Statement of Thomas D. Shope
Principal Deputy Assistant Secretary for
Fossil Energy
Subcommittee on Energy and Air Quality
Committee on Energy and Commerce
U.S. House of Representatives

March 6, 2007

- Department of Energy's Carbon Sequestration Program purpose is to develop and deploy carbon capture and storage technologies because they offer a relatively low cost way to reduce greenhouse gas emissions and to initiate large-scale domestic projects where none now exist.

- Program investment to date is in excess of $300 million. DOE is requesting an additional $79 million for FY2008, up from $18 million in FY '01, an increase of almost 340 percent.

- The Carbon Sequestration Program has two parts – Core Research and Development and Deployment and Demonstration.

- Core Research element includes capture, sequestration, breakthrough concepts and the monitoring, mitigation and verification of CO_2 in geologic storage, and mitigation of non-CO_2 greenhouse gases. The portfolio contains more than 70 projects.

- Lowering the costs of capture is a critical element.

- Overall goal is 90 percent capture and 99 percent storage permanence by 2012 with no more than a 10 percent increase in the cost of energy services, and to have ready by 2012 a portfolio of technologies capable of market penetration after 2012.

- Objectives include post-combustion capture at a cost of power no more than 20 above that of a non-capture plant; and pre-combustion capture for IGCC generation at no more than 10 percent above the non-capture plant.

- The Deployment-and-Demonstration element centers on the seven Regional Carbon Sequestration Partnerships, involving more than 400 entities in 41 states, four Canadian provinces and three Indian Nations, whose mission is to develop sequestration capacity and infrastructure.

- The partnerships have compiled the National Carbon Sequestration Atlas, identifying several hundred years of geologic storage capacity.

- Current activities involve 25 small scale field tests of geologic storage. Future activities will involve seven large-volume tests and could identify candidate sites for new plants modeled on FutureGen, the near-zero emission power plant.

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Mr. Chairman, Members of the Committee, it's a pleasure for me to appear before you today to discuss the general subject of carbon sequestration.

The availability of affordable energy is an important component of economic growth. The use of fossil fuels, however, can result in the release of emissions with potential impacts on the environment. Of growing significance are emissions of carbon dioxide (CO_2) which contribute to global climate change.

Balancing the economic value of fossil fuels with the environmental concerns associated with fossil fuel use is a difficult challenge. Carbon capture and storage technologies provide a key strategy for reconciling energy and environmental concerns. By capturing CO_2 before it is emitted to the atmosphere and then storing it in underground geologic formations, the use of fossil fuels in power generation can be largely decoupled from growth in atmospheric concentrations of CO2 emissions.

On a global scale, carbon capture and storage technologies have the potential to be a cost-effective option for overall climate change mitigation and increase flexibility in reducing greenhouse gas emissions. Furthermore, a particularly beneficial aspect of certain carbon dioxide capture and storage (CCS) technologies is that the majority of their component parts – carbon capture, transportation and storage– rely on commercially available technologies, enhancing the availability of CCS technologies as viable mitigation options.

The Global Energy Technology Strategy Program (GTSP), a public and private sector research collaboration, has identified near-term, medium-term and long-term benefits associated with carbon capture. In the near term, carbon capture and sequestration technologies will allow the growth of a modern industrial economy – including electricity generation – to chart a viable path forward into a carbon-constrained world. In the medium term, carbon capture and sequestration technologies will facilitate a smoother transition of the global economy to a low greenhouse gas (GHG) emissions future. In the long term, carbon capture and sequestration will make valuable commodities like electricity and hydrogen with low associated GHG emissions cheaper than they would be if such technologies were not available.

The U.S. Department of Energy (DOE) is taking a leadership role in the development of carbon capture and storage technologies. The coal program supports DOEs mission to promote America’s energy security through reliable, clean, and affordable energy by developing the technological capability to dramatically reduce pollutant emissions from coal fired power plants and dramatically reduce carbon emissions to achieve near zero atmospheric emissions. Through its Carbon Sequestration Program – managed within DOE's Office of Fossil Energy and implemented by the National Energy Technology Laboratory (NETL) – DOE is developing technologies through which CCS will become an effective and economically viable option for reducing CO_2 emissions. The Carbon Sequestration Program works in concert with other programs within the Office of Fossil Energy that are developing technologies integral to coal-fueled power generation with carbon capture: Advanced Integrated Gasification Combined Cycle, Advanced Turbines, Fuels, Fuel Cells, and Advanced Research. If successful, this research and development could enable carbon control technologies to help overcome the various technical, economic and potential public acceptance barriers currently limiting widespread commercial applications, including cost-effective CO_2 capture, long-term stability (permanence) of CO_2 in underground formations, monitoring and verification, integration with power generation systems, and public acceptance.

