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**BEFORE THE**  
**ENERGY AND NATURAL RESOURCES COMMITTEE**  
**UNITED STATES SENATE**  
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Thank you, Mr. Chairman and members of the Committee. I appreciate this opportunity to provide testimony on the United States Department of Energy's (DOE's) research efforts in carbon capture and storage. The Department of Energy has not had an opportunity to fully analyze S. 1013, and therefore, cannot take a position on the bill at this time.

**INTRODUCTION**

Fossil fuel resources represent a tremendous national asset. An abundance of fossil fuels in North America has contributed to our Nation's economic prosperity. Based upon current rates of consumption, the United States probably has sufficient coal to meet its need for the next century. Making use of this domestic asset in a responsible manner will help the United States to meet its energy requirements, minimize detrimental environmental impacts, positively contribute to national security, and compete in the global marketplace.

Fossil fuels will play a critical role in our Nation's future energy strategy. By developing technologies to mitigate the release of carbon dioxide (CO<sub>2</sub>) into the atmosphere, we can continue to use our extensive domestic coal resource while reducing the impacts on climate change. Carbon capture and storage (CCS) can play a central role in fossil fuels remaining a

viable energy source for our Nation. CCS is the primary pathway DOE is pursuing to allow continued use of fossil fuels in a carbon-constrained future.

Through fossil energy funding under the American Recovery and Reinvestment Act and annual appropriations, DOE's Coal Program is working to accelerate the development and industry deployment of CCS to meet future energy needs.

The remainder of my testimony will highlight CCS activities that are underway in the Coal Program.

### **COAL PROGRAM**

DOE provides a national leadership role in the development of advanced coal technologies. DOE Office of Fossil Energy's Coal Program has returned substantial benefits to consumers and taxpayers across a broad range of innovative technologies that are now in use throughout the world. For example, DOE and the private sector responded to the challenge of dramatically reducing the emissions of particulate, sulfur, nitrogen oxide, and mercury from coal-based energy systems with the development of technologies that enable coal-based power plants to meet environmental controls and limits placed on these pollutants. These technological innovations have resulted in significant environmental benefits: reducing pollutant emissions, reducing water use, minimizing wastewater discharge, and reducing solid wastes. DOE research and demonstration capabilities are well suited to address new challenges associated with the reduction of greenhouse gas emissions as a climate change mitigation strategy.

The Coal Program – administered by DOE's Office of Fossil Energy and implemented by the National Energy Technology Laboratory – is designed to address climate concerns of coal usage by developing a portfolio of revolutionary advanced carbon capture and storage technologies that will be economically feasible for deployment by industry. In partnership with

the private sector, efforts are focused on maximizing efficiency and performance, while minimizing the costs of these new technologies. In recent years, the program has been restructured to focus on CCS. The program pursues the following two major strategies:

- 1) capturing carbon dioxide; and
- 2) storing it in geologic formations.

Capturing and storing carbon dioxide and improving the fuel-to-energy efficiency of CCS will help address pollutant emissions reduction, water usage, and carbon emissions on a per unit of electricity basis. These plans strive to achieve dramatic reductions in emissions and ensure that current and future fossil energy plants will meet all emerging requirements for a safe and secure energy future.

Coal research has resulted in important insights regarding future innovations. New engineering concepts have been developed to convert coal into gases that can be cleaned and then used to generate power or produce fuels. New approaches to clean power generation are emerging that hold promise for integration with coal-based or combined coal and biomass energy plants. Technologies for achieving CCS are stretching beyond basic research, defining pathways in which greenhouse gas emissions can be permanently diverted from the atmosphere. With these building blocks, a new breed of coal plant can be created — one that generates power and produces high-value energy with much less environmental impact. DOE's work includes a focus on high priority CCS enabling technologies, such as advanced integrated gasification combined cycle, advanced hydrogen turbines, carbon capture, and fuel cells. These research areas provide the supporting technology base for all CCS development.

## **CARBON CAPTURE & STORAGE INNOVATIONS**

As part of our Coal Program, we are addressing the key technology challenges that confront the wide-scale industrial deployment of CCS through industry/government cooperative research on cost-effective capture technologies; monitoring, verification, and accounting technologies to assess permanence of storage; permitting issues; liability issues; public outreach; and infrastructure needs. As an example, today's commercially available CCS technologies will add around 80 percent to the cost of electricity for a new pulverized coal plant, and around 35 percent to the cost of electricity for a new advanced gasification-based plant.<sup>1</sup> The program is aggressively pursuing developments to reduce these costs to less than a 10 percent increase in the cost of electricity for new gasification-based energy plants, and less than a 30 percent increase in the cost of electricity for pulverized coal energy plants.<sup>2</sup>

The existing research program has been performing CCS field tests for many years, where the seven Regional Carbon Sequestration Partnerships are drilling wells in potential storage locations and injecting small quantities of CO<sub>2</sub> to validate the potential of key storage locations throughout the country. Substantial progress has occurred in the area of monitoring, verification, and accounting of CO<sub>2</sub> storage with the development and refinement of technologies to better understand storage stability, permanence, and the characteristics of CO<sub>2</sub> migration.

