. LOVELACE. The only place where anybody regulates it would be State-owned land.

Senator TESTER. Thanks, Bonnie.

I will just go ahead. Scott, you spoke of goals for 2012 to 2020. I was asked a question previously by my good friend—when carbon sequestration was going to happen. Can you give me an idea on a large-scale basis?

Mr. KLARA. Our goal within the Department's program is by the year 2020 if the technology base will be sound enough and costs driven down substantially, that the technology could be ready for wide-scale deployment in and around that time.

But I would caution that even under the best circumstances, it is going to cost additional money to use carbon capture and storage. So additional incentives, whatever you want to call it—I have got to be careful on the technology side within the Department, but there has got to be some driver or some way to recoup the costs of CCS, I think, to really make it widely deployable.

But from a technology standpoint, we feel pretty confident that the program will obtain some major, major goals in the technology-readiness in pretty good shape around the year 2020.

Senator TESTER. This June, July, sometime this summer, we are going to be dealing with a climate change bill, Lieberman-Warner. I do not know if it is going to pass or not. I do not know what the final form of it is going to look like.

Have you had an opportunity to take a look at that bill? Has the Department had an opportunity to take a look at that bill to see if your goals match up with those goals, if it were to pass?

Mr. KLARA. We are currently internally taking a look at that, and we could get you some comments as our analysis gets more complete over the course of the next month or so.

Senator TESTER. I would love that.

Now, my final question is, what would it take to move it up, to move up the technology standpoint, from a capture standpoint, a transportation standpoint, and a storage standpoint? What would it take to move those years up? Let us say we want set the goal at 2015. Is it simply unattainable, or what would it take to do that?

Mr. KLARA. I cannot speak to a specific funding number without us doing some more detailed analysis back within the Department. But certainly some opportunities for acceleration do exist, and those opportunities would be to look at more CO_2 capture technology options in parallel because not all of them will succeed, and we need more than one in the portfolio.

The other thing would be to actually demonstrate these at commercial scale and provide more opportunity for commercial scale testing.

Senator TESTER. Now, you have got seven partnerships throughout the United States that takes in almost a 100 percent land mass. What has been the private sector's response as far as—is it truly a partnership with the private sector, and if so, to what extent?

Mr. KLARA. I think the best way to address that question is to look simply at the cost share provided for those initiatives. We are getting cost share around the 40 percent range amongst all partnerships.

Senator TESTER. About 60 public, 40 private?

Mr. KLARA. Correct. As you might imagine, most of that comes from industry sources, commercial entities. So I think that is a very key indicator of the interest and significance that companies and organizations are placing on initiatives like the regional partnerships, to be able to put that much skin in the game to make that occur.

Senator TESTER. Thank you.

Tim, you talked about BLM has been working on data, oil field injectionsites. That is what I heard. Is that correct? They have got some data as far as where the CO_2 can go. Is that correct as far as the——

Mr. SPISAK. Where the CO_2 could go?

Senator TESTER. Yes.

Mr. SPISAK. We track more where there has been injection for enhanced recovery; and there are about 42 wells on Federal lands where that has occurred.

Senator TESTER. Is that inventory complete, though?

Mr. SPISAK. We are in the process of identifying that. MMS has in their systems codes for CO_2 and CO_2 injection. We are querying them now about what data they have. We are also looking at some third party sources for that data to identify where the best and most cost effective means of getting that.

Senator TESTER. Does the process you are going to use to account for that? Is that process complete?

Mr. SPISAK. It is like any other accounting for oil and gas. The CO_2 is another component of that.

Senator TESTER. OK. So it's not complete?

Mr. SPISAK. The actual data acquisition is not complete.

Senator TESTER. When do you anticipate when it will be complete?

Mr. SPISAK. The end of this year.

Senator TESTER. I want to talk a little bit about split estates, too.

Mr. SPISAK. Sure.

Senator TESTER. I visited with Bonnie. You heard the question. The question I have for you, Tim, is how do you see split estates? Who owns it? Is it the mineral owner's responsibility? Whose responsibility is it? Or is it the landowner's?

Mr. SPISAK. You mentioned CO_2 in your question. Let me take both. The CO_2, we believe, is a leasable mineral like a natural gas, but the pore space for storage of CO_2 we see as—our general opinion is that it is invested in the surface owner.

Senator TESTER. OK.

Mr. SPISAK. So the conflicts that she mentioned I think are very real.

Senator TESTER. All right. There is no Federal law on this; right, on who owns this?

Mr. SPISAK. Not to my knowledge.

Senator TESTER. Would it be recommendational to let it be litigated or be proactive?

Mr. SPISAK. I think anytime we could be proactive and kind of set down some kind of a base foundation, I think we will be better off in the long run.

Senator TESTER. OK. The last question I had dealt with rights-of-way for transportation. Right now is there in the code anything for right-of-way for CO_2 lines comparable to gas lines or——

Mr. SPISAK. Rights-of-way for any kind of pipeline on Federal land we do not really see being very much different than any other oil and gas pipeline. There are some little differences in the properties of CO_2 that you need to be careful of. It is heavier than air. So in low spots, it is going to accumulate, if there was a leak. Other than that, it is pretty much like any other commodity that we are putting through a pipeline.

Senator TESTER. Sounds good.

I think that is it. Thank you very much.

Senator DORGAN. Senator Tester, thank you.

Mr. Klara, let me also ask the question that Senator Tester asked in a different way. You talked about the year 2020, and that is 12 years away. Our concern is, as we move forward with climate change legislation, that we have targets that are somewhat compatible with the capability to be able to capture carbon and do so in a way that meets the targets in the legislation. It may well be that we are not able to wait 12 years, and it seems to me if we provide increasing funding for the Department of Energy and the laboratories and so on, that there needs to be more aggressive targets for finding commercial-scale technologies.

Your reaction?

Mr. KLARA. Again, certainly there are opportunities we have to accelerate our timeframes, and you can decide through appropriations, et cetera, the best way for us to manage through that.

I would also indicate, too, that do not mistake the 2020 timeframe as the first day you get deployed. There are many opportunities, say, in the course of the next 5 to 10 years where some more immediate sequestration can occur away from power plants, for example. There are sources of CO_2 from natural gas production. There are acid gas sources from natural gas production, et cetera, where we could start to sequester sooner and start to get some additional lessons learned, as well as starting to get our feet wet in sequestration.

So, I would believe that when I say 2020, I believe that the technology there would be ready for us to go full blazes.

Senator DORGAN. Let me ask. The Secretary of Energy's Office called yesterday and is setting up a phone conversation with me today. I am going to be on the road today, but we are going to have a phone conversation, I guess by my cell phone. But I think he wants to talk about FutureGen.

The cancellation of the FutureGen project by the Secretary and the conversion of FutureGen into probably two or three other projects, is that going to set back the timeframe? Because FutureGen was kind of the big bang approach that the administration was using to try to demonstrate some commercial technology in this area.

Mr. KLARA. I am sure the Secretary will give you the departmental comments on that and the path forward.

Senator DORGAN. What is your opinion?

Mr. KLARA. My opinion is that the FutureGen project was deemed to be a project with costs spiraling very high year after year and that it was deemed necessary to take an additional look at maybe different paths forward. Right now we are trying to pursue a different path forward, and for example, we are still getting comments from industry and potential participants to try to set that path.

Senator DORGAN. My concern is, though, that we have wasted a lot of time. I do not necessarily quarrel with the Secretary's decision, and I will be anxious to visit with him again today about it. I have asked him to come down and testify at a hearing before our subcommittee, and we are trying to do that at end of April.

But I am afraid we have lost a lot of time here, moving down one road and then taking a U-turn and trying to find another road because the search for this technology at commercial scale is an urgent search, in my judgment.

Ultimately, my interest and I expect the Department of Energy's interest is to find a way to create zero-emission coal-fired generating plants. I believe that we should be capable of that using advanced technology in the years ahead, but it requires us to be on an urgent path to get it done.

It is going to require more funding than the President is requesting, and that is why I increased his funding request by $70 million this year. I will have to do more in the coming year, given his current budget request, which is far short of what is necessary. It is one thing to talk about the urgency of it. It is quite another thing to represent that in the budget request, and the President has fallen far short. So we are going to have to pump some additional funding in if we are going to find the answers to these questions.

Let me thank all three of the witnesses for being with us today and coming to Bismarck and presenting testimony. Thank you very much.

The next panel that we will have includes those from the production side of these issues talking about the challenges they see and they face. Sandi Tabor will represent the Lignite Energy Council. She is the general counsel. You may come forward, if you would. The Lignite Energy Council is from Bismarck, North Dakota.

Lee Spangler is the Director of Big Sky Carbon Sequestration Partnership in Bozeman, Montana. Gary Loop is the Chief Operating Officer and Senior Vice President of Dakota Gasification Company in Bismarck. Gordon Criswell is the Manager of PPL in Billings, Montana. John Harju, the Associate Director of Research, PCOR Project in Grand Forks, North Dakota.

Let me thank all of you for being here. I am going to call on you first, Sandi Tabor, and I would like to ask if we can pass the microphone down.

All of your statements will be included as a part of the permanent record. We would ask that you summarize.

STATEMENT OF SANDI TABOR, GENERAL COUNSEL, LIGNITE ENERGY COUNCIL, BISMARCK, ND

Ms. TABOR. I will. Thank you, Senator. Good morning to you, Senator Dorgan, and you, Senator Tester.

My name is Sandi Tabor. I am the General Counsel of the Lignite Energy Council, and I think I am here today because I also chair a CO_2 storage workgroup that has been formed by the industry. It includes representatives from all the key agencies in the State of North Dakota, including the Department of Health, the Attorney General's Office, and the Oil and Gas Division of the North Dakota Industrial Commission. It also includes the North Dakota Petroleum Council and representatives from the lignite industry.

Our group's mission is to look at the issues surrounding CO_2 storage and sequestration from a State perspective and what we need to do in order to be prepared to help our industry move forward on this most important issue.

I am going to summarize just a few key points from my testimony. The first of which is that CO_2 sequestration is a key element for existing plants attempting to survive in a carbon-constrained world, and as such, flexibility in regulation is key. Back in March 2007, the EPA issued a guidance document that said that the pilot projects on sequestration should use a class V well under the Underground Injection Control Program.

In their comments in that guidance, they recognized the importance of a balanced approach. That we have some flexibility in regulation that recognizes the differences in the country in geologic formations, recognizes the differences and the different demands that sequestration might require, while at the same time making sure that there is protection of public health and water quality.

What we now just want to emphasize is that it is very important, as EPA moves forward on the final regs, that they remember that flexibility is important.

We also want to urge the Federal Government to rely on the expertise developed by the Department of Energy's regional partnerships like the Big Sky Partnership and the PCOR Partnership. They have years of experience. They have developed and gathered many, many, many volumes of data, and they are the ones who are in the fields working with the industry. We hope the EPA will rely on the expertise that they have developed and work in partnership with them as they move forward on the new regs.

We also want to urge that the Federal Government, the EPA in particular, look at the rules, the model rules that were developed by the Interstate Oil and Gas Compact Commission. Again, those rules were developed by people from industry and State regulators who have expertise in the area dealing with CO_2 and what happens when you inject CO_2 into the ground, particularly as it is used with the oil and gas industry. It may not provide the EPA with every answer, but it certainly should serve as a good basis for moving for-

ward. We just think it is imperative that those model rules be looked at and considered.

We also want you to understand—and I think the lady from Montana probably addressed this—that there are some issues regarding sequestration that are simply State issues, and one of them is property rights. Who owns the pore space and eminent domain issues and—issues. That is one of the key things that our group is going to be working on. What do we do and how do we manage property rights and who owns the pore space?

We think in North Dakota that the surface owners do. We think that is the common law in many of the States across the country. Our real challenge is deciding whether we want to introduce legislation to finalize that, much like what Wyoming did not so long ago.

Another key element is liability. It does not take much of a rocket scientist to understand that even as Gary Loop will tell you with the CO_2 sequestration and capture project that they are doing at the Valley Station here in North Dakota, it is going to cost millions of dollars, hundreds of millions of dollars just to do that project. To actually build a new plant is going to cost billions of dollars.

Guess what? When you are planning a new plant, you need to know all the liabilities. You need to be able to plan that and do your risk assessments. We think it is pretty important that the Federal Government, the State government, and the industry work together on trying to decide how we are going to deal with long-term liability of CO_2 sequestration.

Finally, two other quick things. Let us remember that CO_2 that is being injected as part of enhanced oil recovery should be considered a commodity, and the old adage of "if it's not broken, don't try to fix" should apply to how you deal with EOR. That has been going on for many years in several States, and we are very concerned that we not worry about trying to regulate and put more impediments on how we use EOR for beneficial uses.

Finally, this is another key issue for us in that in some message we hope EPA takes to heart. CO_2 should not be regulated as a hazardous waste. There are all types of implications on that. We really encourage the EPA to try and again work with industry, look at the data that is being collected now through EOR. You know, a lot of that CO_2 that is pumped out into the ground through EOR stays there. So there are some resources that are available for the purposes of trying to decide what happens in the long term already existing and just looking at what is happening with EOR.

With that, thank you for your kind attention and I am sure, when the time comes, I will know what the right answers are.

[The prepared statement of Ms. Tabor follows:]

PREPARED STATEMENT OF SANDI TABOR, GENERAL COUNSEL, LIGNITE ENERGY COUNCIL, BISMARCK, ND

Thank you for the opportunity to submit written comments and to address the Subcommittee on the challenges associated with the large-scale capture and storage of carbon dioxide. I chair a workgroup consisting of state agencies and industry representatives examining CO_2 sequestration regulation in North Dakota. My testimony will focus on the issues facing the federal government and states, like North Dakota, as we move forward to establish a regulatory framework for the transportation and storage of CO_2.

OVERVIEW OF THE ND LIGNITE INDUSTRY

The North Dakota lignite industry mines approximately 30 million tons of lignite every year. At present production levels, North Dakota has more than an 800-year supply of lignite. Seventy-nine percent of the coal we mine is used to generate electricity for more than two million people in the region. North Dakota produces approximately 4,000 megawatts of power, over half of which is exported to neighboring states.

The North Dakota lignite industry is responsible for 25,000 direct and indirect jobs in the state. We generate personal income of $700 million and over $2.2 billion of business volume annually. We also pay over $80 million in state taxes each year. The lignite industry is a significant part of the State's overall economy, and is especially important to western North Dakota.

The primary objective of the Lignite Energy Council is to maintain a viable lignite coal industry and enhance development of the region's lignite coal resources. Our membership of over 300 members located across the Upper Great Plains includes mining companies; major producers that use lignite to generate electricity, synthetic natural gas and other valuable byproducts; and businesses that provide goods and services to the lignite industry.

BACKGROUND

The Lignite Energy Council's message to you today is simple . . . in order for coal to remain a viable energy resource in a carbon-constrained world we must develop flexible regulations to accommodate the geologic storage of CO_2. This mission will be accomplished if the federal government works with states and quasi-state entities, like the Interstate Oil and Gas Compact Commission (IOGCC), to develop regulations that take into account the unique aspects of individual projects. Regulation of CO_2 sequestration should provide opportunities for regulators to make use of the information gained from each project and recognize the evolution of best practices. Finally, the rules must provide the regulated community with the certainty needed to make investment decisions.

The need for a regulatory framework for the geologic storage of CO_2 was recognized by the U.S. Department of Energy (DOE) and its National Energy Technology Laboratory (NETL) in 2003 when DOE funded an effort to develop model rules spearheaded by the Interstate Oil and Gas Compact Commission's CCGS Task Force (Task Force). The Task Force reviewed the technology of geologic storage and developed a model statue and model rules for states to use when developing their own regulatory oversight of geologic storage of CO_2. The Task Force model rules provide detailed guidance on a variety of topics including licensure, operations, bonding, project development, and closure.

The EPA also began a process for developing regulations for geologic sequestration utilizing as its platform the Underground Injection Control (UIC) program of the Safe Drinking Water Act. The timeline for the process includes distributing draft regulations in June 2008 and issuing final rules in 2011. The EPA is examining a number of issues, many of which are addressed in one fashion or another in the Task Force rules. In particular, the EPA is considering strict well-construction standards to prevent corrosion; strict secondary containment requirements such as extra cap-rock to prevent leakage into groundwater aquifers; periodic evaluation of the geologic area around the well; and earlier and more frequent public participation provisions. One of the issues they have not attempted to address deals with property rights, such as who owns the pore space into which the CO_2 will be injected.

NORTH DAKOTA'S EFFORTS

On August 2, 2007, the Oil and Gas Division of the Mineral Resources Department of the ND Industrial Commission (NDIC) published proposed rules dealing with the storage of carbon dioxide. The rules dealt with not only enhanced oil recovery (EOR) efforts, but also the long-term storage of CO_2. The rules addressed permitting requirements, site access, eminent domain, permit transferring, amalgamation of subsurface property rights, operational standards, safety plans, monitoring requirements, closure requirements and long-term liability.

The Lignite Energy Council presented testimony at a hearing on September 4th raising concerns over the statutory authority for some of the provisions contained in the proposal. In particular, our comments discussed eminent domain, cooperative agreements between North Dakota and government entities outside the state, subsurface property rights, closure of storage facilities, long-term liability for storage facilities and jurisdiction over long-term CO_2 storage. We also asked the Oil and Gas

Division to consider streamlining the permitting process and to eliminate the requirement for obtaining more than one permit.

In light of the comments received on the proposed rules, the Oil and Gas Division agreed to pull the proposal from further consideration and to join a workgroup consisting of representatives from the ND Attorney General's office, the ND Department of Health, the ND Petroleum Council, and representatives from the lignite industry. The North Dakota CO_2 Storage Workgroup (Workgroup) will consider not only the development of regulations, but also identify statutory changes needed to address state specific issues, like property rights.