The overall goal of the Carbon Sequestration Program is to develop, by 2012, fossil fuel power generation systems viable for commercial deployment that achieve 90 percent CO_2 capture with 99 percent storage permanence at less than a 10 percent increase in the cost of energy services. Reaching this goal requires an integrated research, development, and demonstration program linking fundamental advances in CCS to practical advances in technologies amenable to extended commercial use. The technologies developed in this Program will also serve as fundamental components of the

FutureGen project, which will be the first power plant in the world to integrate permanent CCS with coal-to-energy conversion and hydrogen production.

The year 2007 marks the 10-year anniversary of the DOE Carbon Sequestration Program that was launched in 1997 as a small-scale research effort to ascertain the technical viability of carbon capture and storage. During that time, the Carbon Sequestration Program has grown into a multi-faceted research, development, and demonstration program that aims to provide the means by which fossil fuels can continue to be used for power generation in a carbon-constrained world. The first 10 years have significantly advanced the knowledge base pertaining to CCS. Much work remains, however, to enable the large-scale implementation and commercialization of this technology. In particular, large field tests are required to validate and improve model predictions of scientific behavior of injected carbon dioxide at scale, demonstrate the engineering and scientific processes for successfully implementing and validating long-term storage of sequestered carbon, and achieve cost-effective integration with power plant systems for capture. Looking forward, it is also important to recognize carbon sequestration as more than just an end-of-process emissions control technology. Carbon sequestration represents a useful element in the entire energy supply picture because it could help provide the means to allow fossil fuels to continue to be used for power generation in a carbon-constrained world, and has application in some cases to facilitating greater recovery of domestic oil, natural gas, and coal bed methane.

Program Overview

The DOE Carbon Sequestration Program (Program) leverages applied research with field demonstrations to assess the technical and economic viability of carbon capture and storage as a greenhouse gas mitigation option. Successful carbon capture and storage technology development and deployment could help provide the means by which fossil fuels can continue to be used for power generation in a carbon-constrained world.

Program Highlights and Accomplishments

Since its inception 10 years ago, the Program has been moving carbon sequestration technology forward to enable its cost-effective use in meeting potential future GHG emissions reduction requirements. Through its technological successes, the Program has played a central role in helping advance international acceptance of carbon sequestration as a leading mitigation option for reducing GHG emissions into the atmosphere. Major Program accomplishments over its 10-year life include:

1. ***Characterization and Validation Efforts Within the Regional Carbon Sequestration Partnership Program.*** The ongoing characterization and validation work by the Regional Carbon Sequestration Partnerships (RCSPs) is laying the groundwork for a future in which large-scale deployment of carbon capture and storage technologies is possible.

2. ***CO_2 Capture Cost Reduction*.** DOE-funded research in CO_2 capture has led to identifying technologies and pathways to reduce costs for CO_2 capture. The Program has conducted research into solvent, sorbent, membrane, and oxy-combustion systems that, if successfully deployed, could capture greater than 90 percent of the flue gas CO_2 at a significant cost reduction when compared to state-of-the-art amine based capture systems. Through the research and system analysis over the past years, potential cost reductions of 30-45% have been identified for the capture of CO_2.

3. ***CO_2 Storage*.** Program efforts in geologic and terrestrial CO_2 storage have led to a far better understanding of the sequestration potential of various storage sites.

4. ***Monitoring, Mitigation, and Verification (MM&V).*** Field projects have demonstrated the ability to "map" CO_2 injected into an underground formation at a much higher resolution than previously anticipated, and confirmed the ability of tracers to track CO_2 migration through a formation which will be an important tool for verifying that the carbon dioxide has remained sequestered. DOE-sponsored research has also led to the development of a novel tool to obtain geochemical samples of water and gas at *in situ* pressure.

5. ***Carbon Sequestration Atlas.* The *2006 Carbon Sequestration Atlas of the United States and Canada*,** developed by the National Energy Technology Laboratory (NETL), the RCSPs, and the National Carbon Sequestration Database and Geographical

