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**Committee on Energy and Natural Resources  
United States Senate  
Carbon Capture and Sequestration Legislation,  
S. 1856, S. 1134, and other Draft Legislative Text**

**April 20, 2010**

Thank you Mr. Chairman and members of the Committee. I appreciate this opportunity to meet with you this morning to discuss carbon capture and storage (CCS) legislation before the Committee.

While this hearing is focused specifically on S. 1856, a bill to amend the Energy Policy Act of 2005 to clarify policies regarding ownership of pore space, introduced by Sen. John Barrasso (R-WY); S.1134, the Responsible Use of Coal Act of 2009, introduced by Senator Robert Casey (D-PA); and CCS legislative text drafted by Senators John D. Rockefeller (D-WV) and George V. Voinovich (D-OH), I would like to take this opportunity to provide an overview of the United States Department of Energy (DOE), Office of Fossil Energy's Clean Coal Research Program and how our Research, Development and Demonstration Program is directly relevant to the legislation being discussed at this hearing.

**Interagency Task Force on Carbon Capture and Storage**

Before I discuss the Office of Fossil Energy's Clean Coal Research Program, I would like to briefly mention the recently announced White House Task Force on Carbon Capture and Storage. On February 3, 2010, President Obama issued a Presidential Memorandum titled "A Comprehensive Federal Strategy on Carbon Capture and Storage." This memorandum establishes an Interagency Task Force on Carbon Capture and Storage, consisting of fourteen Executive Departments and Federal Agencies, which are tasked with developing a comprehensive and coordinated Federal strategy to speed the commercial development and deployment of clean coal technologies. The co-chairs of the Task Force are DOE and the Environmental Protection Agency (EPA).

The Task Force is charged with proposing a plan to overcome the barriers to the widespread, cost-effective deployment of CCS within 10 years, with a goal of bringing 5 to 10 commercial demonstration projects online by 2016. Ultimately comprehensive energy and climate legislation that puts a cap on carbon will provide the largest incentive for CCS because it will create stable, long-term, market-based incentives to channel private investment in low-carbon technologies. The Task Force plan will explore incentives for commercial CCS adoption and address any financial, economic, technological, legal, institutional, social, or other barriers to deployment. The Task Force will consider how best to coordinate existing administrative authorities and programs, including those that build international collaboration on CCS, as well as identify areas where additional administrative authority may be necessary. The co-chairs

will report progress periodically to the President through the Chair of the Council on Environmental Quality.

As the Department's delegate and co-chair of this Task Force, I am diligently working with representatives of EPA to assemble the proposed plan within 180 days of the release of the Memorandum.

## **CLEAN COAL RESEARCH PROGRAM**

The Office of Fossil Energy's (FE) Fossil Energy Research and Development Program creates public benefits by enhancing U.S. economic, environmental, and energy security. The program carries out three primary activities: (1) managing and performing energy-related research that reduces market barriers to the environmentally sound use of fossil fuels; (2) partnering with industry and others to advance fossil energy technologies toward commercialization; and (3) supporting the development of information and policy options that benefit the public.

The FE Clean Coal Research Program - administered by the Office of Clean Coal and implemented by the National Energy Technology Laboratory - supports DOE's overall mission to achieve national energy security in an economic and environmentally sound manner. In the Coal Program, there are four key priorities: 1) developing technologies for globally competitive carbon dioxide (CO<sub>2</sub>) capture for power plants and industrial sources, 2) establishing the basis for long-term geologic storage and CO<sub>2</sub> reuse, 3) improving the efficiency of both existing and new coal-fired power generation plants, and 4) implementing computer modeling and simulation to accelerate the Research and Development (R&D) path from discovery to commercialization and reduce costs.