Presently, the Workgroup is reviewing legal issues associated with certain provisions of the proposed rules. Of particular interest are a number of potential legislative issues including:

- Who should regulate the storage of CO_2;
- Who owns the pore space and how should property interests be addressed for purposes of storing CO_2; and
- Should the State of North Dakota assume post closure liability for the CO_2 project and if so, should the state implement a long-term liability funding mechanism?

The first issue involves which government entity should serve as the agency responsible for administering CO_2 storage regulations. In North Dakota, the NDIC has broad authority over developing and producing oil and gas. This authority extends to the unitized or collective management of oil and gas resources for enhanced oil recovery. The NDIC also oversees the regulation of the long-term presence of CO_2 once tertiary recovery has ended.

Current North Dakota law does not authorize the NDIC to regulate the storage of CO_2 not associated with enhanced oil recovery (EOR). Under the UIC program, the ND Department of Health regulates Class 1, 4 and 5 wells, while the NDIC (through the Oil and Gas Division) regulates Class 2 and 3 wells. The EPA issued a guidance document in March 2007 instructing State and EPA Regions to use Class V (experimental technology wells) when permitting pilot projects designed to evaluate the technical issues associated with CO_2 injection projects. Thus, for purposes of pilot projects in North Dakota, it would appear that the ND Department of Health would handle a CO_2 sequestration pilot project using a Class V permit application. Unfortunately, the EPA guidance addresses the immediate concern of pilot projects, but it does not address the larger issue of commercial scale demonstration storage projects. In light of the fact that Basin Electric Power Cooperative and the Energy and Environmental Research Center (EERC) plan to conduct a CO_2 capture and sequestration project in North Dakota in the near future, providing guidance regarding regulations is imperative.

The second issue involves the ownership of the pore space into which the CO_2 would be injected. The majority view among states is that the pore space and the subsurface geologic formation belong to the surface owner. This view is based on the proposition that a landowner owns everything above and below her land. In fact, it is a view recognized in North Dakota law. N.D.C.C. § 47-01-12. The question, however, is whether this North Dakota statute contemplated ownership of the pore space. While it is an unanswered question in North Dakota, other states have addressed the issue. For instance, in Wyoming, the state legislature recently enacted legislation confirming the majority view (H.B. 89, 2008). While we believe that pore space is owned by the surface owner, the Workgroup is contemplating the merits of following Wyoming's lead and drafting legislation for consideration by the 2009 North Dakota Legislative Assembly.

A more difficult issue is how to deal with a number of surface owners who may be affected by CO_2 storage projects. Getting consent from everyone with an interest is unlikely and questions involving eminent domain and constitutional protections for private property must be considered as the regulatory program for long-term storage is developed. The Workgroup is also considering how best to address this sensitive issue.

The third issue involves post closure liability or financial assurance measures for well closure, post-closure monitoring and remediation practices. Two states have addressed the issue, taking opposite positions on the solution. For instance, the state of Texas addressed the ownership and liability issues by statute in May 2006. The law focused on transferring the right, title and interest in CO_2 captured by a clean coal project to the Railroad Commission of Texas on behalf of the state. The transfer must occur at no cost to the state (other than administrative and legal costs associated with the transfer). The transfer does not relieve the owner or operator of a clean coal project of liability for any act or omission regarding the generation of CO_2 performed before the CO_2 was captured, but does alleviate any potential liability for

the storage of the CO_2. The law allows the commission to sell CO_2 that is captured by a clean coal project and not injected for permanent storage in a geologic formation.

On the other hand, the state of Washington placed full liability on project developers to ensure that CO_2 is safely stored for the long term under proposed regulations scheduled to be finalized by the end of June.

Another state that has considered CO_2 sequestration issues is Wyoming. The Wyoming legislature recently enacted two bills establishing the framework for a regulatory program and addressing property rights. Neither bill, however, addressed the liability issue, deferring the issue for more debate later in the year.

The EPA has also struggled with the issue of financial assurance measures. For example, they wonder whether they should require post-closure well monitoring, and if so, for how long after closure. They question what standards should be used to determine whether monitoring is required. Another issue involves financial assurances to cover monitoring costs and remediation costs in the event of contamination. There is some discussion that the monitoring period could last as long as 300 years. With this in mind it is no wonder that the federal government and states alike are skittish when it comes to addressing the issue.

The Task Force rules provide a framework to address the long-term liability during the post-closure period. The major issue with post-closure is how to deal with long-term monitoring and liability issues. Under the Task Force model rules the operational bond is released at the conclusion of the closure period. Regulatory liability for ensuring that the site remains a secure storage site is transferred to a trust fund administered by the state or a state-contracted entity. Future monitoring, verification and remediation activities are paid for by a state administered trust fund. Revenues generated from a per ton injection fee assessed to the site operator provide the operating capital for the trust fund.

As the North Dakota Workgroup tackles the long-term liability issue, we will look to the Task Force model rules for guidance. Our concern is that stored CO_2 not be treated as a hazardous waste with the associated tentacles of liability which stretch far into the future (perhaps 300 years or more).

CONCLUSION

In summary, we applaud the EPA's efforts to involve many groups and individuals in the regulatory process. There are simply too many issues that require joint cooperation between the federal government, state governments and industry, in particular resolving long-term liability questions and establishing a mechanism to fund long-term monitoring requirements. It is important, however, to recognize that certain issues, like eminent domain and property rights, fall within the preview of the state. Although the efforts of the Department of Interior as it evaluates how to handle pore space issues on federal lands may prove instructive. Unfortunately, the demand for guidance from companies ready to begin CO_2 demonstration projects may force states like North Dakota to develop regulations earlier than present federal timelines.

We should also remember to capitalize on the experiences of entities like the EERC and the Weyburn project in Canada regarding the injection of CO_2 for EOR. The storage of CO_2 during EOR sheds light on many of the questions being raised about what will happen to CO_2 during geologic storage.

And finally, there are three points from the Lignite Energy Council's position on global climate change that merit consideration. First, CO_2 must not be treated as a hazardous waste. Second, CO_2 used for EOR must be treated as a commodity. And finally, the federal government must work with state governments and industry to resolve issues surrounding long-term liability for CO_2 sequestration. We are hopeful that as the development of regulations continues, open doors and open minds will prevail, and that reasonably flexible regulations will be developed.

Thank you for your consideration.

Senator DORGAN. Ms. Tabor, thank you very much. I appreciate your testimony.

Next, we will hear from Gordon Criswell, Environmental Manager, and Colstrip Steam Electric Station in Montana. Mr. Criswell, thank you for being with us.

STATEMENT OF GORDON CRISWELL, ENVIRONMENTAL MANAGER, PPL MONTANA, BILLINGS, MT

Mr. CRISWELL. Thank you, Chairman Dorgan, Senator Tester. I am pleased to be here today to discuss the challenges associated with the rapid deployment of large-scale carbon capture and storage technologies.

PPL owns generating plants in six States. In Montana, PPL is part owner and operator of the Colstrip Plant, which is one of the largest coal-fired power plants in the West. It also owns and operates the Corette coal-fired power plant in Billings, along with 11 hydroelectric facilities across Montana.

As a major energy producer, PPL recognizes its responsibility to address climate change in a reasoned and informed way. Our climate change response strategy includes increasing the efficiency of existing plants, pursuing the expansion of existing generating facilities that do not emit greenhouse gases, for example, hydro plants and nuclear plants, as well as development of renewable energy projects.

We were one of the first companies to join the Big Sky Carbon Sequestration Partnership, which is exploring carbon capture and sequestration technologies and geologic reservoirs. We also participated in the Montana Governor's Climate Change Advisory Committee.

As an early member of the FutureGen Industrial Alliance, PPL spent time and resources in the alliance to build a near-zero-emissions coal-fired power plant. This type of project is needed to assess the true potential of carbon capture and storage, and the cost is too large for private industry to do alone.

In my remarks to you, I would like to focus on three areas of concern that we have with the deployment of large-scale carbon capture and storage technologies. These concerns are feasibility, liability, and transport.

Feasibility is a major issue. Carbon capture and storage technologies may not be ready in time to comply with early emission reduction requirements of the Lieberman-Warner bill that the Senate will be expected to consider this summer. No technology has been tested on a commercial scale, as has been discussed here. Feasibility claims are based on small-scale pilot plant studies. Most of the technologies have big energy bounties. Installing carbon capture equipment on existing plants could consume from 10 to 30 percent of the electricity they generate.

A second concern is liability. Before deploying any carbon capture and storage technology on a large scale, we should have assurances that carbon dioxide could not find its way back to the surface or contaminate other resources.

A basic question must be resolved for carbon capture and storage to gain acceptance. Who is responsible for carbon dioxide stored underground? As Congress considers a national policy, we believe that Illinois could be viewed as a potential model. In their efforts to be selected for the FutureGen site, Illinois policymakers took a step in the right direction by accepting responsibility for stored carbon dioxide.

Government should encourage private industry to make the major capital investment that carbon capture technology will re-

quire. However, industry will be reluctant to make that investment if it also faces potential unlimited liability issues related to carbon dioxide stored underground.

A complicating factor in the liability issue is property rights. States and the Federal Government have no statutes or legal precedent designating ownership of geologic reservoirs or regulatory authority for geologic sequestration. This situation makes it impossible for companies to move forward with sequestration plans.

The third major concern is transport. Large, pressurized pipelines would have to be built to move carbon dioxide from where it is produced to where it will be sequestered. In addition to the cost of the pipeline construction, this raises issues of common carrier status, siting authority, and eminent domain.

Until the issues of feasibility, liability, and transport are addressed, progress on carbon capture and sequestration in Montana and elsewhere will be slow. Congress has an opportunity to provide leadership by working with the States to identify challenges to carbon capture and storage and develop a feasible, cost-effective national solution. National standards are needed to address these issues to provide consistency and regulatory price certainty for energy companies and uniform environmental protection for the public.

In closing, I would like to stress that PPL Montana believes coal has an important role in securing Montana's and the Nation's energy future. If the technology can be successfully developed and deployed and the issues noted above are adequately addressed, carbon capture options for existing and developing power plants would help address our Nation's significant energy and environmental challenges while providing a clean, reliable source of electricity for Montana and the Nation.

Thank you for this opportunity to testify.

[The prepared statement of Mr. Criswell follows:]

PREPARED STATEMENT OF GORDON CRISWELL, ENVIRONMENTAL MANAGER, PPL MONTANA, BILLINGS, MT

Chairman Dorgan and Senator Tester, I am pleased to appear at your subcommittee field hearing to discuss the challenges associated with the rapid deployment of large-scale carbon capture and storage technologies. My name is Gordon Criswell from PPL Montana LLC, a subsidiary of PPL Corporation. I am the Environmental Manager of the Colstrip Steam Electric Station in eastern Montana. PPL owns generating plants in six states, including 4,200 megawatts of coal-fired generation in Montana and Pennsylvania. PPL generated 53.6 billion kilowatt-hours of electricity in 2007, of which 8.4 billion kilowatt-hours were generated in Montana.

PPL Montana is part owner and operator of the Colstrip plant. Colstrip is one of the largest coal-fired plants in the West, a four-unit, 2,200-megawatt plant with 365 employees. PPL Montana operates the Colstrip plant on behalf of five other co-owners, including Avista Corp, NorthWestern Energy, PacifiCorp, Portland General Electric and Puget Sound Energy. Colstrip recently was awarded Voluntary Protection Program "Star" status from OSHA—its highest honor—meaning the agency recognized we go beyond compliance to protect worker health and safety. PPL Montana is also owner/operator of the Corette coal-fired plant in Billings, Montana, and 11 hydroelectric generating facilities throughout the state.

We are proud to report that Colstrip meets all state and federal emissions standards. As part of the way we do business, we are continually searching for ways to improve our environmental performance. One of the most serious global environmental challenges we face is climate change, and we have been studying its ramifications and how to address it for some time. As a major energy producer, PPL recognizes the responsibility to address climate change in a reasoned and informed way. PPL is active in the search for new technologies that can lower greenhouse

gas emissions and allow for the continued use of coal, which generates about 50 percent of the nation's electricity. We believe coal should continue to have an important role in the country's energy future.

PPL has participated in a number of efforts that have helped us better understand how to respond to potential state and federal climate change policies that will require reductions in carbon emissions. We also have taken specific steps that will help us reduce carbon emissions over time:

- We were one of the first companies to join the U.S. Department of Energy's Big Sky Carbon Sequestration Partnership at Montana State University in Bozeman. Our participation in the Partnership has provided us crucial information about carbon capture and sequestration technologies and geologic reservoirs.
- Although the proposed FutureGen plant has been the subject of considerable debate and ultimately may not be built, PPL spent considerable time and resources participating in the FutureGen Industrial Alliance. FutureGen was a public-private partnership to design, build, and operate the world's first coal-fueled, near-zero emissions power plant. We are disappointed that the Department of Energy has decided to end funding for this project. This type of project is needed to assess the true potential of carbon capture and sequestration, and it requires too large an investment for private industry to do alone. Government funding and incentives are essential to this type of technology development.
- PPL continues to make improvements to its coal-fired power plants to increase efficiency and reduce carbon intensity, the amount of carbon dioxide they emit per megawatt generated. For example, over the next 12 months, we plan turbine upgrades at the Colstrip plant in Montana and the Montour and Brunner Island plants in Pennsylvania.
- About 40 percent of the electricity generated by PPL in 2007 came from non-carbon-emitting sources. PPL is pursuing the expansion of existing generating facilities that do not emit greenhouse gases. We have approval from the Nuclear Regulatory Commission to increase generation at the Susquehanna nuclear power plant in Pennsylvania. We have installed more efficient equipment that allows us to generate more electricity at the Kerr hydroelectric project in Montana. We are redeveloping the Rainbow hydroelectric facility near Great Falls, Montana. We have asked the Federal Energy Regulatory Commission for approval to expand the Holtwood hydroelectric facility in Pennsylvania for additional low-impact hydro generation. We plan to repower the Orono hydroelectric facility in Maine as part of an agreement with private and government agencies and the Penobscot Indian Nation to open hundreds of miles of the Penobscot River to Atlantic salmon migration.
- A subsidiary of PPL develops, owns and operates renewable energy projects with a generating capacity of 23 megawatts. These projects generated 44 million kilowatt-hours of electricity in 2007. We have developed four landfill methane recovery projects and have three others under construction. We have developed solar energy projects capable of generating 3.3 megawatts and have another 480 kilowatts in planning.
- PPL's CEO, Jim Miller, appeared with Senators Jeff Bingaman and Arlen Specter last July to introduce S. 1766, the Low-Carbon Economy Act of 2007, which would create a market-based cap-and-trade system to reduce carbon dioxide emissions. PPL believes the Bingaman-Specter legislation conforms most closely with PPL's climate change principles, particularly with respect to how the bill aligns emission targets and timetables with the expected pace of technology development.
- In Montana, we participated as a member of the Governor's Climate Change Advisory Committee and helped develop 54 recommendations for reducing greenhouse gas emissions in the state.
- In Pennsylvania, PPL recently retired two older coal-fired generating units that emitted about 1.3 million tons of greenhouse gases per year and has participated in a statewide effort to create a climate change "roadmap" of actions that can be taken by all sectors of the economy to address climate change. PPL also participated in a Carbon Management Action Advisory Committee that identified opportunities to use state resources in support of climate change response.

Our participation in these efforts and our investigation of technologies has led us to the following conclusion: the United States most likely will have a national cap on carbon emissions from coal-fired power plants sometime in the near future, but technologies to achieve the cap may not be commercially available, at least in time to use as a compliance strategy with the early phases of required reductions under the Lieberman-Warner bill that the U.S. Senate is expected to consider this summer.

Many are viewing carbon capture and geologic sequestration of carbon dioxide as a viable means of achieving emissions limits under federal legislation. Our primary concerns about carbon capture and geologic storage are related to feasibility, liability and transport.

None of the capture and sequestration technologies being tested right now have been proven on a commercial basis and any claims about their feasibility are based on pilot plant studies. All of the technologies include significant energy penalties. Extensive testing of these technologies will reveal whether or not they will represent significant challenges to the "balance of plant" operations. Will installation of these technologies affect other systems at the plant? Will they increase other emissions? The technologies currently being tested—at very small scale—at other plants could consume at least 10 to 30 percent of the energy produced at coal plants just to run the capture equipment. That represents a huge economic challenge, and would necessitate additional energy production from other sources in order to meet customer power demand.

Beyond technical feasibility, liability is perhaps the most significant challenge to overcome in geologic sequestration. We do not know at this time whether or not pumping large volumes of compressed carbon dioxide thousands of feet below the surface of the Earth into geologic reservoirs will itself become an environmental liability. With any such technology solution we would have to be assured that the carbon dioxide could not find its way back to the surface or cause other unintended consequences, such as contaminating other resources.

Significant unresolved issues remain about who will be responsible for carbon dioxide stored deep underground. Illinois has taken a step in the right direction by accepting state responsibility for stored carbon dioxide. PPL believes that federal policy makers could view the Illinois approach as a potential model for addressing liability issues, as it shapes a national policy. Government should encourage private industry to make the major capital investment that carbon capture technology will require. However, industry will be reluctant to commit to these large capital costs if it also faces potential unlimited liability costs related to carbon dioxide stored underground.

Property rights issues are another hurdle to geologic sequestration. Montana has split estates—meaning one piece of property may have different surface rights and mineral rights owners. Montana, and, for that matter, the federal government, also have no statutes or legal precedent designating ownership of geologic reservoirs or regulatory authority for geologic sequestration. This situation makes it impossible for an energy company to move forward with any plans to sequester carbon dioxide underground even if it was technologically possible.

However, Montana is moving forward with answers to these questions. An interim committee of the Montana Legislature is evaluating a draft rule developed by the Interstate Oil and Gas Compact Commission. The draft rule would assign ownership of the pore space of a geologic reservoir to the surface rights owner and liability for stored carbon dioxide with the injector. Regulatory authority for carbon sequestration would be assigned to a state Oil and Gas Authority.