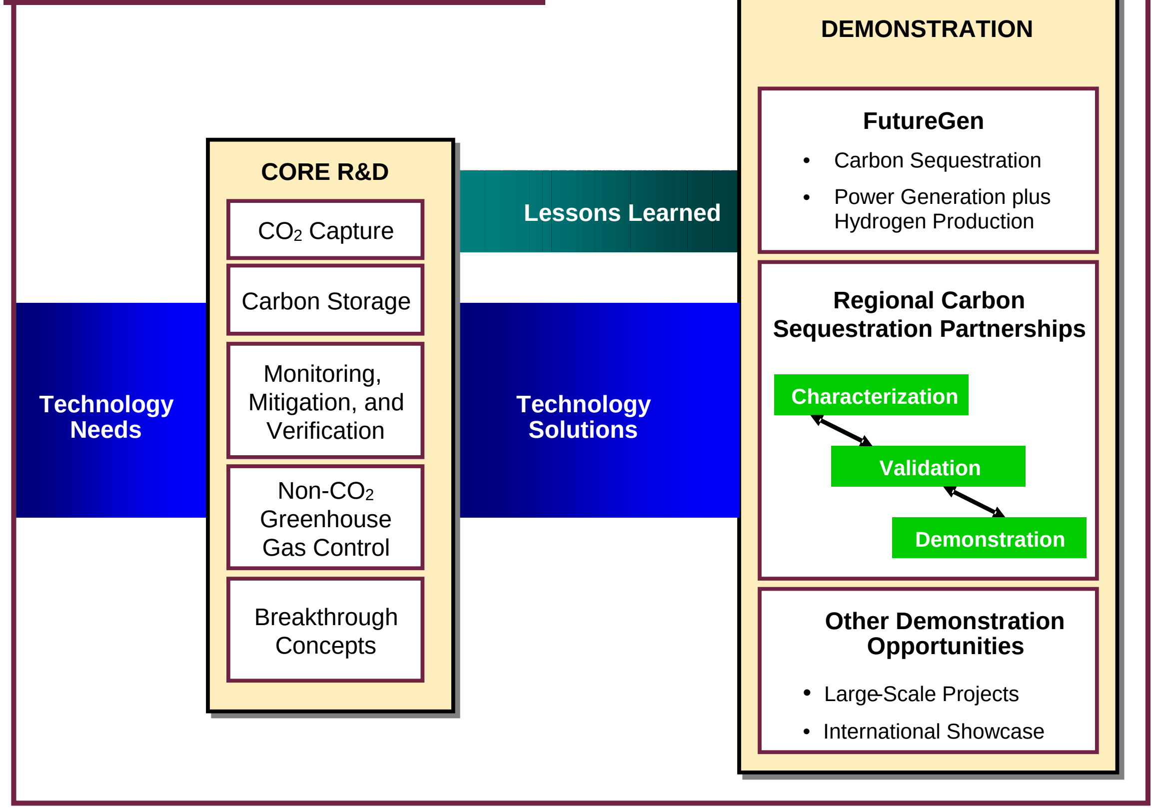
Information System (NATCARB), contains information on CO_2 emissions point sources, geologic formations with sequestration potential, and terrestrial ecosystems with potential for enhanced carbon uptake – all referenced to their geographic location to enable matching sources and sequestration sties. An interactive version of the Atlas is available through the NATCARB website (www.natcarb.org).

6. ***Systems Analysis.*** The NETLs Office of Systems, Analysis, and Planning (OSAP) conducts innovative assessments of CO_2 capture and separations processes. OSAPs work in this area has increased our understanding of the issues surrounding integration of CO_2 capture systems with different fuel conversion systems, thereby leading to the potential to significantly reduce costs.

DOEs Carbon Sequestration Program Structure

The Carbon Sequestration Program contains two main elements: *Core R&D* and *Demonstration*. The following figure shows how these elements are linked. The Core R&D element converts recognized technology needs in several focus areas into technology solutions that can then be demonstrated in the field. Lessons learned from the field tests are fed to the Core R&D element to guide future research and development.

Figure 2. U.S. DOE Carbon Sequestration Technology Development Efforts



Core R&D involves laboratory and pilot-scale research aimed at developing new technologies and new systems for GHG mitigation. The Core R&D portfolio includes technology development projects cost-shared with industry; research grants; and research conducted through NETLs OSAP and The Office of Research and Development (ORD). This effort encompasses five focus areas: CO_2 capture; carbon storage; monitoring, mitigation and verification; non-CO_2 greenhouse gas control; and breakthrough concepts.

The largest components of the Program's Demonstration element are the seven Regional Carbon Sequestration Partnerships Programs. The seven RCSPs are examining regional differences in geology, land practices, ecosystem management, and industrial activity that may affect the deployment of carbon sequestration technologies. Activities conducted in the seven RCSPs will provide the knowledge needed to help advance carbon sequestration as a viable GHG mitigation option across the U.S. and Canada.

The Carbon Sequestration Program also supports development of technologies for FutureGen, a key DOE project aimed at building a highly efficient and technologically sophisticated power plant that can produce both hydrogen and electricity while capturing and sequestering CO_2 emissions. FutureGen will serve as a full-scale demonstration of carbon sequestration technologies, thereby providing a venue for evaluating technologies emerging from Core R&D efforts.