Currently, we are pursuing the demonstration of first generation carbon capture and storage technologies with existing and new power plants and industrial facilities using a range of capture technologies and storing CO<sub>2</sub> in a variety of geologic formations. The goal is to have five to ten large-scale demonstrations in operation by 2016. In parallel, to drive down the costs of CCS as a potential climate change mitigation technology, the FE Coal Program is pursuing R&D to increase base power plant efficiency and thereby reduce the amount of carbon dioxide that has to be captured and stored per unit of electricity generated. FE is developing a spectrum of technologies to evolve coal into a low-carbon energy source that is economically competitive in 2020 and beyond.

There are a number of technical and economic challenges that must be overcome before cost-effective CCS solutions can be implemented to address climate change. Funding from the American Recovery and Reinvestment Act (Recovery Act) is helping to address these challenges. The Recovery Act provided an additional \$3.4 billion for FE R&D to expand and accelerate the commercial deployment of CCS technology. The experience gained from both the capture and storage demonstrations funded by the Recovery Act will be a critical step toward achieving widespread, cost-effective deployment of CCS. In addition to the Recovery Act projects, the core research, development and demonstration activities that leverage public and private partnerships will support the goal of broad, cost-effective CCS deployment in the post-2020 timeframe.

## **Core Research and Development Activities**

The Clean Coal Research Program is comprised of core research and development activities and major demonstration programs. The Program is further enhanced through the CCS activities authorized under the Recovery Act.

DOE provides a worldwide leadership role in the development of advanced coal technologies. We are moving aggressively to address new challenges associated with the reduction of greenhouse gas emissions as a climate change mitigation strategy. In partnership with the private sector, efforts are focused on maximizing efficiency and performance, while minimizing the costs of new CCS technologies. Improving the efficiency of CCS systems will help address pollutant emissions reduction, water usage, and carbon emissions. The Program strives to enable dramatic reductions in emissions and to improve technologies applicable to current and future fossil energy plants and industrial facilities so they can cost effectively meet emerging requirements for an economically secure and environmentally sound energy future.

The following CCS-enabling R&D activities support the development of technologies that can then be tested for commercial readiness in our demonstration programs. These R&D activities provide the supporting technology basis for all CCS development.

**Carbon Sequestration** - The Department's Sequestration program focuses on the key technology challenges that confront the wide-scale industrial deployment of CCS. These challenges are being addressed 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. Developing low-cost pre-combustion capture technologies and establishing the technical basis for carbon sequestration will lead to a decrease in the atmospheric release of CO<sub>2</sub>, thus allowing us to use our domestic fossil fuel resources responsibly by reducing their impacts on global climate change.

Essential to these objectives are the Regional Carbon Sequestration Partnerships (RCSP). The Partnerships are a central piece of our CCS research efforts that develop the knowledge base and infrastructure for the wide-scale deployment of geologic storage technologies. The Partnerships address key infrastructure issues related to permitting, pore space (underground reservoir) ownership, site access, liability, public outreach, and education. The Partnerships also conduct field tests across the United States to characterize the geographic differences in fossil fuel use, potential storage sites, and different regional approaches to addressing CCS. The Partnerships encompass all of the geologic storage sites in the country that are potentially available for carbon sequestration. The Regional Partnerships represent more than 350 unique organizations in 43 States, three Native American Indian Nations, and four Canadian Provinces.

**Innovations for Existing Plants (IEP)** - The IEP program develops low cost, efficient technologies to reduce CO<sub>2</sub> emissions from new and existing pulverized coal-fired power plants. The program focuses on

advanced post-combustion ultra-supercritical steam cycle, oxy-combustion, and CO<sub>2</sub> compression technologies in direct response to the priority placed on addressing the existing and new coal-fired power plants. Dramatic cost and energy penalty reductions for carbon capture are essential for broad deployment of existing plant CCS retrofits, both domestically and in developing economies.