The remaining issue of significance regarding geologic sequestration of carbon dioxide is transport. Large pressurized pipelines would need to be constructed to transport captured carbon dioxide from power plants to depleted oil reserves for enhanced oil recovery or to deep geologic reservoirs for sequestration. Efforts in the 2007 Montana Legislative Session to assign common carrier and eminent domain status for carbon dioxide pipelines were unsuccessful.

Until the issues of liability, regulation and transport are addressed by the federal government and the states, progress on carbon capture and storage in Montana and elsewhere will be slow. Congress has an opportunity to help provide leadership by working with states to identify challenges to carbon capture and storage and develop a feasible, cost-effective national solution. National standards are needed to address these issues to provide consistency and regulatory certainty for energy companies and uniform environmental protection for the public. Forums like today's hearing are a good start to the dialogue that is necessary between Congress, state and federal agencies and energy companies.

I would like to stress that PPL Montana believes coal has an important role in securing Montana's—and the nation's—energy future. Montana is the sixth largest producer of coal in the nation and has more recoverable coal reserves than any other state. As noted earlier, coal generates just over 50 percent of America's electricity. If the technology can be successfully developed and deployed, and the issues noted above are adequately addressed, carbon storage options for existing and developing power plants would help address our nation's significant energy and environmental challenges, while providing a clean, reliable source of electricity for Montana—and the nation. Thank you for this opportunity to testify.

Senator DORGAN. Mr. Criswell, thank you very much.

Next, we will hear from Lee Spangler. Dr. Lee Spangler is the Associate Vice President of Research at Montana State University and is the current director of two research efforts. One is a PCOR project, the Big Sky Carbon Sequestration Project, and Dr. Spangler is also coordinating the development of a facility to test CO_2 soil and surface detection technologies. Dr. Spangler, thank you for being with us.

STATEMENT OF LEE SPANGLER, DIRECTOR, BIG SKY CARBON SEQUESTRATION PARTNERSHIP, BOZEMAN, MT

Mr. SPANGLER. Thank you. I am also Director of the Zero Emission Research and Technology Center, which is a collaborative involving five DOE national labs and two universities that is focused on basic science on sequestration.

The country and the States in this region, in particular, face a dilemma. We have enormous coal reserves that can make a major contribution to the Nation's economic development and energy security, but we face the need to utilize these resources in a climate-friendly fashion. Carbon capture and storage, CCS, holds promise as a method of climate-neutral coal use by capturing the produced carbon dioxide and storing it safely underground.

North Dakota and the State of Montana—and Montana with 25 percent of the Nation's coal reserves and with MSU as the lead institution in the Big Sky Partnership—both of these States are poised to help address the issue of national energy security and of climate change mitigation.

There are many challenges to the deployment of large-scale CCS technologies, and they can probably be categorized as technological, logistical, economic, and regulatory. Current regulatory challenges include defining ownership of pore space, as has been discussed previously, underground injection control and the classification of CO_2, and liability, especially given the long-term storage requirements to effect climate change mitigation. I address these issues in a little more detail in the written testimony.

Right now I would like to emphasize the need for some flexibility in the regulatory environment. Enhanced oil recovery, natural analogs, other underground injection and storage programs all provide confidence that CCS is viable, but there are still differences between these cases and long-term CO_2 storage. In certain cases where there are proven seals and extensive knowledge of the geology, we can have a higher degree of confidence and can pursue sequestration on an industrial scale. But there are other cases where laboratory or small-scale tests are very promising, but we really need to answer additional technical questions before we go to the large-scale.

Given the varying degrees of knowledge about different geological cases, research, development, demonstration, and the deployment can take place simultaneously instead of sequentially for these different cases. However, this would require flexibility in the regulatory environment so that permitting more experimental studies at smaller pilot scales is not overly burdensome.

Another potential barrier to deployment is public acceptance. There is a widely recognized need for CO_2 detectors near the sur-

face for health, safety, and environmental reasons and to provide public assurance. Such sensors have been deployed at current sequestration pilot sites, but these sites have been properly characterized and chosen to meet the goal of storing the injected CO_2 without seepage. As a result, the surface detection methods have not really been tested at these sites, so it is difficult to determine efficacy of and detection limits for the measurement methods.

The Nation via DOE is addressing this in the ZERT program where we have created a first-of-its-kind field laboratory with a controlled release of CO_2 through a shallow, perforated, horizontal well. The system is designed to be on a realistic scale with a low flow of CO_2. The amounts released are small, equivalent to about six cars idling. But since the CO_2 flux is known, it allows us to investigate the detection limits and verify that the technologies can perform as needed.

In concluding, I would like to remark that the DOE partnership program is providing critical technical knowledge concerning the behavior of CO_2 in the subsurface, but just as important, it is exposing the private sector, the general public, government, and regulatory agencies to the challenges and issues relevant to CCS.

Because there are significant geologic, cultural, economic, and regulatory differences across our Nation, the regional design of the partnership program was extremely well founded, and I would consider the seven large-scale demonstrations really at a minimum. All through this program, valuable exposure I will experience, with all aspects of CCS, is made available to all the sectors, public and private, in the regions. I certainly encourage your continued support of this program.

[The prepared statement of Mr. Spangler follows:]

PREPARED STATEMENT OF LEE SPANGLER, DIRECTOR, BIG SKY CARBON SEQUESTRATION PARTNERSHIP, BOZEMAN, MT

Energy and energy security are critical to the economic well being of any state or nation. Fossil energy resources have proven to be an abundant and relatively inexpensive source of energy to the developed world, but there is compelling evidence that the carbon dioxide that is necessarily produced in the process of generating energy from fossil sources is contributing to global climate change. While ultimately the solution to global climate change may be renewable energy, existing technologies cannot meet current energy demands. The country, and states in this region in particular, face a dilemma; they have enormous coal reserves that can make a major contribution to their nation's economic development and energy security, but they face a need to utilize these resources in a climate friendly fashion. Carbon Capture and Storage (CCS), holds promise as a method of climate-neutral coal use by capturing produced carbon dioxide and storing it safely in underground geologic formations instead of releasing it to the atmosphere. Given that the populous developing countries of China and India also have large coal reserves, the importance of developing this technology is even more critical. I direct two efforts that address CCS. The Big Sky Regional Carbon Sequestration Partnership; one of seven DOE funded regional partnerships focused on validating and demonstrating geologic sequestration. And the Zero Emission Research and Technology Center, ZERT, a collaborative with five DOE national labs and two universities focused and basic science and technology issues relevant to CCS.

PARTNERSHIP BACKGROUND

The overarching objective of the Big Sky Carbon Sequestration Partnership (BSCSP) is to promote the development of a regional framework and infrastructure required to validate and deploy sequestration technologies. To achieve this objective, Phase II focuses on the most promising geologic and terrestrial field validation tests coupled with market assessments, economic analysis and regulatory and public out-

reach. This project benefits the United States by providing a comprehensive assessment of the sources and potential sinks for carbon dioxide (CO_2) in the Big Sky region. This information on sources and sinks is being integrated with the data from other partnerships to provide a comprehensive database covering the entire nation. This effort also provides information to evaluate potential pilot sequestration projects in the Big Sky region with respect to the effectiveness, efficiency and permanence of the sequestrated carbon.

Within the Big Sky region, including Montana, Idaho, South Dakota, Wyoming and the Pacific Northwest, industry is developing new coal-fired power plants using the abundant coal and other fossil-based resources. Of crucial importance to future development programs are robust carbon mitigation plans that include a technical and economic assessment of regional carbon sequestration opportunities and participation in the BSCSP's field validation tests. Therefore, BSCSP is working closely with industry and national and international collaborators to design Phase II geologic and terrestrial field tests to be effective, relevant to commercial development needs and broadly transferable. More information regarding the Phase II objectives can be found at the BSCSP website: http://www.bigskyco2.org.

The target areas and key highlights for the Phase II activities include:

1. Conduct a geologic demonstration project in a prominent geological formation located throughout the region mafic rocks or basalts. This project involves a small volume injection into the Grande Ronde to establish the potential of this formation for permanent sequestration. Since the last reporting period, geologic efforts have been proposed to conduct two new saline aquifer projects that involve evaluating naturally occurring CO_2 reservoirs as potential CO_2 storage/sequestration sites. The first project seeks to evaluate existing cores from the Madison Formation that have had prior exposure to naturally occurring CO_2 for millions of years and to compare those cores from the same formation without naturally occurring CO_2. Secondly, BSCSP will evaluate the potential of using naturally occurring CO_2 reservoirs in geologic domes as potential CO_2 storage sites for enhanced oil recovery (EOR) and as long term permanent sequestration alternatives.
2. Conduct pilot projects to demonstrate and validate the technical and economic feasibility of the major terrestrial carbon sinks, implement monitoring and verification protocols, and assess the impacts to existing ecosystems. The terrestrial sinks provide a near-term solution to partially offset industrial CO_2 emissions and enhance the production of the agricultural land base.
3. Develop a national mafic rock atlas and assess the regional and national long-term sequestration potential of these geological formations through modeling studies, laboratory testing, and insights developed from mafic rock pilot projects.
4. Address both the technical and economic potential for carbon sequestration and assess the economic implications of carbon sequestration in the region.
5. Establish the Big Sky Energy Future Coalition or similar venues that annually bring together industry, academia, environmental non-governmental organizations and regulatory and governmental officials to build dialogue on the role carbon sequestration can play in providing a technology solution to the region's energy requirements.

During Phase III (beginning in late 2009) the Partnership will begin preparations for a large volume sequestration test in the Jurassic/Triassic Nugget Sandstone Formation on the Moxa Arch of southwestern Wyoming. The test has the potential to inject three million tons of carbon dioxide (CO_2) into the saline formation at depths of 12,000 over three years. The Nugget sandstone is similar to the Tensleep, Weber, and Navajo formations, which have been identified as regionally extensive sequestration targets in the western US. The CO_2 will be supplied by Cimarex Energy from their gas plant in the Riley Ridge Field. The Cimarex plant, scheduled for completion in late 2008 or early 2009, will extract methane and helium from gas produced from the Madison Limestone at 18,000 feet. The produced gas is 75% CO_2 with accompanying methane, hydrogen sulfide and helium. The non-economic portion of the gas will be re-injected into the Madison Limestone. The plant will produce approximately 1.5 million tons of high pressure CO_2 per year. The CO_2 for the project (92% CO_2 and 8% H2S) will be diverted in a short lateral pipeline for injection into the Nugget Formation on Wyoming State Trust lands. Information from the project will be used by Cimarex to evaluate the potential to establish a commercial sequestration facility.

The overarching objective of the Phase III Large Volume Injection is to demonstrate the long-term safe operation of large injection volume into a regionally significant sink. The primary research objectives in support of this goal are to:

1) Evaluate the Nugget Sandstone saline aquifer responses to injection of commercial scale volumes of supercritical CO_2 and derive the relevant economic information for future projects.

2) Track the post-injection migration and containment of the CO_2 in the Nugget Sandstone to compare with pre-injection reservoir model predictions and use the data to refine multiphase flow reactive-transport modeling of CO_2 sequestration in saline formations.

3) Evaluate the various MMV procedures used for their performance during deep sequestration. The depths in this project represent the upper limits of those proposed for Phase III projects, and may be used to help establish economic criteria for deep sequestration.

ZERO EMISSION RESEARCH AND TECHNOLOGY CENTER (ZERT) BACKGROUND

The Zero Emissions Research and Technology (ZERT) Center, is a collaborative involving five DOE National labs (Los Alamos National Lab, Lawrence Berkeley National Lab, the National Energy Technology Lab, Pacific Northwest National Lab, Lawrence Livermore National Lab) and two academic institutions (Montana State University and West Virginia University) and is focused on the basic science issues behind geologic carbon sequestration. The major objectives of ZERT are to:

1. Improve computational tools for simulation of CO_2 behavior in the subsurface. This includes adding algorithms to address CO_2 specific behavior such as reactive transport, development of coupled models to include geomechanics, inclusion of hysteretic effects, parallelization, etc.

2. Test efficacy of near-surface detection techniques, help establish detection limits for those techniques, and provide data to assist in development of transport models in the near-surface region. A field test site to help accomplish this objective.

3. Develop a comprehensive risk assessment framework that will allow flexible coupling of multiple computational models for different components/processes of the system. The tool developed, CO_2-PENS, is the first-ever performance and decision analysis tool specifically developed for CO_2 sequestration.

4. Perform gap analysis to determine critical missing data for CO_2 properties in the subsurface including thermodynamic properties of CO_2-brine mixtures, reaction rates, relative permeabilities, etc. We perform laboratory based experiments to generate that key data using pressurized batch and flow-through vessels to reproduce sub-surface conditions.

We have developed a unique field site for verification / testing of near surface detection technologies and transport codes. This site consists of a shallow horizontal well with a 70 m screened section divided into zones via a packer system that allows individualized control of flow rate. Five Department of Energy (DOE) National Labs and two universities tested detection technologies including eddy covariance, free space LIDAR, hyperspectral imaging, two soil gas flux measurement systems, resistivity, water chemistry, LIDAR measurements of the soil gas in the shallow subsurface, tracer studies, and stable isotope studies.

CHALLENGES TO DEPLOYMENT

There are many challenges to deployment of large scale carbon capture and storage technologies. These can be characterized as follows: 1) technological; 2) logistical; 3) economic; and 4) regulatory.

Technological.—Oil and gas companies that have provided us with mature technology to understand and safely operate successful underground natural gas storage. Similarly, the use of CO_2 for enhanced oil recovery (EOR) has been in place for over 30 years in various oil and gas fields throughout the United States, Canada and abroad. CO_2 injection for permanent sequestration is an excellent analogue to both natural gas storage and EOR but it has not been done at an equivalent scale. Consequently, our understanding of the geochemical, geophysical and other technical advantages or disadvantages of various geologic sinks requires testing at a scale that is commensurate with the operation of a commercial sequestration facility. Currently, DOE funding is being made available to the Big Sky Carbon Sequestration Partnership and the other six regional partnerships to begin to examine this volume of sequestration as part of the Phase III projects.

Currently, one of the biggest challenges to testing commercial scale geologic sequestration is the lack of availability of CO_2. While our experience with sequestration has been advanced by the technologies described above, capture of large volumes of CO_2 from fossil fuel plants is extremely limited to sources such as that currently available from the syngas plant operated by Basin Electric in North Dakota,

the Exxon Mobil gas stripping facility in southwestern Wyoming, or non-anthropogenic sources from naturally occurring CO_2 reservoirs. Capture technologies, while advancing quickly, remain largely as voluntary collaborations between emitters and capture plant builders to evaluate the technological advantages of a range of competing approaches. Because the deployment of these technologies remains experimental and largely voluntary the actual costs and opportunity costs of deploying these systems remains costly and with unavoidable risks to the power producer in terms of operational downtime or capture and compression process failures.

Logistical.—As mentioned previously, much remains to be done to adequately characterize potential geologic sinks on a site specific basis to allow sequestration to proceed safely and with a high probability of permanent storage. Currently, areas where extensive site characterization work has been completed such as areas with extensive oil and gas exploration and production, are not necessarily proximal to large sources of CO_2 emission. Assuming that technology emerges that effectively and economically captures CO_2, transporting the CO_2 to areas suitable for permanent storage or for EOR could prove extremely costly. Some have argued that the pipeline infrastructure required for transportation of CO_2 could approach that of the current natural gas infrastructure that was put in place over the past 50—60 years.

Pipelines are becoming increasingly difficult to build due to skyrocketing costs of obtaining rights-of-way. For interstate pipelines, questions remain as to how CO_2 pipelines will be classified; will these pipelines receive common carrier status and therefore be granted eminent domain powers? Some states have begun to address this issue but most have not.

Economic.—In the absence of a price signal or command and control instruments that limit CO_2 emissions, there is little incentive for capital investment in capture, transportation and sequestration facilities. Recent regulatory decisions by individual states or consortia of states and Canadian provinces have created performance standards or capped GHG emissions at historical levels. This has created market incentives to begin to reduce emissions or to begin to contemplate electrical generating facilities that incorporate capture as a means to take advantage of clean markets. However, a lack of capture technologies designed to scale, the anticipated cost of capture, transportation, and sequestration continues to reduce interest in new clean coal plants, retrofitting existing plants, and promoting sequestration. This is particularly problematic for those entities that must secure financing from outside sources or for facilities that have not negotiated a market for the produced CO_2 such as EOR. Conversely, new builds that do not plan to sequester CO_2 are having difficulty securing financing and obtaining permits because of current regulatory uncertainty.

Public Acceptance/Assurance.—New approaches and technologies inherently raise public concern. In an area with technical issues such as CCS, engaging the public and clearly articulating current relevant experience with underground injection, EOR, and natural analogs as well as safeguards that can be put in place is critical.

Development and testing of those safeguards is critical as well. There is a widely recognized need for detecting the CO_2 near the surface for Health, Safety and Environmental reasons and to provide public assurance. Such sensors have been deployed at sequestration pilot sites, but these sites have been properly characterized and chosen and meet the goal of storing the injected CO_2 without seepage. As a result, the surface detection methods have not really been tested at these sites, so it is difficult to determine efficacy of and detection limits for the measurement methods. DOE is addressing this in the ZERT program where we have created a first of its kind field laboratory with a controlled release of CO_2 through a shallow, perforated, horizontal well. The system is designed to be on a realistic scale (10% to 1% of the physical extent of some known natural CO_2 leaks) and the amounts of CO_2 released are low (less than the CO_2 emissions from 6 idling cars), but since the CO_2 flux is known, it allows us to investigate the detection limits and "footprints" of a variety of technologies to verify that they can perform as necessary.