Research is also focused on developing technology options that dramatically lower the cost of capturing CO<sub>2</sub> from fossil fuel energy plants. This research can be categorized into three pathways: post-combustion, pre-combustion, and oxy-combustion. Post-combustion refers to capturing CO<sub>2</sub> from the stack gas after a fuel has been combusted in air. Pre-combustion refers

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<sup>1</sup> 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.

<sup>2</sup> The goal for pulverized coal is under development.

to a process where a hydrocarbon fuel is gasified to form a synthetic mixture of hydrogen and carbon dioxide, and CO<sub>2</sub> 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, which produces a mixture of CO<sub>2</sub> and water that can easily be separated to produce pure CO<sub>2</sub>. This research is exploring a wide range of approaches: membranes; oxy-combustion concepts; solid sorbents; CO<sub>2</sub> 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, in conjunction with basic research in these areas now being conducted by the DOE's Office of Science.

A central piece of our CCS research is DOE's field test program, which is being implemented through the Regional Carbon Sequestration Partnerships. DOE's field test program reflects the geographic differences in fossil fuel use and potential storage sites across the United States and targets the use of regional approaches in addressing CCS. It encompasses field tests representative of approximately 97 percent of coal-fired and industrial CO<sub>2</sub> emissions, about 96 percent of the total U. S. land mass, and essentially all the geologic storage sites in the country that can potentially be available for carbon sequestration. The field tests are conducted through partnerships comprised of state agencies, universities, and private companies, with the goal of developing the knowledge base and infrastructure for the wide-scale deployment of CCS technologies. The Regional Partnerships represent more than 350 unique organizations in 42 States, three Native American Indian Nations, and four Canadian Provinces. It is important to note that the non-Federal cost share for the field test program is greater than 35 percent, which is a key indicator of industry and other partner interest that will lead to the success of this program.

Each partnership is focused on a specific region of the country with similar characteristics relating to CCS opportunities.

DOE is addressing key infrastructure issues related to permitting, pore space (underground reservoir) ownership, site access, liability, public outreach, and education. DOE works closely with the Environmental Protection Agency (EPA) and others in developing CCS regulation strategies, which will provide additional certainty for future CCS deployments.

Over the course of these research initiatives, DOE will jointly 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 and the U.S. Geological Survey, will serve as guidelines for a future geologic sequestration industry in their regions, and help transfer the lessons to all regional stakeholders.

#### **DEMONSTRATIONS AT COMMERCIAL -SCALE**

The success of the Coal Program will ultimately be judged by the extent to which emerging technologies are deployed in domestic and international marketplaces. Both technical and financial challenges associated with the deployment of new advanced coal technologies must be overcome in order to be capable of achieving success in the marketplace. Commercial-scale demonstrations help the industry understand and overcome start-up issues and component integration issues associated with the implementation of a new technology and systems, and gain the early learning commercial experience necessary to reduce risk and secure private financing and investment for subsequent plants.

DOE is implementing large-scale projects through the Regional Partnerships and CCS demonstrations including the most recent round of the Clean Coal Power Initiative (CCPI). The

Development Phase (Phase III) of the Regional Partnerships is focused on large-scale field tests of geologic carbon sequestration on the order of 1 million metric tons of CO<sub>2</sub> per year, and addresses the liability, regulatory, permitting, and infrastructure needs of these projects. The Partnerships have brought an enormous amount of capability and experience together to work on the challenge of infrastructure development. CCPI is primarily focused on component and subsystem testing at commercial scale to gain operational integration experience. The CCPI Round 3 solicitation specifically targets advanced coal-based systems and subsystems that capture or separate CO<sub>2</sub> for sequestration or for beneficial use, and is also open to any coal-based advanced carbon capture technologies that result in co-benefits with respect to efficiency, environmental, or economic improvements.

#### **THE AMERICAN RECOVERY AND REINVESTMENT ACT**

The American Recovery and Reinvestment Act (Recovery Act) appropriates \$3.4 billion for "Fossil Energy Research and Development." These Recovery Act funds will help fund activities targeted at expanding and accelerating the commercial deployment of CCS technology to provide a key thrust to the Coal Program to accelerate, by many years, the advances needed for future plants with CCS.