**Advanced Integrated Gasification Combined Cycle (IGCC)** - Advanced IGCC technology utilizes a pre-combustion pathway to convert coal or other carbon-containing feedstocks into synthesis gas, a mixture composed primarily of carbon monoxide and hydrogen used as fuel for power generation. We are developing advanced gasification technologies to meet the most stringent environmental regulations and to facilitate the efficient capture of CO<sub>2</sub> for subsequent sequestration. Gasification plants are complex systems that rely on a large number of interconnected processes and technologies. Advances in the current state-of-the-art, as well as development of novel approaches, are required to make these systems affordable and reliable for commercial deployment. The program continues to focus on developing the next generation technology in gasification systems related to fuel flexible gasifiers, coal feed systems, high temperature contaminant removal, revolutionary oxygen supply technology, and CO<sub>2</sub> capture technologies. Specifically, we are targeting improvement in IGCC that could yield up to a 5 percentage point efficiency gain while reducing the system cost. These added improvements are targeted toward allowing IGCC to be deployed as a competitive option in the post-2020 time frame by reducing the cost of future systems and improving their reliability.

**Fuels** - The Fuels program is focused on reducing technology barriers for the reliable, efficient and environmentally friendly conversion of coal to hydrogen for utilization in advanced IGCC systems. Efforts for hydrogen production focus on generation at the plant for large-scale, central power applications and exclude transportation. Activities include support for the bench-scale development of hydrogen separation technologies and components.

**Fuel Cells** - Fuel cell systems when coupled with coal gasification for large scale power generation hold great potential for leapfrog advances in efficiency. Fuel cells also produce very low emissions, are modular in nature, and can be scaled to almost any deployment size. The ultimate goal of the program is to develop large (>100 MW) fuel cell power systems that produce electric power from coal using integrated coal gasification and CO<sub>2</sub> separation processes that capture at least 90 percent of the CO<sub>2</sub> emissions. The program is driving to reduce the cost of fuel cell technology by an order of magnitude compared to current technology and enable low-cost fuel cells scalable to MW class ultra-clean systems with potential for up to 60 percent electrical efficiency for central power generation.

**Advanced Turbines** - The Advanced Turbine program consists of a portfolio of laboratory and field R&D projects focused on performance-improvement technologies with great potential for increasing efficiency and reducing emissions and costs in coal-based applications. Future gasification based power systems outfitted with CCS will require high efficiency hydrogen turbines. Hence, the current focus of the Advanced Turbine program is the combustion of pure hydrogen fuels in greater than 100 MW size gas turbines and the compression of large volumes of CO<sub>2</sub>. The Advanced Turbines program aims to improve

the firing temperature and throughput of the next generation of combustion turbines for coal-based integrated gasification combined cycle power systems that capture and sequester CO<sub>2</sub>.

**Advanced Research** - The Advanced Research Program is a bridge between basic research and the development and deployment of innovative systems capable of creating highly efficient and environmentally benign electricity and power. The objective of the program is to support development of critical enabling components that provide cross cutting benefits across the entire coal research program. Example developments that are being pursued include high temperature materials for ultra-supercritical plants, enabling efficiency increases up to 3 percentage points for coal-fired plants, revolutionary sensors and controls, and advanced computing/visualization techniques. The Advanced Research Program will continue to push revolutionary advances in efficiency improvements, computational analyses and projects aimed at a greater understanding of the physical, chemical, and thermo-dynamic barriers that currently limit the use of coal and other fossil fuels.

Additionally in FY 2011, a multi-lab partnership will be initiated to develop a comprehensive, integrated suite of computational models for accelerating the development of carbon capture technologies. The scientific underpinnings of the suite of models will ensure that learning from successive generations of a technology or learning from even competing technologies is maximized. The simulation-based confidence will reduce the risk in incorporating multiple innovative technologies into a new plant design, thereby significantly reducing the development cycle required to move novel technologies to commercialization.

### **Demonstrations at Commercial-Scale**

Program success will ultimately be judged by the deployment of emerging technologies into the marketplace. Both technical and financial challenges associated with the deployment of new advanced coal technologies must be overcome in order to achieve success in the marketplace. Commercial-scale demonstrations help the industry understand and overcome component integration and start-up performance issues, and by reducing technology and economic risk, improve the opportunity for private financing and investment for subsequent plants.