Regulatory.—Perhaps the most daunting challenge for large scale deployment of CO_2 sequestration is the uncertainty surrounding the regulatory environment. These challenges can be categorized as follows:

Ownership of pore space.—Most state and federal mineral law addresses the extraction of minerals and prescribes ownership. The law is much less clear on the ownership of the remaining pore space—does it belong to the mineral right holder or the surface owner? Obviously, for sequestration to occur on a large scale that has the potential to affect numerous surface or mineral owners, this question must be addressed for the process to proceed.

Underground Injection Control.—Current EPA guidance would suggest that sequestration pilots can occur under Class V experimental well des-

ignations. However, it remains unclear whether projects at the scale of Phase III DOE large volume tests would be a "pilot." Secondly, moving to commercial scale sequestration may involve the need for additional clarification at both the state and federal level. Finally, as additional research requires the need for more pilot scale activities to adequately characterize potential geologic sinks, sufficient flexibility must remain within the UIC program to accommodate conducting this research.

Measuring, Monitoring and Verification.—As geologic sequestration becomes increasingly technologically feasible and if capture and transportation costs can be economically reasonable, it will be important to maintain MMV requirements that are economically and technologically feasible as well. The "precautionary principle" should not preclude the assumption of reasonable risk to ensure that CO_2 remains safely and securely stored for the long term. For CCS to remain a viable alternative to GHG emissions, the regulatory environment should recognize that cost containment for MMV is as important for successful sequestration as capture and transportation.

Liability.—Perhaps the biggest concern for those entities considering geologic sequestration is the long term liability for the CO_2 once injection operations cease. The intention for most sequestration operations is to sequester the CO_2 over the life of the facility and then based on operational experience over that time period, being able to state with some certainty that the CO_2 will remain in the formation where it is stored permanently. Assuming this liability in perpetuity is obviously beyond the capability of most operations given the changing nature of corporate structures, dissolution of corporations, etc.

Our experience with geologic sequestration over the next 5-10 years may demonstrate that assumption of this liability is reasonable and that underwriters, based on this experience, will be willing to offer liability protection at a reasonable cost. However, in the interim period while we carry this research forward and attempt to commercialize the technology, the possibility of indemnification from reasonable liability would expedite the deployment of both capture and sequestration technologies.

The DOE partnership program is providing valuable technical knowledge concerning the behavior of CO_2 in the sub-surface. Just as important, it is exposing the private sector, the general public, government, and regulatory agencies to the challenges and issues relevant to CCS.

Senator DORGAN. Dr. Spangler, thank you very much. We appreciate your testimony as well.

Next, Mr. John Harju, Associate Director for Research at the EERC in Grand Forks, North Dakota, and is involved in the PCOR project, a regional CO_2 reduction partnership. Mr. Harju, thank you. You may proceed.

STATEMENT OF JOHN A. HARJU, ASSOCIATE DIRECTOR OF RESEARCH, PLAINS CO_2 REDUCTION PARTNERSHIP, GRAND FORKS, ND

Mr. HARJU. Thank you, Senator Dorgan and Senator Tester.

It is in my current capacity at the EERC I oversee this PCOR Partnership. The PCOR Partnership encompasses all or part of nine States and four Canadian provinces, and the four Canadian provinces really provide additional experience and knowledge and an international framework to advance CCS technology.

Within this partnership, we have approximately 80 public and private sector partners contributing either financially or with time or equipment or other experiences to the advancement of CCS. At present, we have most of the region's electrical generating capacity involved, many of the region's engineering firms, all of the region's regulatory bodies, and many of the region's oil and gas companies.

We have four modest-scale field tests underway at present, and we have two large-scale tests on the order of a million tons a year each designated for implementation in the near term.

Our region generates about 600 million tons of CO_2 annually, and to give you some perspective on what that might mean in the context of enhanced recovery opportunities, we have on the order of tens of billions of tons of storage capacity simply in depleting or depleted oil and gas reservoirs in the region. So it is a very, very significant opportunity, and it is an opportunity upon which an incredible experience base can be drawn. More than 30 years of experience has been generated through enhanced recovery. Approximately 6 to 7 trillion cubic feet of CO_2 has been put into long-term geologic storage already over the course of that effort, largely in west Texas and New Mexico.

Currently about 2.5 billion cubic feet a day of CO_2 is transported via pipeline and injected through these enhanced oil recovery operations. That equates to about 40 million tons a year of CO_2 that are put into long-term geologic storage.

In turn, very well established regulatory regimes already exist. The IRGCC guidelines that have been mentioned earlier, of which I am a co-author to, recognize that that experience base and do go into such issues as unitization, a well-established oil and gas procedure for delineating subsurface ownership, well-established U.S. DOT guidelines for the pipeline transport of CO_2. Two very significant experience bases that cannot be ignored, one being natural gas storage and the Natural Gas Storage Act as promulgated by Congress many years ago now, do provide very consistent regulatory analogs for implementing CCS.

Another more recent, but also very useful analog from the regulatory side of the equation is that of acid gas injection. It is my contention that only modest adaptation of these rules is necessary.

I also want to focus in a little bit on a term that we have heard a little bit—well, we have heard consistently through most of the other folks on the panels today, and that being "liability." I think a better term to start with is that of "custody." Liability infers a damage, and it is my contention that that—in well-chosen locations, that liability will be the exception rather than the rule, and that custody is what we really need to focus in on.

Within oil and gas-producing States around the Nation, what we already have are very well-established programs where fees are levied on the operations, bonds are issued on operations. Those fees and/or bonds are utilized in the event of any liability that may occur as a function of that long-term custody. I think those are the programs to look to as we attempt to provide financial assurances to the private sector as they look at deploying CCS on a wide scale.

Finally, in this regulatory regime, it is certainly my belief that the States are best equipped. They understand the geology of their States. They understand the socioeconomic implications of any of these actions within their own States.

Regulatory regimes need to have the flexibility to accommodate the excellent sites with very minimal monitoring, and they also need the flexibility of ruling out sites where CO_2 probably should not be in place.

I will close at that point. I see my time is up, and I thank you for the opportunity.

[The prepared statement of Mr. Harju follows:]

PREPARED STATEMENT OF JOHN A. HARJU, ASSOCIATE DIRECTOR OF RESEARCH, PLAINS CO_2 REDUCTION PARTNERSHIP, GRAND FORKS, ND

CARBON MANAGEMENT AND GLOBAL WARMING

Carbon dioxide (CO_2) is a gas composed of one atom of carbon and two atoms of oxygen. CO_2 occurs naturally in the atmosphere, is essential to plant life and, as a greenhouse gas (GHG), helps create the greenhouse effect that keeps our planet livable. CO_2 is exhaled by humans and is used to put the bubbles in soft drinks, as a coolant (dry ice), and in fire extinguishers.

GHGs, including CO_2, trap a portion of the sun's energy in the Earth's atmosphere and make our planet warm enough to support life. Human (anthropogenic) activity, including the use of fossil fuel, generates a significant volume of GHGs like CO_2. There is concern that the anthropogenic GHG entering the atmosphere is causing increased warming and that this warming will affect climate on a global scale. CO_2 sequestration—the capture and long-term storage of CO_2—is one of several carbon management actions that helps to control anthropogenic CO_2 emissions to the atmosphere.

THE PCOR PARTNERSHIP

The PCOR Partnership, led by the University of North Dakota Energy & Environmental Research Center, is one of seven regional partnerships established by the U.S. Department of Energy National Energy Technology Laboratory to assess carbon sequestration opportunities that exist nationwide. The PCOR Partnership covers an area of over 1.4 million square miles in the central interior of North America and includes all or part of nine states and four Canadian provinces. The central interior of North America contains several seismically stable geologic basins that are ideal sinks for geologic CO_2 sequestration. These basins have been well characterized because of commercial oil and gas activities. The geologic characteristics of the oil and gas reservoirs offer significant opportunities for developing the expertise and infrastructure required to make geologic CO_2 sequestration a commercial reality while maintaining, and even enhancing, the regional economy.

The coal-fired electrical utilities in the region produce over 60% of the CO_2 emissions from stationary sources. With the distinct possibility of carbon management becoming more important in the future, industries that rely on fossil fuels are looking to CO_2 sequestration as a strategy for carbon management. Further, many of the region's oil fields could develop CO_2-based enhanced oil recovery (EOR) projects with the increased availability of CO_2. The PCOR Partnership has developed a regional vision for the widespread commercial development of CO_2 sequestration. The vision includes several key elements: 1) targeting tertiary EOR opportunities; 2) employing the existing oil and gas regulatory structure and agencies for oversight; 3) developing a protocol for the establishment of geologic sequestration units that is based on the standard oil field practice of unitization; 4) developing rigorous site selection criteria that will allow for the adoption of commercially viable measuring, monitoring, and verification (MMV) procedures; and 5) developing the information needed to monetize carbon credits to reduce the costs of industrial projects. The realization of this vision will result in the development of EOR-based opportunities, to be followed by non-resource-recovery-based sequestration when the EOR opportunities have been exhausted.

THE PCOR PARTNERSHIP REGION

The variable nature of the sources and sinks reflects the geographic and socioeconomic diversity of the PCOR Partnership region. In the upper Mississippi River Valley and along the western shores of the Great Lakes, large coal-fired electrical generators power the manufacturing plants and breweries of St. Louis, Minneapolis—St. Paul, and Milwaukee. To the west, the prairies and badlands of the north-central U.S. and central Canada are home to coal-fired power plants, natural gas-processing plants, ethanol plants, and refineries that further fuel the industrial and domestic needs of cities throughout North America.

Geological formations deep beneath the surface of the region hold incredible potential to store CO_2. Oil fields already considered to be capable of sequestering CO_2 can be found in five states and all of the provinces of the region. Saline formations and coalfields exist in basins that, in some cases, extend unbroken over thousands

of square miles. Many large sources in the region are proximally located to large-capacity sinks. In some cases, the infrastructure necessary for CO_2 sequestration is already largely in place. CO_2-based EOR and enhanced coalbed methane (ECBM) are value-added sequestration technologies that have the potential for future large-scale deployment in the region.

The economic viability of near-term sequestration will require a value-added component, and EOR and/or ECBM are likely to provide the needed impetus for large-scale injection of CO_2 into geologic formations. EOR and ECBM then become vehicles to help pay for the additional characterization and infrastructure required for future storage in nearby formations.

Bountiful oil fields in the PCOR Partnership region have a potential capacity to store over 10 billion tons of CO_2. The U.S. portion of the Williston Basin includes over 20 large oil fields that are suitable for large-scale CO_2-flood EOR operations. One of the PCOR Partnership's Phase III demonstration projects involves capturing CO_2 from a coal-fired power plant and transporting it via pipeline to an oil field in the U.S. portion of the Williston Basin, where it will be injected for simultaneous EOR and sequestration. It is anticipated that a minimum of 1 million tons of CO_2 will be injected annually through this effort.

CO_2, EOR AND SEQUESTRATION—THE CASE FOR POLICIES THAT FACILITATE COLLABORATION

Events currently unfolding at national and state levels have strong implications with regard to the pace of deployment of technologies and strategies to reduce CO_2 emissions. CO_2 sequestration policies are under rapid development. This factor, along with an urgency of implementing emission reductions because of heightened public awareness, shows we are at a critical policy juncture with respect to carbon management.

One serious concern has to do with any policy that might marginalize EOR as a sequestration tool. The emission reduction potential and sequestration associated with EOR is immense, and revenues from oil produced will offset the cost to the economy and will, ultimately, accelerate more widespread deployment. With the growing energy concerns in the United States, the contributions of CO_2 EOR in the advancement of carbon capture and sequestration need to be placed front-and-center in the policy debate.

THE CASE FOR CO_2, EOR

EOR involves injecting substances into a reservoir through thermal, chemical, and gas-miscible processes. One example of a gas-miscible process is that of a CO_2 flood. CO_2 is injected into an oil reservoir via pipeline whereupon it expands and thereby pushes additional oil into production. EOR can recover an average of 35% of the remaining oil; some of the injected CO_2 returns with the recovered oil and can then be reinjected into the reservoir to minimize operating costs while maximizing economical and environmental benefits.

The era of CO_2 EOR effectively began with two large-scale floods in west Texas 35 years ago. The industry has grown since then to become a major factor in the industry in Texas, Wyoming, New Mexico, and Mississippi and produces over 90 million barrels of oil a year for the U.S. economy. The chief limiting factor of growth in other areas with oil properties has been a ready source of CO_2.

Industry estimates from the Permian Basin region of west Texas and New Mexico suggest 6 to 7 mcf of CO_2 is permanently stored per barrel of oil recovered. Since over a billion barrels have been recovered there, that represents 6 to 7 tcf (340-400 gigatons) of stored CO_2.

So what does all of this mean for CO_2 sequestration? First, an existing industry has evolved that possesses the operational practices to handle large volumes of CO_2 safely and effectively. The industry's best practices can be extended into the field of CO_2 sequestration with almost seamless ease. Surface CO_2 handling (including gas processing, compression, and transportation), well designs, injection practices, and surveillance of emplaced CO_2 are all directly applicable. Assurance of long-term storage is the key feature that needs to be demonstrated.

Second, the EOR industry is seriously constrained by availability of CO_2. With coal plants and other industrial facilities seeking to find a home for their CO_2, it becomes only a matter of economics, CO_2 capture technology improvements, and mutual trust to develop joint ventures between these two industries that are so critical to America's future.

Third, the domestically produced oil from EOR has been the sole revenue stream to fund EOR projects—from the source of CO_2, to the pipelines, to move it to the injection site, to produce the oil. Should EOR qualify as sequestration, the oil rev-

enue will act as a critical resource to offset the huge infrastructure costs that, otherwise, will need to be funded by the public through higher energy costs. Storing the CO_2 and funding the infrastructure from the additional oil recovery would occur at the same time that important barrels of domestic oil contribute to U.S. energy security.

Fourth, CO_2-based EOR is important in that it extends the life of existing oil fields. Up to an additional 30 years of life can be gained by CO_2-based EOR. This reduces the need to develop new fields and greatly enhances our domestic oil supply, while sustaining vital revenue streams to state and local governments from the attendant tax collections.

BARRIERS

Just as in nature with deep-sourced, natural CO_2, there are low-risk sites that will permanently entrap CO_2, and there are places where it may migrate, perhaps even to the surface. CO_2 is a naturally occurring substance, and movement within the subsurface is very common. Rather than trying to fashion rules that protect against surface escape in all subsurface conditions, regulatory oversight needs to recognize the ubiquitous presence of the molecule while identifying low-risk sites for entrapment and provide flexibility in regulation to accommodate the attendant risk level.

The CO_2 EOR experience within the oil and gas industry can provide pathways to successful sequestration on a very large scale. The oil and gas industry can provide the tools of exploration, the science and experience to assess risks of site permanency and, most importantly, the tools and techniques to design and construct the wells for emplacement.

One of the largest potential barriers to deployment of sequestration projects would be the specification of overly complex well design and monitoring of sites. Experience shows that exotic well designs add little benefit, while, on the other hand, judicious site selection adds greatly to the security of emplacement. For example, subsurface sequestration formations overlain by bedded salts provide optimal conditions for long-term storage. The focus of regulation should be performance criteria, not design criteria.

The need for managing and mitigating any risks that may arise from the long-term custody of the emplaced CO_2 is also a critical item. The Interstate Oil and Gas Compact Commission has developed guidelines that are based on current practice for handling long-term liability in the oil and gas industry. The financial assurances provided therein seem to be the most viable solution to long-term custody issues and any potential liabilities that may arise.

EOR AND SEQUESTRATION: SEPARATE PATHS?

Recent policy actions seem to be charting separate paths for CO_2 EOR and sequestration. For reasons stated earlier, recognizing EOR as a CO_2 storage event is critical. Advancements in using coal in such a way as to capture and sequester the byproduct CO_2 are important steps for America's energy future. Disqualifying CO_2 stored during EOR as an offset to emissions will do nothing but delay the necessary commercial demonstrations of those technologies and further burden an already-stressed energy infrastructure. One example of an action working against this progress is setting up separate well design requirements for sequestration as compared to the proven designs currently used in CO_2 EOR.

CONCLUSIONS

Industry participation in the ongoing policy debates about CO_2 injection projects is critical. Special contributions are needed in categorizing appropriate sequestration sites, well design requirements, and CO_2 emplacement surveillance and monitoring. Regulations need to be developed in the context of a robust industrial knowledge base for carbon management issues. In most cases, existing oil and gas regulations can be applied with little or no modification to ensure that CO_2 sequestration is a safe and practical method for carbon management. The need for managing and mitigating any risks that may arise associated with the long-term custody of the emplaced CO_2 is also very important, and a Petroleum Insurance Fund-type approach may be an effective solution to any attendant issues related to excursions from the sequestration site. It is critical that EOR activities not be precluded or discounted as CO_2 sequestration opportunities.

Senator DORGAN. Mr. Harju, thank you very much. We appreciate very much your testimony.

Finally, we will hear from Gary Loop, Chief Operating Officer and Senior Vice President of the Dakota Gasification Company, a subsidiary of Basin Electric Power Cooperative. Gary has served in the refinery and the crude oil industry since 1982, and 3 and-a-half years as chief executive officer of a privatized power company in Zambia, Africa. A Berkeley, California native, he joined the Dakota Gasification Company in May 2006.

Mr. Loop, thank you very much. You may proceed.

STATEMENT OF GARY G. LOOP, CHIEF OPERATING OFFICER AND SENIOR VICE PRESIDENT, DAKOTA GASIFICATION COMPANY, BISMARCK, ND

Mr. LOOP. Thank you, Mr. Chairman and Senator Tester. I appreciate the opportunity to testify here this morning.

We at Basin have about 3,500 megawatts of power, mostly coal-generated. So you can understand why we really have a clear interest in all the issues that have been discussed here today and share your sense of urgency to begin to find answers to go forward, because not only do we have to deal with these, but we need to build more power stations to meet the growing needs of our members.