The Conference Report accompanying the Recovery Act identifies the following major initiatives that will complement and accelerate efforts in the Coal Program:

**Maintain Fossil Energy R&D Program:** \$1 billion to be used to conduct fossil energy research and development programs.

**Additional Funds for the CCPI Round 3:** \$800 million to be used to augment funding for the CCPI Round 3 competition.

**New CCS Initiative for Industrial Applications:** \$1.52 billion to be used for a competitive solicitation for a range of industrial carbon capture and energy efficiency improvement projects, including a small allocation for innovative concepts for beneficial CO<sub>2</sub> reuse.

**Expand Geologic Site Characterization:** \$50 million to be used for site characterization activities in geologic formations. DOE expects to require projects to complement and build upon the existing characterization base created by the Regional Partnerships, looking at broadening the range and extent of geologic basins that have been studied to date.

**Initiate a Geologic Sequestration Training and Research Grant Program:** \$20 million for geologic sequestration training and research grants. This program will emphasize advancing educational opportunities across a broad range of colleges and universities.

These Recovery Act investments will also be complemented by the Carbon Sequestration research efforts of the baseline Fossil Energy R&D program. In particular, the efforts of the Regional Carbon Sequestration Partnerships highlighted earlier, can be viewed as another form of federal partnership in infrastructure investment. These Partnerships efforts, spanning our Nation and parts of Canada, will aid in understanding all the critical aspects that would be needed to support wide-scale deployment of CCS technology, taking into consideration the regional differences in geology, infrastructure development needs, and industrial activity that can affect the deployment of carbon sequestration technologies. The Partnerships have also supported studies by the Interstate Oil and Gas Compact Commission (IOGCC) that have



resulted in the recent development of a model for a regulatory framework to support CCS deployment.<sup>3</sup>

Just recently, under DOE's sponsorship, the Southeast Regional Carbon Sequestration Partnership (SECARB), in partnership with the IOGCC, began a new study, to evaluate the legal and regulatory feasibility of developing a pipeline infrastructure in the U.S. specifically dedicated to the transport and storage of CO<sub>2</sub>. The primary objective of the study is to identify barriers and opportunities associated with the wide-spread construction of pipelines for the transport of CO<sub>2</sub> for the purposes of carbon sequestration, enhanced oil recovery and other commercial purposes. A CO<sub>2</sub> Pipeline Task Force<sup>4</sup> will be formed as part of this 18-month activity to leverage the combined expertise of the oil and gas community to create guidance documents that encompass regulatory, legal, environmental, and educational aspects. A particular focus will be to incorporate the federal entities having key roles in these matters such as the Federal Energy Regulatory Commission, various elements of the Department of Transportation, and the Bureau of Land Management as part of the study.

## Conclusions

In order to shift to a low-CO<sub>2</sub> emission energy future in the U.S., we must create an economically viable national CCS system. This can only occur in parallel with the development of a national set of definitive policies and incentives that encourage technology development and reward investments in and capital formation around improved carbon performance.

CCS requires a systems approach that includes not only site evaluation, characterization and selection, but must also address rules for liability throughout a project's short-, medium-,

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<sup>3</sup> Storage of Carbon Dioxide in Geologic Structures, *A Legal and Regulatory Guide for States and Provinces*, September 25, 2007

<sup>4</sup> A project "kick-off" meeting for the Task Force is expected to occur at the IOGCC Mid-Year Meeting scheduled for May 11-13, 2009 in Anchorage, Alaska and plans for a review of their final report to occur at the IOGCC Mid-Year Meeting scheduled for May 23-25, 2010 in Lexington, Kentucky.

and long-term life. Nation-wide industrial CCS deployment will also require an infrastructure for CO<sub>2</sub> transportation and storage and the development of an agreed upon set of measurement, validation and accounting standards, practices, and procedures. Finally, whatever structure is created must encompass the input of a broad range of stakeholders in the decision process on proposed projects (developers, regulators, financiers, insurers, project operators, policymakers, and the affected public).

Today, nearly three out of every four coal-burning power plants in this country are equipped with technologies that can trace their roots back to the Department's Coal Program. These efforts helped accelerate production of cost-effective compliance options to address legacy environmental issues associated with coal use. Clean coal and CCS technologies will likely play a critical role in mitigating CO<sub>2</sub> emissions under potential future carbon stabilization scenarios. DOE's program is ensuring that enabling technologies will be available. The United States must continue to show leadership in technology development and future deployment to bring economic rewards and new business opportunities both here and abroad.

I applaud the efforts of this Committee and its Members for taking a leadership role in addressing these timely and significant issues. I would be happy to respond to any questions members of the committee may have.