The Department is implementing large-scale CCS projects through the Large-Scale Sequestration Field Tests being performed by the Regional Partnerships; the Clean Coal Power Initiative (CCPI); and FutureGen.

**Large-Scale Sequestration Field Tests** – A central piece of our CCS research is DOE's field test program, which is being implemented through the Regional Carbon Sequestration Partnerships. This 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. The Partnerships encompass essentially all the geologic storage sites in the country that can potentially be available for carbon sequestration. 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 interests leading to the success of

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

The Development Phase (Phase III) of the Regional Partnerships is focused on large-scale field tests of geologic carbon sequestration up to 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.

In FY 2011, several of the nine large-scale RCSP CO<sub>2</sub> injection projects are scheduled to begin injecting CO<sub>2</sub> for large volume (1 million tons/year) geologic storage tests. Most of the large-scale field tests will have completed the first stage of the projects consisting of site selection and characterization, National Environmental Policy Act (NEPA) review, pre-injection monitoring, and permitting. One project will have concluded its injection of about 2 million tons of CO<sub>2</sub> and will be conducting post injection monitoring at the site. These large-volume injections are needed to demonstrate that the formations selected for storage have the capability and capacity to store CO<sub>2</sub> from coal-based energy systems and industrial facilities.

**Clean Coal Power Initiative** – The mission of the Clean Coal Power Initiative (CCPI) is to enable and accelerate the deployment of advanced carbon capture and storage (CCS) technologies to ensure clean, reliable, and affordable electricity for the United States. The CCPI is a cost-shared partnership between the government and industry to develop and demonstrate advanced coal-based power generation technologies at the commercial scale.

CCPI demonstrations address the reliability and affordability of the Nation's electricity supply from coal-based generation. CCPI demonstrations will meet technical requirements set forth in the Energy Policy Act of 2005. By enabling advanced technologies to overcome technical risks involved with scale-up and bringing them to the point of commercial readiness, CCPI accelerates the development of both advanced coal generation technologies and the integration of CCS with both new and existing generation technologies. The CCPI also facilitates the movement of technologies into the market place that are emerging from the core research and development activities.

**FutureGen** – The FutureGen Project intends to conduct novel large-scale testing to accelerate the deployment of a set of integrated advanced coal gasification-based electric power production technologies linked with CCS. This project would be the first of its kind to store CO<sub>2</sub> in a deep saline geologic formation. The Department is currently reviewing the renewal application submitted by the FutureGen Alliance on March 19, 2010.

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

The primary goals of the FE Recovery Act Program are to:

- Demonstrate CCS technology to reduce greenhouse gas emissions from the electric power and industrial sectors of our economy.
- Become the world's leader in CCS science and technology.
- Implement projects to support economic recovery by creating new jobs in pursuit of a secure energy future.

Recovery Act projects will leverage federal funding, stimulate private sector investment, accelerate delivery of CCS technology, and demonstrate the integration of coal-based energy systems and industrial processes with capture and permanent storage of CO<sub>2</sub> in geologic formations. Recovery Act projects are logical extensions of several important, ongoing Clean Coal Research Program baseline activities.

The FE Recovery Act R&D Program is comprised of five components, with the following specific objectives:

- **Expand and Extend Clean Coal Power Initiative Round 3 (Expand CCPI-3)** - Accelerate integrated CCS demonstrations by expanding and extending the opportunity for several additional CCS electricity generation demonstrations for both new and existing plants under DOE's ongoing CCPI-3 competition.
- **Industrial Carbon Capture and Storage** - Expand DOE's focus of CCS on advanced coal power systems to industrial CCS applications.
- **Geologic Sequestration Site Characterization** - Accelerate the comprehensive characterization of large-volume geologic reservoirs, thus augmenting existing data under the Regional Carbon Sequestration Partnerships.
- **Geologic Sequestration Training and Research** - Develop the next generation of scientists and engineers by expanding ongoing training and research efforts conducted primarily through the University Coal Research and Historically Black Colleges and Universities programs.
- **Carbon Capture and Storage** - Provide a fully integrated, advanced coal gasification-based power plant with utility-scale CCS technology capable of safely and permanently storing 1 million metric tons of CO<sub>2</sub> per year.