We also believe in the government and private partnership, and we want to take a leadership role in that where we can.

We have the only coal-to-gas commercial-size operation in the United States, and we, as a part of that, remove CO_2 from our products. So we have been capturing CO_2 to the tune of 3 million to 4 million tons a year for 20 years. However, we have been simply releasing it back to the atmosphere until 2000 when we began to sell our CO_2 after building a 200-mile pipeline into Canada, and it is used as EOR up there now in two fields.

So we are currently sending 3 million tons a year up there and have already sequestered over 13 million tons, making us the largest carbon capture and sequestration project in the world.

If one looks at what we are doing, though, we capture carbon from a stream that has a low gas volume, very high pressure, allowing us to use methanol. We can do this in a very proven technology—and, I mean $10 to $15 a ton.

We are looking at a project next door. We are joined at the hip to a power plant next door that is burning pulverized coal, and they, of course, have higher gas volumes in a post-combustion, low-pressure. So methanol will not work there. So we are looking at ammonia or a mean type systems. These are untested at any demonstration plant, let alone a commercial-scale.

We went out for bids for people who could come in and do a project on a slip-stream of our total, but it would be a large project, 120-megawatt equivalent of flue gas. We have got estimates ranging from $30 to $50 a ton to remove this carbon.

What we do have what we think is a unique opportunity. We are in a place where there is existing CO_2 transport and sequestration opportunities and infrastructure, along with operating and marketing expertise. We have an ammonia source right next door. At PGC we make ammonia. We have an ammonium sulfate manufacturing capability, and in these amine and ammonia systems, you must remove the sulfur down to very, very low levels, but those

systems then must do something with that sulfur. We have excess capacity to turn that into a saleable product.

Now we will look a little bit at the region we are in. If we look at Williston Basin, which is in South Dakota, Montana, and North Dakota, and just looking at the portion that is in the United States, we believe, using some very preliminary data, that if you took all the CO_2 being emitted from electric power plants in that region and just use them for EOR in what we believe is out there, we could sequester for 50 years.

If you look at the saline aquifers—the data gets more sketchy here, but it is beginning to look like you could burn all the carbon—all the coal in the region and sequester the CO_2 in the aquifers. Again, it has got a lot of legal issues and other issues, but physically the space appears to be there.

But we are very interested in the 50-year number. Whether it is 40 or 50 or 60, that is a big number and could easily handle paying for the capital of projects. This is a good area, we think, to develop technologies because as you are developing them, they will cost more. Hopefully, over time, as you learn how to do it, the costs will come down. So we are very interested and see this as a good opportunity.

If you look at a cost of $30 or $50 a ton to capture the CO_2, we think pipeline and transportation costs are in the $15 to $30 a ton range and that the value of the CO_2 as EOR ranges from $20 to $35. That would give you this huge range of anywhere, in the most optimistic case, of $10 a ton all the way up, in the most pessimistic, to $60 a ton. We refer the $60 a ton, it is kind of a hopeless case, but the $10 a ton, maybe this might work. That number is in the range of people who have talked about it, as incentive type numbers, to drive people to make this decision.

The last area I would like to talk about—and I do not know how many of you have the slides we handed out, but the very last page shows a picture of some maps. Right now we have pipeline running from our plant and neighboring AVS, running up into Canada. But we are looking to build another 110–mile pipeline south down into a large number of oil fields, and are talking to potential customers down there where we could send our AVS production or even some of our existing production. Further, we could expand that as we look at plants we are building in Grand Forks or potentially trying to build out in South Dakota. These are 250- to 100-mile-long pipelines that could all be interconnected and give us a very large system.

The reason this is important is one issue that has not been talked about today is that when you try to connect yourself to somebody else, if you are just one on one, then when either one has a problem, the other one has to go down, it increases the hidden costs of some of these things. But having a system with multiple sources and multiple customers using it, then when any one of them has a problem, you can distribute the flow of CO_2 around and it protects everybody. Some of us like Basin in this area could build our own system, but there are issues for how you build a system where one source might participate.

But those are kind of the major issues. We do seek, as you do, an aggressive program. We believe that projects like ours should

get funding, whether it is ours or something similar to it, that are cheaper where you only have to buy the piece you are interested in. The other pieces of the infrastructure are already in place. It is a cheaper way to do it. We think we should be moving now because if you are going to finance it, it is a lot better if you know how much it is going to cost and whether it is even going to work. So that is kind of the gist of our whole presentation here today.

Thank you.

[The prepared statement of Mr. Loop follows:]

PREPARED STATEMENT OF GARY G. LOOP, CHIEF OPERATING OFFICER AND SENIOR VICE PRESIDENT, DAKOTA GASIFICATION COMPANY, BISMARCK, ND

Mr. Chairman and members of the committee, my name is Gary Loop and I serve as the COO and Senior Vice President of the Dakota Gasification Company. I appreciate the invitation to testify today, and I am here to provide you with Dakota Gasification's view on the challenges of large-scale carbon capture and storage.

EXPERIENCE WITH CARBON CAPTURE & STORAGE

The Dakota Gasification Company (DGC) is a subsidiary of Basin Electric Power Cooperative. Basin Electric is an electrical generation and transmission cooperative with 125 member cooperatives located in nine states. Our generation resources include approximately 3,500 megawatts of coal, gas, oil and wind, but we are primarily a coal-based utility. The question of what to do with the Carbon Dioxide (CO_2) produced by these plants is casting a shadow over their viability. Coal produces approximately 50% of the nation's electricity and it is a vital part of our nation's energy security. The federal government should undertake an aggressive strategy to mitigate the risk of a carbon-constrained future. For its part, Basin Electric is taking a leading role in finding these answers.

The best and largest example of Carbon Capture & Storage (CCS) is happening right here in North Dakota at DGC's Great Plains Synfuels Plant near Beulah. The Great Plains Synfuels Plant is the only commercial-scale coal gasification plant in the United States that manufactures natural gas. The synfuels plant gasifies lignite coal to produce 160 million standard cubic feet of synthetic natural gas daily. The $2.1 billion plant began operating in 1984. In 2000 DGC began capturing the CO_2 produced at the plant, and shipping it through a 205-mile pipeline to Weyburn, Saskatchewan to be used for enhanced oil recovery (EOR) in an aging oil field. Today, DGC provides all the CO_2 to the largest carbon sequestration project in the world located just across the border in Canada. Through 2006, Dakota Gasification has successfully captured and marketed over 10 million tons of CO_2 to two Canadian customers. Total CO_2 demand is 152.7 million standard cubic feet per day. The CO_2 is expected to be permanently sequestered in the oil reservoir and is being monitored by the International Energy Agency (IEA) Weyburn CO_2 Monitoring and Storage Project.

ENHANCED OIL RECOVERY; A BRIDGE FOR TECHNOLOGY

The current effort to sequester carbon from coal based facilities requires massive amounts of capital. One of the important findings at the August 13, 2007, hearing of the Energy and Water Development Appropriations Subcommittee that Senator Dorgan held in Bismarck, ND, was that captured carbon might be used in increasing our oil production. Demonstrating carbon capture from coal-based generation and using it for enhanced oil recovery could prove to be extremely beneficial to North Dakota and the nation by increasing our oil production while at the same time sequestering CO_2.

However, even the potential for revenue from selling CO_2 does not fully support the business case of adding carbon capture to a coal fired electric plant. A combination of construction and production incentives is necessary to make such a system financially and commercially viable. To fully develop EOR opportunities we need incentives similar to those that the wind, ethanol and bio-diesel industries receive. EOR can provide the transitional path to fully develop carbon capture technologies and help produce the energy our nation desperately needs in an environmentally sound manner if long term incentives similar to the Production Tax Credits (PTC) and accelerated depreciation provided for wind are offered. However, even these incentives will not be adequate if CCS costs are as high as currently projected and EOR is not an option.

There is great risk in being the first to commercialize the newest technology, whether it's using low-rank coals in an Integrated Gasification Combined Cycle (IGCC) plant for electricity generation or retrofitting pulverized coal power plants for carbon capture. For construction of either IGCC or Supercritical Pulverized coal, it takes 7-8 years for permitting, front end engineering & design, procurement and construction, CCS could take up to 10 years or longer to achieve commercial deployment. The federal renewable production tax credit has greatly helped expand wind energy development in the United States. A similar effort could help make substantial progress with CCS from existing power plants. The right federal incentives could make investing in carbon capture technologies more attractive and potentially accelerate demonstration of carbon capture and EOR from existing powers plants.

POTENTIAL FOR STORAGE THROUGH CCS

Our experience at the Great Plains Synfuels Plant makes clear the tremendous opportunity for the development of new technology through the use of EOR. Within the Williston Basin we can store 100% of the carbon emitted from all of the region's electrical generation for the next 50 years using EOR alone. For purposes of this discussion, we are defining region as all of North Dakota, South Dakota, Montana and the Northeast corner of Wyoming. After 50 years of EOR, should this storage capacity be exhausted, the capacity of saline aquifers within the region exceed the carbon content of all the known coal reserves within that region.

RANGE OF COST

In a nutshell, the costs to capture and transport the carbon range from hopeless to maybe it might work. Our best estimate shows that it will cost from $30-50/ton to capture the CO_2 and from $15-30/ton to transport it to potential EOR sites. If we can recoup $20-35/ton from the sale of the CO_2, that provides us with a range of the total cost of between $10-60/ton for the total process. At $60/ton this proposal is hopeless. However, if we diligently work to refine and reduce these associated costs, $10/ton it maybe might work. To give some idea of the scale of these projects, keep in mind that it takes about $1 MM/mile to construct a pipeline. It is 80 miles from the DGC plant to the Cedar Creek Fields, and it is 240 miles from the NextGen site near Selby to the Cedar Creek Fields.

DEVELOPMENT OF EOR

One of the main considerations in the development of EOR is the surety of supply. Oil and gas companies need to be assured that once they have invested the massive amounts of capital to prepare oil fields for EOR that the CO_2 continues to be available. Likewise, generators of CO_2 need to be assured that once they have invested in the capture technologies, the plant, and the pipelines that the market for CO_2 is not interrupted. To provide this assurance, each user needs multiple sources of CO_2 and multiple sinks for EOR. The system will need the reliability of multiple CO_2 sources to give it an uninterruptable supply. The generators need the assurance that they won't have to shut down power plants if something happens at the end of the CO_2 pipeline.

WHERE FROM HERE

As I mentioned earlier, incentives are the key. A targeted tax credit for the capture and storage of CO_2 will help overcome the obstacles to demonstrating CCS technology. Senator Dorgan sponsored such a tax credit out of the Senate Finance Committee last fall, but it failed along with a variety of other energy incentives primarily due to its cost. To address these concerns, we propose altering the original proposal to limit the tax credit to three projects nationally. Since we are talking about demonstrating new, untested technology, we think this approach is appropriate. The attached legislation would provide a $15 per ton of CO_2 for each project, as long as the facility uses coal as a primary fuel sources and captures at least 1 million tons of CO_2 annually for use in EOR or enhanced gas recovery projects. The credit would be capped at 10 million tons per project over a 10 year period, and would be available to a taxpayer that captures, treats, compresses and physically performs or contractually ensures the injection of the CO_2. This ensures that the producer of the CO_2 or the oil company that purchases the CO_2 can benefit, bringing down the cost of CSS to a more manageable level.

We believe these targeted changes will help reduce the overall costs of the bill to around $450 million dollars. However, when you factor in additional revenues the federal government would receive from increased oil production due to EOR, those costs could be even lower.

Mr. Chairman, this proposal will go along way to advancing CCS technology in the United States, and we hope you and the committee will support it. Thank you again for the opportunity to speak with you. I am available to answer any questions you or the other committee members may have.

CARBON CAPTURE COMMERCIAL DEPLOYMENT TAX CREDIT DEMONSTRATION

Proposal

Provide a $15 per ton tax credit (indexed for inflation) for the capture of carbon dioxide (CO_2) for use in enhanced oil recovery (EOR) or Enhanced Coalbed Methane (ECBM).

- The credit would be limited to 3 projects nation-wide that have a nameplate capacity to capture at least 1 million tons per year of CO_2 from an (industrial source) for EOR or ECBM.
- Each project would be limited to receive a tax credit on 10 million tons over a ten year timeframe.
- Preference to be given to projects already involved in a DOE Regional Partnership.
- Priority will be given to projects located geographic area where CO_2 can be utilized in qualified oil and gas recovery.
- Priority will be given to a project with the existing infrastructure and capability to effectively capture, transport, and sequester CO_2.
- Tax credits would be treated as a general business credit under the Internal Revenue Code and indexed for inflation.
- The credit would be available to the taxpayer that captures, treats, compresses and physically performs or contractually ensures the injection of the CO_2.
- Allow for accelerated depreciation of CO_2 pipelines.

Need

Carbon Capture and sequestration is an expensive proposition even when done under the most favorable conditions. We estimate the cost of carbon capture of $30-50 dollars a ton, and from $15-30 dollars a ton to transport it to potential EOR sites. Assuming a utility can sell the CO_2 to an oil field operator for EOR or ECBM for $20-35/ton, the $15 tax credit described above would significantly reduce the net cost of carbon capture to the utility.

Benefits

By limiting the cost of carbon capture, the technology can be more readily deployed. The added benefit of using the CO_2 for EOR or ECBM would result in greater energy independence by using a domestic resource to enhance productivity of domestic oil and natural gas resources.

Cost

Over 10-years the cost of this tax credit would be $150 million per project, for a total cost of $450 million. This cost would be eliminated or substantially reduced through the taxes resulting from the increased production, refining and ultimate sale of oil and gas products.

Senator DORGAN. Mr. Loop, what prevents you from moving now? Is it that it is not commercially feasible to do so without incentives and tax credits and loan guarantees and so on?

Mr. LOOP. That is correct. In the best case, we would lose $10 a ton, and in the worst case, we might lose $60 a ton. So that is a huge risk, and so we would be looking for participation to help share that risk and to share all the data with.

Senator DORGAN. Assume there is no—excuse me, assume there is no participation by any other interest and legislation comes along that says you must do this in order to use coal, then you do it and you pass the costs along to the consumers. I assume those are very significant costs at that point.

Mr. LOOP. They could be. It is at $10 to $60 a ton, and so that is right.

Senator DORGAN. I mean, you say in your testimony, in a nutshell, the cost to capture and transfer carbon ranges from hopeless, to maybe it might work.

Mr. LOOP. That is correct.

Senator DORGAN. That is not a very positive outlook.

[Laughter.]

Senator DORGAN. Do you have anything more positive to say than hopeless or maybe it might work?

Mr. LOOP. Maybe it might work, is out there. We feel very strongly. If we cannot build a great big FutureGen, then start taking some of these projects in various parts of the country, build them. Let us find out what it is going to cost and see if this is even a viable answer, or do we have to look for the longer range. Do we have to grow algae? What is the answer? Because we can pass laws, but if it does not work, it is not going to do any good.

Senator DORGAN. Right.

As I understand it, it is much easier to capture the carbon in your gasification plant than it is in a coal-fired electric generating plant because it is a different process.

But I am trying to condense what I have heard from this panel. It is how we capture it, and I guess, to some extent, we kind of know how to capture it. The question is what it costs? What do we do with it once we capture it? Then other questions that people have not really thought much beyond that—I think this discussion in many ways revolves around a question of how do we capture it, what do we do with it.

But the other issue is who owns it? Who is responsible for storing it? How long does that responsibility exist? How long will someone guarantee custody? Is it to be treated as a commodity or a pollutant? All of these are central to the question of even embarking on a project to capture and sequester or store or use. Right?

Ms. TABOR. That is right.

Senator DORGAN. So, Ms. Tabor, tell me what the consequences are you alluded to them but did not describe it, of how CO_2 is classified as either a pollutant or a commodity. What are the consequences of each?

Ms. TABOR. I think the biggest concern for the industry is classifying CO_2 as a hazardous waste implies that there are much more stringent regulations that are going to be required. I think if you look at the rules that were passed by the—or that are proposed by the State of Washington, they say that they are going to use less restrictive well classification under the UIC. But, in fact, they are actually using many of the requirements from a class 1, which is a hazardous waste type structure.

I think what John Harju mentioned, and from the—are suggesting that if you put it in the right geology and remain—on the same type of regulation—and that's part of the issue. Automatically asserting as a hazardous waste implies much more stringency, and actually, I think, raises concerns with the industry and things like super——

I think the other thing that comes up, there is some case law that suggests that you could actually have trespassed or some sort of issues, legal bases, when you define something as hazardous waste. The Circuit has a case that actually suggested that it was impossible cause of action. So again, you know there are unintended consequences of in any way of implying that this is a hazardous waste.

The commodity angle is pretty simple. It is, in fact, a commodity, for EOR in particular. We just really strongly urge that we leave it that way because right now, EOR is our beneficial use, and it is our way to provide an option for industry to be able to move forward.

Senator DORGAN. If we had held this hearing 10 years ago in this room, much of the discussion would be to deny that there is going to be a need to capture carbon because to do so would be not achievable. It would be sort of a "pie in the sky" idea that is way out of bounds in terms of cost. But now that we are at a point where because of climate change and other issues, we are going to have to find a way to do these things.

So, Mr. Criswell and Mr. Spangler and Mr. Harju, you are all involved in these PCOR partnerships. I am curious whether we can see down the road very far. Is this an area of technology that might well be like other areas? I mean, would you have guessed 15 years ago that the Internet was going to exist as it exists today? Would you have guessed 15 years ago, when you were carrying around a cell phone the size of a shoe box, that at some point it will slip into your pocket and you will forget it is there?

I mean, technology has just dramatically moved forward in ways that none of us predicted. Can the same hold true if we really put our shoulders to the wheel here and put a lot of resources and do a lot of work in research? Can the same hold true with respect to capturing carbon and building these plants as zero-emission plants? Are you optimistic about that, or are you, to quote a word I heard a while back from another witness, "hopeless"? Although to be fair to Mr. Loop, he said "hopeless" or "maybe it will work."

I am actually focusing on the "maybe it will work" approach, Mr. Loop.

But tell me your assessment of all of this.

Mr. CRISWELL. Sure, I will start on that. I guess I would consider myself cautiously optimistic. I have a lot of faith in what the United States can do with the people we have, the knowledge we have, and the technologies we can develop. There has been a lot of discussion about the amine and the ammonia processes and then ground sequestration. I am not sure that is the best approach. Recently we have been involved with some people that are looking at some things. We have talked with algae people that you talked about, and I think the way to go is to look at a beneficial use out of this whole process.

Recently I was at an EERC's facility in Grand Forks here in North Dakota where an individual was testing a product to remove CO_2. It looked very promising. The results were very promising at that scale. The next step then is we develop that, we research it, and can we apply it commercially at these plants?

One of the bigger challenges I see is the magnitude of the material we are talking about. Anytime you burn a ton of coal, you are going to get about a ton of CO_2 produced. So you can imagine the large facilities like at Colstrip, where we burn close to 10 million tons of coal a year, that is a lot of CO_2 we got to handle. So scaling it up to commercial will be a challenge, but I am optimistic that we can get there. We need to encourage the research and push that to get it developed.

Senator DORGAN. Dr. Spangler, are you optimistic?

Mr. SPANGLER. Yes, I am, again, somewhat cautiously. The scale-up problem is challenging. I think we know enough about geology to say that there is a pretty high likelihood that we can find places where we can sequester safely. In terms of vicinity to the point sources of emission, cost of transportation, those are all issues.

I do not think you are going to get necessarily a breakthrough technology on the sequestration end. I think the bigger challenge is to capture that or for things that can be done or there may be breakthroughs that can dramatically reduce the price of the capture, and there's a variety of technologies that have been looked at this small scale. The other issue there is can we scale them up to the types of operations that you have coal-fired power plants.

Senator DORGAN. Mr. Harju.

Mr. HARJU. I am probably, even slightly more optimistic than my counterparts. If you look at the technologies that are, for the most part, being contemplated for commercial scale or just south of commercial scale demonstration today, what there are is incremental improvements to technology that has been used to remove CO_2 from natural gas for about a half century, a very different application, but again, very much a proven technology in that prior application. No optimization really has been done today to adopt those technologies for post-combustion capture of CO_2.

I think that a solid set of incentives toward industries that are ready to step out and make—take major risks in the hope that incrementally, and maybe even monumentally improve these technologies is sensible. Of course, I think continuing robust investments in the R&D, if they continue to move that along, are prudent as well.

Senator DORGAN. Mr. Loop, my understanding is that you are actually capturing about 50 percent of the CO_2 from that plant, and then selling that. Is that correct?

Mr. LOOP. That is correct.

Senator DORGAN. Are there substantial additional costs to capture more than the 50 percent? Do the costs increase as the percentage increases?

Mr. LOOP. Yes. Part of the CO_2 coming out of our facility is coming from the ammonia plant. But we are actually now investigating the economics of capturing that and taking advantage of the EOR opportunities and the fact that we already have a pipeline. So we are looking for economic ways to capture even more.

Senator DORGAN. Senator Tester.

Senator TESTER. Yes, thank you.

We will continue with you, Mr. Loop. You said in 2000 you started pumping up to Canada for enhanced oil recovery. Who built that pipeline? Who paid for it?

Mr. LOOP. We did. The DGC paid for it.

Senator TESTER. What did it run a mile at that point?

Mr. LOOP. Probably the lower half a million dollars a mile.

Senator TESTER. OK. The CO_2 you are pumping out for oil recovery, are there pollutants in it?

Mr. LOOP. There is H_2S in it, less than about, what, 1.2 percent, I believe.

Senator TESTER. OK.

Mr. LOOP. That is the only one that I am aware of.

Senator TESTER. Alright. If you could pass the mike down to Mr. Harju and Mr. Spangler.

I have a couple questions for both of you.

I think in order to solve this problem, we need a public/private partnership, which is what both of your partnerships, sort of—partnerships, I guess. The question I had is I ask the DOE what kind of cost share they—what kind of support they got from the private sector. They said about 60/40. Is that pretty equivalent to what you are receiving?

Mr. HARJU. Our phase 3 project, which was recently awarded last fall, was funded at greater than 50 percent by the private sector.

Senator TESTER. Is that set to go through the other phase?

Mr. HARJU. I think it—ours has ramped up toward that, but we have been well beyond minimum cost share standards throughout the effort.

Senator TESTER. Good.

Lee Spangler.

Mr. SPANGLER. Comparable. We are probably more at the 30 percent level.

Senator TESTER. OK. Throughout the panel here, I have heard several folks—I will just direct it at you, Mr. Spangler, and you, Mr. Harju—about storage. Kind of like we know that if you put it there, it is going to stay there. Did I get a wrong impression here, or is that what you guys have found through your research? Has your research focused on it at all?

Mr. SPANGLER. That is one of the primary goals of the research, to ensure that it stays where you plan to have it. That comes through careful characterization of the geology. There is a variety of trapping mechanisms to ensure it can stay underground and in the formation you place it in. But you do need to do the proper characterization. You need to ensure there is a quality cap rock that will not let it penetrate. So, yes, that is a major goal.

Mr. HARJU. I would certainly echo Lee's comments. Effectively, what you can say, at least in this region and I think in most regions, nature has very much pre-selected good geologic sinks for us. We now know a tremendous amount about existing oil and gas reservoirs and their ability to confine fluids for hundreds of millions of years. That we know.

There are other formations in, and you have heard the term "saline aquifer" which has incredible potential, but about which we know comparatively little about what kind of permanence we can expect from those types of geologic sinks. Therein is a key element of research that really needs to be done. I think that the partnership's program has done a monumental job of starting to advance that understanding.

Senator TESTER. So you are working with the saline aquifers?

Mr. HARJU. Yes. We have two phase 3 test anticipated or are at various stages implementation right now. One of which is on the order of a million tons a year into an existing oil and gas reservoir. The other of which is, will be considerably more—to than that into a saline reservoir.

Senator TESTER. Did you have a further comment, Lee?

Mr. SPANGLER. Yes. Also within our region and within Montana and Wyoming in particular, there is a number of domal structures that have naturally occurring CO_2 in them, and there is a significant additional capacity within those structures. Those, of course, you have a high degree of confidence because the CO_2 is already contained there and has been for millions of years.

Senator TESTER. What is your take on the pollutant issue of CO_2?

Mr. SPANGLER. In terms of classification of CO_2 itself?

Senator TESTER. Yes.

Mr. SPANGLER. If it were classified as a hazardous waste, I imagine it would be about the only one you could by food quality. So to me that is not necessarily a sensible route.

Senator TESTER. You can pass it or keep it to either John. One of your focuses, you said, was storage? What are your other focuses? If you have any other focuses, what are they? Go ahead.

Mr. HARJU. I think that the capture is—our greatest opportunity to really advance CCS technology is by ratcheting down the cost of capture. There is very significant opportunity therein, and I think investments on the part of the Federal Government toward that end are essential.

Senator TESTER. OK. Go ahead, Gordon. Thank you very much.

Gordon, if I heard you correctly, you talked about another entity you were working with that is doing some work on carbon capture or sequestration or transport, or one of those. How long has that been going on and what are your results? Has it been positive? Yes, go ahead.

Mr. CRISWELL. It has been very recent, it was in the last month or so that I was out at the EERC. It was an individual who was trying to develop carbon capture technology, on his own, he has got experience in the cement industry and he has found a byproduct of the cement industry that appears to be able to capture CO_2 gas from power plants using some similar to a wet-scrubbing process that we currently have at Colstrip. So, of course, we were very interested.

We signed a confidentiality agreement with him because of his initial stages, and you can imagine that he does not want a lot of that information to get out. But initial results of that testing at EERC were very promising. Of course, we did not determine a lot of materials needed. It was more a first research step to say, does this process truly capture CO_2, and it appears that it does.

So, we are interested in it from the standpoint that it may allow us to use existing equipment or expand on that existing equipment.

As far as beneficial use goes, there may be some opportunities with that in this cement industry, but a lot of more work needs to be done on that. So, it's just real recent work.

Senator TESTER. You are in partnership—but I know for a fact in Colstrip with many, many different companies. Each owns a partial part of it. With that business structure, how do you see the advent of carbon capture happening?

Let me get right to the point. Do you think it will happen without regulation?

Mr. CRISWELL. I don't believe it will happen in regulation. That is my personal opinion. The other owners at the Colstrip facility

are very proactive, and they are encouraging that Colstrip look at research work and potentially, possibly use Colstrip as a demonstration project. So we are evaluating a couple of research efforts that are underway. One is with EPRI, the Electric Power Research Institute has some carbon capture work they got going on. Just today the EERC has a—they have identified a proposal to evaluate carbon capture technologies. The owners of the Colstrip facility are encouraging that we participate among them.

Senator TESTER. Good. I would hope that you would do it without regulation, but I have heard that before. I appreciate your honesty.

Mr. CRISWELL. I am being honest with you.

Senator TESTER. Yes, I appreciate your honesty.

Sandi, real quick. At the beginning of your comments, you talked about working group outside—you talked about a working group. And I guess my question is, is it outside the seven partnerships or is it with——

Ms. TABOR. Yes. The workgroup that I'm referring to actually was formed as a result of some issues that we raised when the State of North Dakota proposed some CO_2 regulations. We raised some concerns that were pretty legal in nature. As a result of that, the Oil and Gas Division of the North Dakota Industrial Commission pulled the rules and just said why do we not get a group together and work on this and come up with some answers.

Senator TESTER. It is a little different than Mr. Criswell's association with the cement folks, but do you share your information? Do you share it with the partnership?

Ms. TABOR. Oh, sure. In fact, the lignite counsel in the industry, Lignite Industry in North Dakota and Minnesota, are power plants, were all members of PCOR.

Senator TESTER. Good.

Ms. TABOR. We also have a State/industry partnership that funnels money into research and development called the Lignite Vision 21 program. So we are pretty involved in helping.

Senator TESTER. OK. You talked pretty extensively about an answer in your statements, and I agree with you it is beneficial use for CO_2. Is your group, or the working group you are with, or anybody who you know of—or maybe this a question that goes to the sequestration groups too. Are they doing any monitoring to make sure it stays down?

Ms. TABOR. I think that's best left to Lee and John to talk about, but my understanding is yes, they are. Of course, many of the proposed regulations monitoring this is pretty much a given.

Senator TESTER. Pass it down. Thank you very much.

Mr. LOOP. In the pilot project—Dakota Gasification setting the two up together to form it is being heavily monitored. In some past commercial operations it was not necessarily.

Senator TESTER. What are the findings that were monitored?

Mr. LOOP. So far it stays——

Senator TESTER. How long has it been——

Mr. LOOP. I am not sure how long the project has been going on.

Mr. LOOP. Commercial operations in—rock in Texas have been going on for 35 years.

Senator TESTER. OK. That is the all the questions I have. I just want to express my appreciation to the previous panel, too, for

those folks that are here and to you guys. I really appreciate the information; appreciate your taking time out of your busy schedule to come today. Thank you.

Senator DORGAN. Senator Tester, thank you very much.

I did not introduce the staff of the Energy and Natural Resources Committee. They are here because the committee is taking a really hard look and close look at what we need to do, what kind of legislation, what kind of initiatives we need to be involved in with respect to this issue of sequestration and capture.

Allison Anderson is with the professional staff of ENR, and Frank Macchiarola from the EC staff director on the minority side. Collin Hayes is with the professional staff of ENR. Rosemarie Calabro, a staff assistant, and Matt Jennings is with Senator Tester's office. Franz Wikinstober is with my office and also works on the Appropriations Subcommittee on Energy and Water.

I want to conclude. First of all, I want to thank this panel. I want to say that in many ways, I think that all these inquiries that are going on by fascinating, interested researchers, some in the PCOR projects, some in research laboratories, some just out on their own, I am hopeful that they will find new ways, new approaches and unlock the mystery of how they solve this in a way that captures carbon, stores, sequesters, or uses it and protects our environment and allows us to continue to use coal. I mean, that is the goal here.

I was thinking, Senator Tester, as I was sitting here. One day I was in Valley City, North Dakota, and a young man came into this place I was. He was wearing Levis and a T-shirt, kind of tussled hair, and he had just driven—he was a North Dakota kid from Valley City—just driven here from California.

He was breathless to tell me about it because he was working in California—probably a 22-year-old guy—working in California on renewable energy. He said I went out there to work on renewable energy. He said I am working on different fuels for vehicles, and I just drove my pickup truck from California back home to Valley City on vegetable oil. He was just breathless about it.

So I said, well, how did it go? He said, well, it worked really well until I got into Montana. It is a true story. I said, what happened? He said, then it got too cold and the viscosity of the vegetable oil just would not work in Montana.

But my point about that, I think there are people like that all over this country who are really interested in solving problems and trying to think through what is the new idea here. We have not really put this up on the board to say, we need the new ideas. we need the new technology; we need to really push to unlock the mystery here of how we capture CO_2, how we sequester and use it.

I think finally the entire country is saying we are going to need to use coal. Fifty percent of all this light and electricity comes from coal. We need to use it. So we need to find a way to use it and protect our environment.

That is the purpose of this hearing. It is the purpose of a number of hearings we have had and will continue to have in the Senate Energy Committee.

As I have indicated previously, it looks like in June we will have climate change legislation, the Warner-Lieberman bill, on the floor

of the Senate. It is very important that we have targets and timetables that have some ability to match as we move forward. We are going to protect this country's environment, but we are also going to find the ways to continue to use our resources in a way that is very responsible.

So I want to thank everyone who came to this hearing, and we will keep open the ability for anyone who wishes to submit additional views or testimony. For those who wish to submit testimony who have not been part of this hearing, you are welcome to do that for 2 weeks after the end of this hearing, and we will include that as part of the permanent record of the hearing.

This hearing is adjourned.

[Whereupon, at 12:17 p.m., the hearing was adjourned.]

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

RESPONSES OF SCOTT M. KLARA TO QUESTIONS FROM SENATORS DORGAN, TESTER, AND BINGAMAN

TECHNOLOGY DEVELOPMENT & INTERAGENCY COORDINATION

Question 1. Previously, the DOE's primarily laboratory, the National Energy Technology Laboratory (NETL), has produced an annual technology roadmap for deployment of carbon sequestration technologies. There is concern from several members of the Senate Energy Committee, including Chairman Bingaman, that there is not enough coordination between the Administrative agencies with respect to carbon capture and storage related issues—including technology deployment, regulatory development, management of facilities on public lands, and more. Rapid deployment of CCS will require a coordinated interagency effort if this is to be deployed in an efficient, cost-effective manner.

When do you expect to finish the next technology roadmap?

Answer. The next technology roadmap is schedule to be released in September 2008.

Question 2. Will this lake into account the R&D efforts being conducted by the Office of Science at DOE?

Answer. The Offices of Fossil Energy (FE) and Science (SC) are collaborating on many fronts to intearate our research and resources. Both oreanizations have worked to facilitate researchers on the large-scale field projects to work with the investigators from SC to collect information and conduct complementary tests that would help to answer fundamental questions about the behavior of CO_2 in the deep subsurface. FE and SC are jointly developing a peer-reviewed plan to be completed this spring that will identify the scientific and engineering test parameters to guide design and selection of large-scale tests. Items to be addressed include: rate of injection, duration of injection, and number and phasing of tests.

The National Energy Technology (NETL) Sequestration Roadmap does not currently include the research and development efforts of SC because the Roadmap's purpose is to describe the "applied" research efforts that are funded by the FE to support the commercialization of carbon capture and storage (CCS) technologies. That said, "basic" research needs will continue to be identified by SC and supported in separate documentation. These basic research areas are very useful in augmenting the science, and although they arc not on a critical pathway to the development of CCS as a commercial technology, they can help inform and improve applied R&D. The field projects conducted in the FE program are open to any researcher that would like to participate so that maximum scientific and applied experience can be achieved by these tests.

Question 3. Has there been any discussion about trying to make a bigger roadmap for CCS deployment that would be expanded beyond just the elements of technology deployment such as timelines for the rulemaking process, proposed rulemaking for public lands, and so on?

Answer. The DOE is coordinating with other agencies on several aspects of its carbon sequestration program. This coordination is expected to increase in the corning months and years, as the research program moves forward with larger-scale experiments. The DOE's Office of Fossil Energy and EPA's Office of Air and Radiation and the Office of Water have been engaged over the past several years in regular staff and upper management briefings where information is shared on the field research and the regulatory development process. DOE has also been invited by EPA to participate in its interagency working group on the development of the draft underground injection control regulations for CO_2 storage wells. The resulting proposed rule is scheduled for release this summer. DOE has also worked with the USGS on the development of the capacity methodology for sequestration sinks. DOE

and the Bureau of Land Management have been working together over the past several months on the development of field projects through our Regional Carbon Sequestration Partnerships in several western states, including Utah. Moreover, the Climate Change Technology Program, led by DOE, has an interagency working group on carbon capture and storage technology development and deployment that is looking at some of these integrative issues.

Question 4. For example, could it interface with the proposed rulemaking being conducted by the EPA for the Underground Injection Control (UIC) Program (as highlighted in Ms. Lovelace's testimony) or the efforts underway by the Interior Department that Mr. Spisak highlighted?