To date, there have been over 90 projects awarded, including the following most recent announcements:

- On October 2, 2009, Secretary Chu announced the first round of funding from \$1.4 billion from the Recovery Act for the selection of projects that will capture CO<sub>2</sub> from industrial sources for storage or beneficial use. The first phase of these projects will include approximately \$21.6 million in Recovery Act funding and \$22.5 million in private funding for a total initial investment of about \$44.1 million. The remaining Recovery Act funding will be awarded to the most promising projects during a competitive phase two selection process.
- On November 6, 2009, DOE issued a cooperative agreement with Hydrogen Energy California LLC to build and demonstrate a hydrogen-powered electric generating facility, complete with CCS, in Kern County, California.

- On March 9, 2010, U.S. Secretary of Energy Steven Chu announced that a project with NRG Energy has been selected to receive up to \$154 million, including funding from the Recovery Act. The post-combustion capture and sequestration project will demonstrate advanced technology to reduce CO<sub>2</sub> emissions and will assist with enhanced oil recovery efforts from a nearby oil field.
- On March 12, 2010, DOE announced the award of a cooperative agreement to Summit Texas Clean Energy, LLC, for the Texas Clean Energy Project to design, build, and demonstrate an integrated gasification combined cycle electric generating facility, complete with co-production of high-value products and carbon capture and storage.
- On March 12, 2010, DOE announced the award of a cooperative agreement to American Electric Power for the Mountaineer Commercial-Scale CCS Project to design, construct, and operate a system that will capture and store CO<sub>2</sub> at an existing coal-fired power plant.

## **INTERNATIONAL COLLABORATIONS**

Recognizing that climate change is a global issue that requires a global response, DOE plays an active leadership role in an international initiative known as the Carbon Sequestration Leadership Forum (CSLF). The CSLF is a voluntary climate initiative of developed and developing nations that, collectively, account for 75 percent of all anthropogenic carbon dioxide emissions. It is currently comprised of 24 members, including 23 countries and the European Commission.

Formed in 2003, the CSLF marshals intellectual, technical, and financial resources from all parts of the world to support atmospheric stabilization of carbon dioxide concentrations, the long-term goal of the United Nations Framework Convention on Climate Change. Members are dedicated to collaboration and information sharing in developing, demonstrating, and fostering the worldwide deployment of multiple technologies for the capture and long-term geologic storage of carbon dioxide at low costs. Additionally, the CSLF is committed to establishing a companion foundation promoting legislative, regulatory, administrative, and institutional practices for safe, verifiable long-term storage.

In addition to the CSLF, the Department is currently cooperating with numerous countries through bilateral agreements and multilateral activities to identify areas of collaboration in promoting and developing clean fossil energy technologies internationally.

## **CONCLUSIONS**

CCS technologies can play a key role as we transition to the clean energy economy of the future. However, cost-effective commercial deployment of CCS can only occur in parallel with the development of a national set of definitive policies that encourage technology development and reward investments in and capital formation around improved carbon performance. Passing comprehensive energy and climate legislation that puts a price on carbon will provide the long-term, market-based incentives to channel private investment into CCS and other low-carbon technologies. Time is of the essence. The Administration wants to see comprehensive legislation sent to the President this year.

Addressing the barriers to CCS deployment requires a systems-based approach that includes not only site evaluation, characterization and selection, but also rules for short-, medium-, and long-term liability. Market driven CCS deployment will also require infrastructure for CO<sub>2</sub> transportation and storage and the development of a uniform 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.

CCS and other clean coal technologies can play a critical role in mitigating CO<sub>2</sub> emissions under many potential future carbon stabilization scenarios. The DOE program has put us on a path toward ensuring that the enabling technologies will be available to effect broad CCS deployment within a decade. Continued U.S. leadership in technology development and future deployment is important to the cultivation of 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 from members of the Committee.