Answer. The Department of Energy (DOE) has been and will continue to be engaged with other agencies and groups in moving carbon capture and storage (CCS) forward towards commercialization. DOE's Office of Fossil Energy and the Environmental Protection Agency's (EPA) Office of Air and Radiation and the Office of Water have effectively worked together over the past several years in sharing information and results of DOE'S field tests. The results of the collaborative effort resulted in EPA issuing guidance in March 2007, on permitting field projects of DOE as Class V experimental wells. EPA and DOE continue to meet regularly at both the staff and management level to discuss field results and the ongoing regulatory process. DOE has been requested by EPA to participate in the interagency working group on the development of the draft underground injection control UIC regulations for CO_2 storage wells. DOE has also engaged the U.S. Geological Survey on the development of the capacity methodology for sequestration sinks, and we anticipate increased involvement over time. DOE and the Bureau of Land Management have been working together over the past several months on the development of field projects through our Regional Carbon Sequestration Partnerships in several western states.

RESPONSES OF BONNIE LOVELACE TO QUESTIONS FROM SENATORS DORGAN, TESTER, AND BINGAMAN

RELATED TO EPA'S UNDERGROUND INJECTION CONTROL (UIC) REGULATIONS

Question 1. Is there a good working relationship between the federal government and state EPA (or EPA-like) offices? Are the feds and states taking the right steps to provide clarity, direction, and appropriate regulation to industry or is it confusion?

Answer. The issue of working relationships is generally very EPA Region-specific. At the general working level, relationships tend to be open and functional; at the policy level, working relationships often go awry, sometimes by specific issue. There is a lack of coordination between headquarters and the regions, with regions often developing their own initiatives and expectations contrary to commitments from headquarters. Most EPA offices and states have developed an understanding of their respective roles and authorities and have figured out when consultation between the offices is needed. As to whether or not the federal personnel and state personnel are taking the right steps to provide clarity, direction, and appropriate regulation to industry, the answer is a mixed bag. Some states are moving forward with independent regulation of CO_2 geosequestration prior to implementation of a federal standard under the UIC program. In such cases it is possible and quite likely that adjustments to promulgated state regulation will have to be made once EPA has finalized its regulations. In other places, legislatures have enacted enabling legislation but the states have not yet begun the process of regulatory development. I believe the EPA is taking the rights steps at this time to provide clear guidance to states regarding how CO_2 geosequestration will be regulated under the UIC program. What is not clear is how the program will be delegated to the states. At present it appears EPA will designate CO_2 geosequestration wells (other than EOR wells) under a new well class (Class VI). Under the current 1422 delegation process states would still have to take Class I, III, IV and V well programs along with a new Class VI geosequestration well class. This could create serious problems as some states would have already chosen not to accept the other well classes. In this regard EPA could consider splitting out the Class VI program from the other well classes for the purpose of delegation. If this occurs it will be much easier for states to make a decision regarding primacy. The key is whether or not EPA would consider such a partial primacy delegation a precedent that would bleed over into the other well classes prompting states to seek primacy for other individual well classes. If they do, it is unlikely they would delegate the Class VI program separately to avoid this possibility.

Question 2. In your written testimony, you state that the EPA's proposed UIC rulemaking "needs to be rapid and separate from the historically slow processes." In your opinion, do you think the current timeline they are on is sufficient for rapid CCS deployment?

Answer. EPA rulemaking has been notoriously slow for other subjects, so their timetable for developing draft regulations for carbon sequestration is amazingly swift. Although they have given themselves quite a bit of time to finalize the regulation after initial publication, they are scheduled to have a draft published in the federal register around July, 2008. Inasmuch as they did not begin actual regulatory development until the beginning of 2008 this is much faster than their normal rule making process. Whether or not it is sufficient for rapid CCS deployment will depend on many things including the following:

- When will the financial mechanisms be in place to make geosequestration a paying proposition?
- How quickly can EPA regions and state agencies gear up to implement the process?
- Will EOR absorb the brunt of the first larger scale projects or will pure geosequestration in deep saline reservoirs be first because they are generally better positioned geographically with respect to power plants? If deep saline implementation is delayed and EOR is handled by the oil and gas agencies this may delay full implementation in saline zones.
- Will the global climate change issue become a less pressing concern, putting geosequestration on the back burner?
- Will the public accept geosequestration from both an environmental and personal cost perspective and if not, will there be a program at all?

Additionally, while the EPA rules are being drafted quickly, many questions remain about the delegation process. Delegation processes have typically been slow and that remains a major concern. During the delegation process, EPA and states need to define any functional EPA veto power. This usually takes the form of an item in the delegation that is kept by EPA for approval. In UIC such an item is an aquifer exemption that takes a long time for EPA to approve. "Add-ons" like this simply add time to processes. A system that involves oversight by EPA rather than separate approvals would allow more rapid deployment.

Question 3a. You presented a rather lengthy laundry list of regulatory shortcomings related to CCS. Among them, you mention the identification of injected substances, site characterization, requirements for well construction, CO_2 monitoring, and more.

Do you feel that the current EPA rulemaking efforts will address most of these shortcomings?

Answer. EPA has not released any early drafts for consideration. However, regulatory concepts have been shared. I expect the EPA regulatory language to be sufficient to implement an actual UIC program for geosequestration. This is necessary because the EPA regions will have to implement the program itself for direct implementation states so the language has to address all of the technical aspects of a program. It should be noted, however, that some of the issues raised, such as safety, do not fall within the purview of the UIC program. For these issues other regulatory authorities may come into play (OSHA etc . . .)

Question 3b. Do you think they are the appropriate agency for developing regulations in all of the areas you mentioned?

Answer. The arguments over whether or not EPA is the right agency to develop regulations for geosequestration is somewhat moot because the Energy Policy Act of 2007 identified underground injection of carbon dioxide as an activity governed by the Safe Drinking Water Act and thus the federal and state delegated UIC program. However, the issues and analyses needed to deploy CCS should be addressed by many interests with a strong role, if chosen, by states who know their terrain, geology, water, etc.

Question 3c. If not—what other agencies do you feel should become involved?

Answer. For the non-UIC aspects of regulation such as capture, transport, safety, etc . . . other federal agencies are already asserting jurisdiction. For example the Department of Transportation has jurisdiction over interstate pipelines and their regulations already deal with transport of supercritical CO_2. As far as the UIC portion of regulations only the EPA and state agencies appear to have any specific jurisdiction. The USGS and/or state geologic offices should play a significant role in site evaluation and monitoring design to be sure the sites are appropriate and can hold the CO_2 in place. The Department of Energy should play a role in verifying the practicality of energy proposals to improve the chances of success and consistency with national energy policies. As a land manager/owner, the BLM needs to

play a role in land use decisions affecting federal land. Because federal actions are likely, a coordinated approach to the National Environmental Policy Act could be a part of the process, whether or not states like Montana with parallel statutes are involved.

Question 4a. It is apparent that the EPA UIC program is chronically underfunded and understaffed. In a recent study conducted by the Argonne National Laboratory, they reviewed questionnaires from many state and regional EPA offices who indicated that the current UIC program is not funded at a level to support the people that will be needed to oversee and implement the program. Essentially, those offices are enforcing the UIC guidelines on a bootstrap budget.

Does your office have the same issues with funding and staffing?

Answer. Yes. The Argonne study mentioned above may be the one GWPC commissioned and states are well aware of the funding shortfalls that would occur if a robust CO_2 geosequestration process were to be implemented nationwide. Frankly, states believe it is not likely that the necessary increases in federal funds for the UIC program will be forthcoming. Today, the entire program for all states is about $10 million. States like Montana have implemented fee programs to pay up to about two-thirds the cost of the Class II program. Many states are looking towards individual fee structures as the preferred funding mechanism for a state geosequestration program. To develop a program from scratch would require program development grants as there is no one to charge fees to until sequestration has begun.

Question 4b. Do you feel that you have the training, expertise, and funding at the present time to adequately implement the existing UIC program?

Answer. No. There are many technical factors associated with deployment of CCS that will require analysis. Few specialists are actually doing this now. There is a general consensus among those in the states and in industry that if geosequestration takes off in a big way there will likely be an insufficient amount of available geologists and engineers to hire. Consider the fact that states will be competing with private industry which can pay more than the state and this could be a major problem.

Question 4c. Do you anticipate that implementation of CCS programs will overtax your staff and budget?

Answer. Yes. Program development costs with contain common elements that will cost each state to develop, adopt and implement. Some costs will depend a great deal on how big the program becomes in each state, how rapidly it grows and what personnel and financial resources are available. Some states have expressed serious concerns about the impact a geosequestration program may have on their current staff but as yet the full measure of how resource intensive geosequestration programs will be is not known. However, given that it appears the programs will be more intensive than typical Class II well programs this is a valid concern. For states without current UIC delegation, the costs could be excessive as it is possible that all UIC classes not delegated would need to be brought on line as discussed earlier. Without an existing industry to charge any fees to, new costs are all a large risk for a state.

RESPONSES OF SANDI TABOR TO QUESTIONS FROM SENATORS DORGAN, TESTER, AND BINGAMAN

STATE CCS REGULATION DEVELOPMENT

Question 1a. There are several examples of regulatory development efforts being conducted at the state level. Your testimony highlighted several of those including those being conducted in North Dakota by the North Dakota CO_2 Storage Workgroup.

How far along is the process?

Answer. We will be reviewing draft legislation at our next meeting in April . . . we expect to have a package of statutes and regulations ready for presentation by the end of June.

Question 1b. When do you anticipate your group will have regulatory recommendations completed?

Answer. See above.

Question 1c. Are you working closely with the Interstate Oil & Gas Compact Commission (IOGCC) on these regulations?

Answer. We are using the IOGCC model rules as our guide and a gentleman involved in the IOGCC process serves on our committee.

Question 1d. As states are developing rules and guidelines for the injection and storage of CO_2, they are borrowing heavily from similar regimes from other programs such as oil and gas. Do you think that these are adequate to address the needs and characteristics of CO_2 storage?

Answer. We are looking at what other states are doing, but are also relying on advice from the ND Dept. of Health and the ND Oil and Gas Division.

Question 2a. You express concern in your testimony that CO_2 should not be treated as a waste, but instead as a commodity for fear that operational liability would be extended for several hundred years.

With that in mind, what do you (and the other members of the panel) think is an appropriate length of time for responsible long-term storage of CO_2?

Answer. We are looking for advice from the research community. The DOE's regional partnerships have invested a great deal of research collecting data and evaluating potential geologic formations. We are fortunate to have a representative from the PCO_2 project on our committee.

Question 2b. What are the legal and practical implications of treating CO_2 as a pollutant versus treating it as a commodity?

Answer. Our point is that CO_2 used in enhanced oil recovery should be considered as a commodity because it is in fact a commodity. As the gentleman from the Big Sky Partnership stated, "If you classify CO_2 as a hazardous waste, it will be the first hazardous waste used in soda pop." The practical implication is that CO_2 is not a hazardous waste but rather a necessary element in our everyday lives. Before sequestered CO_2 is classified as a hazardous waste, potential unintended consequences (or future causes of action) must be evaluated. For instance, we should consider the ramifications of existing case law suggesting that trespass by hazardous waste injection is a valid cause of action.

Question 2c. You don't discuss leakage at all—are you concerned about possible leakage from storage sites? Do potential leakage depend on the type of geology in a given geologic strata or region of the country?

Answer. We are aware that leakage may be an issue and will rely on the technical expertise of the committee members from the state regulatory agencies in conjunction with our members from the oil and gas industry and the PCO_2 R partnership to help us address monitoring programs.

Question 2d. What do you feel are appropriate "acceptable" leakage rates for long-term storage?

Answer. This is a question which is best answered by those who have an expertise in the technical aspects of what monitoring requirements are necessary.

RESPONSES OF GORDON CRISWELL TO QUESTIONS FROM SENATORS DORGAN, TESTER, AND BINGAMAN

INDUSTRY PRIORITIES AND PROJECT DEVELOPMENT

Question 1. You represent a utility that operates in Montana and several other states that are addressing these regulatory issues. In your testimony, you stress the need for regulators at the state and federal level to address the regulatory issues such as liability, transport of CO_2, landowner rights and other 'rules of the road' issues that will need to be in place for energy companies to make the necessary investment into CCS projects. We will have to consider all of these issues.

From your perspective, which of the regulatory issues (liability, landowner, right-of-way, etc) need to be addressed first that would help companies like yours begin making investments into CCS in the near-term?

Answer. The issues of liability and land-owner rights need to be addressed first. There are existing CO_2 pipelines, and right-of-ways (ROWs) have been dealt with in some states and in Canada. In order to ensure regulatory certainty, ROWs undoubtedly will have to be addressed at the federal level in the context of CCS.

The primary liability issue for CCS is ownership of the geologic reservoir pore space and ongoing liability for sequestered carbon dioxide (CO_2) that may resurface or migrate to groundwater or reservoir pore space owned by other entities. Several states have addressed this issue in different ways. Texas and Illinois assigned long-term liability for stored CO_2 to their respective states while Wyoming assigned ownership of pore space to surface rights owners. It remains unclear how Montana will address the issue, but the state indicated it may attempt to establish a bonding system similar to its mining reclamation program.

The U.S. Environmental Protection Agency (EPA) recently announced it will issue a draft rule this summer establishing a nationwide permitting program under the Safe Drinking Water Act's (SDWA) Underground Injection Control program for stor-

ing carbon dioxide from fossil fuel power plants in underground geologic formations. However, the present scope of rulemaking does not resolve industry concerns over long-term environmental liability.

Congress has a great opportunity at this time to approve a uniform approach to pore space ownership and long-term liability for sequestered CO_2. The most logical approach is to assign ownership of the pore space to surface owners; assign liability in the near term for leakage and migration to the entity responsible for pumping CO_2 into geologic reservoirs or for transporting it via pipeline; and then transfer long-term liability for leakage and migration to the states once the sequestration operation has been designated by the state to be safe after testing and monitoring. In effect, the title transfer should take place once the CO_2 is in the ground during the life plant.

Right-of-way is certainly an important issue, but it may be best addressed after national guidance has been established for long-term CO_2 storage. In Montana, an attempt to pass legislation that would have applied common carrier and eminent domain status to CO_2 pipelines failed. Many legislators recognized that CO_2 pipelines should probably be treated like other existing pipelines in the state, but also understood that CO_2 may represent a different public health and environmental hazard than petroleum resources.

Question 2. Several states and the federal government are considering these regulatory issues. From your perspective, are there certain issues regarding CCS that should be addressed at a federal level and some at a state level? If so, which issues should the federal government address and which ones should be left to states?

Answer. The federal government is certainly in the best position to handle long-term liability issues, given the uncertainty of the long-term viability of geologic reservoirs and the possibility of interstate CO_2 migration. However, the issue of ownership of the pore space is more complicated. States typically take the lead on designation of surface rights, water rights and mineral rights. However, Montana and many other states have no statutory authority or case law to assign pore space ownership. Federal guidance in this area may be well received by the states.

Transporting CO_2 via pipeline should be under the regulatory authority of the U.S. Department of Transportation—just as it is for petroleum resources. This would eliminate the problem of being subject to a variety of permitting and siting requirements by various states and municipalities. However, additional federal guidance may be necessary since the health and environmental issues associated with CO_2 are different than for petroleum.

Question 3. You state that the capture technology has not been proven to scale. At this time, does PPL have any plans to be an "early mover" in deploying CCS technology? Have you considered funding a project that could serve to prove the technology at scale?

Answer. PPL was an early participant in the FutureGen project, a public-private partnership designed to construct and operate the world's first near-zero emissions coal-fired power plant that could capture and store CO_2 at scale. PPL and its partner-owners of the Colstrip Steam Electric Station in Eastern Montana also recently agreed to fund a carbon capture research project at the Energy and Environment Research Center at the University of North Dakota. As partners in this project, we expect to be provided the latest research information about developing CO_2 capture technologies.

PROJECT LIABILITY

Question 4a. Presently, CO_2 can be used for EOR projects. Thus far, there have been no reported known leakages from oil & gas fields employing CO_2 for these projects. With three decades of experience with EOR, oilfield operators feel safe with assuming liability while the field is operating. You aren't specific as to what sort of liability you are concerned with.

Are you referring to post-closure liability and the potential for property damage?

Answer. Post-closure long-term liability is the primary issue, but the states or the federal government must also be willing to take the liability during the operating phase of the facility. Given the volume of CO_2 to be stored it is not practical for energy companies to assume this liability.

Question 4b. Or are you referring to the uncertainties around what long-term storage and 'acceptable leakage' will be defined as—should a carbon emissions trading scheme be enacted by Congress?

Answer. There are many uncertainties about long-term storage—particularly the issues of migration, resource contamination and "acceptable leakage." It will be difficult for states to develop rules on these issues without federal guidance. Without

federal guidance, it will be impossible to create the regulatory certainty and level playing field energy companies will need to invest in carbon capture and storage.

PPL supports enactment of the carbon emissions trading program described in S. 1766, the Low Carbon Economy Act introduced by Senators Bingaman and Specter. This program sets annual targets and allows sources to buy, sell and trade credits to achieve significant emissions reductions without harming the U.S. economy.

RESPONSES OF LEE SPANGLER TO QUESTIONS FROM SENATORS DORGAN, TESTER, AND BINGAMAN

PUBLIC AWARENESS AND PARTICIPATION

Question 1a. You mention the point of public acceptance and awareness. I appreciate you mentioning this point. Carbon capture and storage is very important to the continued use of coal and other fossil resources. But what does that really mean to the average person? What comes to mind for the person in the local café or those owning land above a sequestration site? If you don't fully engage and involve local communities and other interests as these projects develop, they will be severely slowed down or halted. The 'not in my back yard' mentality will flourish if we don't have this in mind as the technology develops. There are many elements to ensuring public support and engaging the public on these.

Can you go into more detail as to what you believe needs to be done in this area?

Answer. The public needs to be engaged and informed about the technology and its importance to carbon management. In my opinion, this process should draw heavily on existing experience with underground systems. There is experience with injection of large amounts of materials (e.g. wastewater) in the existing underground injection programs. These volumes compare to what sequestration would require. There is also CO_2 specific experience with EOR and with naturally occurring CO_2 reservoirs. There is also underground natural gas storage. These all indicate that buoyant fluids can be stored safely for geologically relevant periods of time. While these cases are not identical to sequestration, they do represent a very significant knowledge and experience base that we can build on. I believe we must also emphasize use of monitoring and modeling of the CO_2 behavior to ensure public safety. If "living models" are developed, simulations that are updated as new monitoring data becomes available, the simulations can be dramatically improved as the sequestration site is being used resulting in a continual improvement of the predictive capability of the models. Finally, we have to have mitigation strategies planned for potential problems. How this is presented to the public is critical, we must let them know that for properly designed projects, no mitigation is needed or expected to be needed, but that we are being comprehensive in our approach and are designing extra safety precautions.

Not surprisingly, there is a great deal of misinformation regarding sequestration. As with any new technology, it will take some time to adequately educate the public about the potential opportunities and risks of geologic sequestration. Our current approach in the Big Sky Partnership as well as a concerted effort by the other DOE funded Partnerships is making substantial progress. As Congress presses for legislation to limit GHGs or to fund expanded research and development approaches for CCS, media exposure will continue to aid the Partnership's efforts to engage the public in a meaningful dialogue to weigh the risks and opportunities of CCS.

Question 1b. How are the regional partnerships carrying out public awareness and participation efforts?

Answer. All the partnerships have outreach efforts as part of the program. It should be pointed out that DOE wisely made this a requirement. Most partnerships are providing general outreach in the form of brochures, websites, newsletters and public meetings. They are also providing more extensive outreach in the communities where pilot projects are being pursued which often includes multiple stakeholder meetings, involvement of local government, etc.

Members of the regional partnerships are typically involved in publicly attended conferences, legislative or gubernatorial briefings, news programs, documentaries, and a myriad of public venues to discuss mitigation of climate change with a focus on CCS. Members of the partnerships routinely contribute to scholarly journals and professional magazines concerning research specific to CCS.

PIPELINE DEVELOPMENT AND LOGISTICAL CONCERNS

Question 2a. You also raised the concern about the increasing difficulty of permitting and building pipelines. To make major CCS projects economically, technically, and logistically operable, industry interests will need to consider where to send the

CO_2 for enhanced oil recovery (EOR) or other purposes. Some companies may be able to build a facility that has a geologic sink for the CO_2 nearby, but there may be cases when pipelines will need to be built over some distances.

Are the challenges faced by CO_2 pipelines the same as those related to oil and natural gas pipelines or are there differences for CO_2 pipeline systems?

Answer. There are differences. If there is water vapor present, this can condense and form carbonic acid which is corrosive. This can be handled by choice of pipeline materials (which can drive up costs) or by specifying allowable impurities in the CO_2 (which can affect cost of separation and capture).

Oil and gas pipelines are considered commodity pipelines or "common carriers" that fall under a variety of state and federal regulations. These pipelines are also afforded the same rights as electrical transmission lines and railroads in as much as builders of these transportation systems can employ eminent domain to secure rights-of-way when landowner resistance may preclude outright purchase of fee title or long term leasing of the property. Conversely, CO_2 pipelines have been granted status as commodity pipelines in some states and in some states the status remains unclear. Problems arise when the potential for these pipelines to cross state lines creates differing regulatory interpretations for siting and building the pipeline. Once a pipeline becomes an interstate pipeline, FERC becomes involved and the requisite NEPA compliance procedures come into play. If states classify CO_2 pipelines differently, the addition of a third party (FERC) can generate a number of regulatory hurdles for permitting and siting.

Because most of the pipelines built to date have occurred in the rural southwest or rural Rocky Mountain region, there has been no need to site these pipelines in areas with moderate or high population densities, thus reducing the amount of public resistance to the line. As CCS becomes more prevalent, particularly with fossil energy plants that are proximal to higher population densities, it is likely that public resistance will increase over HSE concerns. This is unfortunate since experience to date with CO_2 pipelines in the southwest, Wyoming, North Dakota, and internationally, has shown the risk of a leak or catastrophic failure to be nominal if at all.

Question 2b. We already have some CO_2 pipeline systems in place for EOR efforts in the Southwest so are the regional partnerships trying to draw from these experiences?

Answer. There are existing pipelines and the industry is drawing on this experience. However, from anecdotal experience, there is not agreement in terms of how low impurities should be specified. This may continue to be a problem because it probably affects which party has additional costs. Another impurity that may be produced CO_2 streams and that requires consideration because of acidity and toxicity is hydrogen sulfide gas.

Question 2c. Which states have started to address these concerns and what have they done?

Answer. In the Big Sky Partnership region, to my knowledge Wyoming is the only state with a significant pipeline expansion planned. Wyoming's legislation directs the Wyoming Oil and Gas Conservation Commission and the Wyoming Department of Environmental Quality to establish regulations concerning CCS. The Wyoming Pipeline Authority oversees pipeline permitting and construction and it is likely the regulations will be favorable to CO_2 pipeline infrastructure development. The Montana legislature recently considered legislation to grant CO_2 pipelines common carrier status and that legislation was tabled in favor of an interim committee to propose legislation in the 2010 session to adopt CCS statutory and regulatory frameworks that will promote carbon sequestration. Finally, the state of Washington passed legislation in 2007 that establishes a CCS statutory framework and regulations are currently undergoing public review prior to adoption in July. Draft regulations reviewed by our Partnership indicate that Washington will adopt standards proposed by the IOGCC for pipelines.

DEMONSTRATION PROJECT

Question 3a. The project you describe in your testimony, involving the Cimarex gas plant sounds like a very worthwhile demonstration project.

Is the plant presently being built or retrofitted w/ CO_2 capture technology?

Answer. This is a planned gas handling plant that takes a geologically naturally occurring gas and separates economic components (helium and natural gas) from CO_2 and H_2S, so in essence it does have separation and capture. It should be noted, however, that this process is different than the separation and capture process needed for power plants.

Question 3b. Is that plant on schedule for its targeted late 2008/early 2009 completion?

Answer. It is on schedule for 2009 completion.

Question 3c. Could you clarify what you mean by the "non-economic" portion of the gas?

Answer. Currently this means CO_2 and CO H_2S although Wyoming is considering treating CO_2 used for EOR purposes as a commercial commodity. Although H_2S is used to produce sulfur, there is currently a greater supply of sulfur than demand making sulfur production uneconomical at the current cost of production.

RESPONSES OF JOHN A. HARJU TO QUESTIONS FROM SENATORS DORGAN, TESTER, AND BINGAMAN

PCOR PROJECT DEVELOPMENT AND FUNDING

Question 1a. In early 2007, the DOE announced its intent to award funds through the Office of Fossil Energy at DOE for the Phase III Regional Partnerships. However, those funds languished until September of 2007 because internal reviews that the Office of Science demanded for the program. I had to push the Secretary of Energy to get those funds released, and one of the competitive awards for $67 million went to the PCOR Partnership.

In your mind, have the internal issues within DOE been resolved?

Answer. We cannot be sure if internal DOE issues have been resolved. In fact, it is my understanding that three of the seven Regional Partnerships have still not received their Phase III funding. This would indicate that there are still internal issues that remain unresolved.

Question 1b. Have you been able to move forward with your work in Phase III or do you still have to respond to additional DOE requirements from the Office of Science?

Answer. While we have been able to move forward with our work, we do spend considerable time responding to various questionnaires and review meetings. These activities seem to involve DOE's Office of Science to a much larger degree than any experienced over the courses of Phases I and II. It also seems that the Office of Management and Budget has an inordinate level of oversight and input as well.

Question 1c. What is the working relationship like with DOE?

Answer. The working relationship with DOE's National Energy Technology Laboratory (NETL) and Office of Fossil Energy (FE) staff has been very good over the entire course of the PCOR Partnership's activities. Any perturbations seem to be much more recent and do not seem to have originated from within NETL or FE.

IMPLICATIONS FOR EOR OPERATORS

Question 1d. There are some clear implications for Wyoming EOR operators in the legislation recently passed into law by the Wyoming state legislature.

What is your opinion of the legislation passed by the Wyoming State Legislature?

Answer. Overall, it rates a grade of "C." It does try to jump-start the sequestration process and give new projects some clarity for moving forward but . . . .

It creates a new and redundant organization within the state to provide oversight of CO_2 activities. CO_2 EOR projects will report to the Wyoming Oil and Gas Conservation Commission (WOGCC), while CO_2 CCS projects will report to the Wyoming Department of Environmental Quality (WDEQ). A set of skills effectively duplicative of the WOGCC will have to be created in the WDEQ. This is no small matter as those WOGCC rules are lengthy, very involved (site permitting, wellbore construction, operational requirements, transportation of injectant, reporting) and have been worked out over many decades. It can be easily shown that significant volumes of CO_2 are stored during the EOR process, and to qualify CO_2 EOR as sequestration is as simple as requiring some monitoring and reporting that is currently not part of the requirements for EOR operations.

An example herein is indicative of the complexity of the overlapping and redundant regulatory oversight: If CO_2 were injected in one interval for EOR and, in the same wellbore(s), injected into a saline formation, the CO_2 operator would be required to permit the well and project(s) with two state regulatory agencies. It is very conceivable that one agency might require activities in conflict with the other. EPA rules currently under construction for sequestration appear to be headed in that direction.

Wyoming has said that an EOR process can be converted into a storage project after EOR is complete. What happens to the CO_2 already stored? Is it disqualified? Since the storage of CO_2 is an ongoing process, credit should be allowed as the

project proceeds. But probably more importantly, the CO_2 source is not able to claim an emission offset (credit) for its captured, compressed, and stored CO_2 until some hypothetical later date. The Wyoming approach disadvantages CO_2 EOR as a storage event. It would be much simpler to require the monitoring and accounting of net storage during the EOR ongoing regulatory process and allow the company capturing the CO_2 to receive its due credit.

Question 1e. Do you think it will adversely affect EOR operators in Wyoming?

Answer. Without a doubt, it will discourage EOR if a CO_2 source needs emission offsets to finance its projects. But probably, as a more likely scenario, it will discourage next-generation coal plants in Wyoming until the complexity of sequestration rules are worked out. And this is in a state that has superposition of CO_2 EOR and coal and should be one of the best locations for next-generation coal-fueled electricity, syngas, and/or other products.

Question 1f. Would you recommend that other states follow Wyoming's lead in developing and passing this sort of legislation?

Answer. They absolutely should develop their rules for CCS. Hopefully they can tailor their particular state conditions to move forward with CCS in a timely way. We fully expect that some states with poor or no sites to qualify for CCS may choose not to develop rules. We feel strongly however, that bifurcating EOR and CCS is counterproductive.

Question 2. With your many decades of experience in EOR operations, do you feel that the CO_2 that is derived from coal facilities poses a contamination risk, as compared to the CO_2 that is mined from the ground? Are you concerned that there will be attempts to inject impure CO_2 into geologic storage sites, as Ms. Lovelace alluded to in her testimony?

Answer. We feel that this is less a technical/scientific issue than it is a regulatory issue. Any subsurface zones that we are contemplating for sequestration are not those that we would ever consider for water withdrawals. We also believe that with well-selected sites, injected CO_2 will remain within those strata, as they will have competent confining seals. We also believe that any leakage from such sites would typically be into other overlying zones that are also typified by marginal-or poor-quality water.

Question 3a. There is concern from some of the Members of the Energy Committee that if indemnification of storage sites is assumed by the states or Federal government, there may be less incentive for the CCS site operators to select a very robust storage site.

You state in your testimony that the focus of regulation should be performance criteria, not design criteria—do you feel this will lead to better site selection?

Answer. We strongly believe that this will lead to better site selection. We believe that there are extremely large capacities for the geologic storage of CO_2 in such well selected sites and that exotic well designs will simply add cost and complexity to these efforts. The further concern is that rigid design criteria incorporating such designs may create a false sense of security regarding the integrity of less appropriate geologic storage sites. Put simply, we feel that some sites will require very little in the way of monitoring, mitigation, and verification (MMV) to assure us that injected CO_2 is staying in zone, while in some other sites there is no suite of MMV technologies that can provide similar assurance.

Question 3b. Has the EERC, in its participation in the IOGCC regulatory development, considered the role of private insurers in covering liability of the storage sites following the closure of each facility?

Answer. The role of private insurers was a topic of considerable discussion and one that I believe is worthy of further consideration. In fact, there is a currently contemplated effort by IOGCC to address this and other related issues. IOGCC is currently seeking funding from DOE NETL to perform this type of work. If funded, we expect that the EERC, through its PCOR Partnership, will continue its significant involvement in this effort.

RESPONSES OF GARY G. LOOP TO QUESTIONS FROM SENATORS DORGAN, TESTER, AND BINGAMAN

INCENTIVES FOR RAPID DEPLOYMENT

Question 1a. Sending a clear signal on long-term financing incentives of these types of projects is critical for their deployment. In your testimony you refer to development of a PTC credit and something akin to an accelerated depreciation program like those offered for wind projects. Over the years, I have worked with my colleagues on the Finance Committee, including Senator Conrad to develop financial

incentives for rapid deployment for renewable such as wind through a PTC. I introduced my own ideas in a bill for a 10-year extension of a PTC. I suggested a tax credit and bond for the capture and storage of CO_2 for EOR purposes and long-term storage. The Senate Finance Committee suggested an accelerated depreciation program, but this was ultimately not passed in a tax package.

Would an accelerated depreciation program for CO_2 pipelines be helpful for companies such as Dakota Gasification in managing the high cost of infrastructure development?

Question 1b. Would tax incentives or bonds for CO_2 capture and storage be beneficial to begin the early deployment of these projects and reduce the cost exposure?

Answer. Yes to both questions. While the gasification process at the Great Plains Synfuels Plant made capture of carbon technically achievable, the compression and transportation of that CO_2 have significant capital costs. Those costs are much higher today than they were when Dakota Gasification built its pipeline and installed compressors. Accelerated depreciation would be helpful, but of limited value because if the equipment is depreciated quickly, then the company will have less depreciation in the future. This benefit is dependant on the time value of money and is of limited value.

The technological hurdles and costs of capturing carbon dioxide at an existing coal-based power plant, like Antelope Valley Station, are much higher. We need to reduce cost exposure to utilities/technology companies that are willing to demonstrate carbon capture at existing power plants. Federal incentives, like production tax incentives, would help greatly mitigate the costs and risks of carbon capture implementation. As far as early deployment, we know that today the oil industry is ready for CO_2 injection for Enhanced Oil Recovery, and would potentially purchase all we could offer. So the market exists today; we just need the technological and financial means to provide the CO_2. Bonding would be helpful, but again of limited value, more like a lower interest loan that must be pay back. In our opinion, production tax credits for CO_2 that are a permanent tax benefit would help the most to accomplish both goals.

Question 2. From a regulatory standpoint, what sort of shortfalls do you see in the existing state regulations that exist for EOR, as they could relate to 'permanent' CCS? Is your company concerned about post-closure site liability and long-term maintenance of the storage facility? Are you aware of a post-closure management plan for the Weyburn field?

Answer. Our analysis suggests that CO_2 injection for enhanced oil recovery is possible today with the rules and regulations in place in North Dakota. The state is in discussion with other states in the region to formulate regional rules and regulations that will address long-term liability, permitting, monitoring and verification protocols. Certainly these will need to be in place to address CCS in geological formations on a permanent basis.

The International Energy Agency (IEA) is monitoring the Weyburn project and issued its phase I report, "IEA GHG Weyburn CO_2 Monitoring and Storage" in 2004. This was the world's first CO_2 measuring, monitoring and verification initiative. The final stage (2005-2011) named, Weyburn-Midale CO_2 project, is building on the successes of the first phase to develop the framework necessary to implement CO_2 geological storage on a worldwide basis.

Question 3. You have experience building a CO_2 pipeline to Canada. How would you address the issue of landowner rights and other regulatory concerns?

Answer. The construction of the pipeline was generally no different than any other pipeline or transmission line for which we would need easements. We mainly deal with the surface landowner, and have built a great relationship with landowners in the region based on past projects. We respect the landowner's rights and work closely with the landowner to correct any problems. The relationship would be the same whether it is a CO_2 pipeline, water pipeline, or transmission line. We also work with residents in the area of our pipeline to advise them of the regulations governing our operation and our intent to be fully compliant with the regulations. This action shows the residents that proper steps are being taken to assure their safety.

We received a permit from the Nation Energy Board to construct the CO_2 pipeline in Canada. In North Dakota we received the necessary permits from the North Dakota Public Service Commission and other regulatory agencies. Because CO_2 is considered an asphyxiant and the high pressures involved with the pipeline, the pipeline and its operation are regulated under the US Department of Transportaion's hazardous materials regulations. The US Department of Transportation, the ND Public Service Commission and Canada's National Energy Board oversee the operation of the pipeline and enforce the regulations.

[Responses to the following questions were not received at the time the hearing went to press:]

QUESTIONS FOR TIM SPISAK FROM SENATORS DORGAN, TESTER, AND BINGAMAN

INTERAGENCY COORDINATION

Question 1. In the legislative hearing held before the full Energy Committee on January 31, 2008, in Washington, D.C., Assistant Secretary Allred testified that the Department of the Interior is interested in conducting a large-scale CCS project on public lands.

Has there been any follow up between the DOI, the DOE, or any other key federal agency in pursuing a large-scale project on public lands?

What kind of coordination is occurring among the agencies to undertake these efforts?

Question 2. In your testimony, you referred to the recently passed Energy Independence and Security Act of 2007 and the provisions related to conducting CCS and public lands. The EISA requires the DOI to submit a report containing a recommended policy framework for CCS on public lands by December 2008. It is critical that we address policy shortcomings in a timely manner to expedite commercial deployment of CCS projects, which is why the short turn around time was requested.

Will less than one year be enough time to develop the policy recommendations that were requested in the EISA?

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