The Carbon Sequestration Program includes several supporting mechanisms performing systems analyses and economic modeling of potential new CO_2 capture processes to identify issues with their integration into full-scale power plants. For example the Program also participates in cross-cutting studies to model future national energy scenarios incorporating carbon capture and storage. Finally, the Program collaborates extensively with other U.S. Government agencies, especially the Environmental Protection Agency, and works with the international carbon capture and storage community through its membership in organizations such as the Carbon Sequestration Leadership Forum (CSLF) to promote the international development of improved cost-effective technologies for CCS.

Challenges

Carbon sequestration technologies encompass two main CO_2 reduction pathways, both of which have a role in mitigating potential climate change. The CO_2 can either be captured at the point where it is produced (point source) or it can be removed from the air. For geologic sequestration systems focused on capture from point sources, the captured CO_2 is permanently stored underground; for terrestrial sequestration systems focused on removing CO_2 from the air, the CO_2 is absorbed by plants or soils.

Capturing the CO_2 from industrial operations is currently an expensive process. There are three capture technology areas — pre-combustion, post-combustion, or oxycombustion. All of these technologies require a series of energy-intensive process steps involving heating and cooling, pressure changes, operation of separation or absorption equipment, purifying the product, storing the product, and then transporting it. In the case of power generation using current capture technologies, the energy needed to capture and separate the CO_2 and regenerate the absorbent currently increases the energy required by 20 percent or more and leads to a substantial increase in the cost of electricity. The result of these operations is a net increase in the cost of electricity or other products from the plant and a decrease in net energy efficiency. The challenge is to develop effective carbon capture technologies that minimize these costs.

The Carbon Sequestration Program is designed to develop the technology base that will enable carbon sequestration to become a viable GHG mitigation option. Important to any such technology road mapping effort is the recognition and identification of challenges that hinder commercialization. Various technical, economic and social challenges currently prevent carbon sequestration from becoming a widely used technology. The Carbon Sequestration Program is addressing these challenges through applied research, proof-of-concept technology evaluation, pilot-scale testing, large-scale demonstration, stakeholder involvement, and public outreach.

Cost-Effective Capture

For geologic sequestration applications in which the CO_2 is stored underground, there are three main cost components: capture, transport and storage (which encompasses injection and monitoring). The cost of capture is typically several times greater than the cost of transport and storage. In today's economic and regulatory environment, carbon capture technologies could increase electricity production costs by 60-100 percent at existing power plants and by 20-55 percent at new advanced coal-fired power plants using Integrated Gasification Combined Cycle (IGCC) technology or supercritical coal plants.

While industrial CO_2 separation processes are commercially available, they have not been deployed at the scale required for large power plant applications, and their application could significantly increase electricity production costs. Improvements to existing CO_2 capture processes, therefore, as well as the development of alternative capture technologies, are important in reducing the costs incurred for carbon sequestration.

Technology Development Efforts – CO_2 Capture

Carbon sequestration begins with the separation and capture of CO_2 from power plant process or flue gas and other point sources. At present, this process is both costly and energy intensive; CO_2 capture accounts for the majority of the cost of the CO_2 sequestration system. Therefore, R&D goals within the Program's CO_2 Capture focus area are aimed at improving the efficiency and reducing the costs of capturing CO_2 emissions from coal-fired power generating plants.

The Program currently funds a large number of laboratory-scale and pilot-scale research projects involving solvents, sorbents, membranes, and oxygen combustion systems (oxy-combustion). Efforts are focused on systems for capturing CO_2 from coal-fired power plants since they are the largest centralized sources of CO_2, although the technologies developed will be applicable to natural-gas-fired power plants and industrial CO_2 sources as well.

- *Capture Technology Approaches*

Depending on the process or power plant application in question, there are three main approaches to capturing the CO_2 generated from a primary fossil fuel – post-combustion, pre-combustion, and oxycombustion. The following sub-sections will elaborate on the three different capture approaches.

- *Post-Combustion Systems*

Post-combustion systems separate CO_2 from the flue gases produced by the combustion of the primary fuel in air. The flue gases, if controlled, would exit the power station into the surrounding atmosphere. These systems normally use a liquid solvent to capture the small fraction of CO_2 present in a flue gas stream in which the main constituent is nitrogen (which comes from air used in the combustion process).

Pulverized coal (PC) plants, which are 99 percent of all coal-fired power plants in the United States, burn coal in air to produce steam. CO_2 is contained in the flue gas at a concentration of 10-15 percent. This is a challenging application for CO_2 capture because:

- The low pressure and dilute concentration dictate a high volume of gas to be treated.
- Trace impurities in the flue gas tend to reduce the effectiveness of the CO_2 adsorbing processes.
- Compressing captured CO_2 from atmospheric pressure to pipeline pressure (1,200 - 2,000 pounds per square inch [psi]) uses a lot of energy and thus represents a large parasitic load.

The CO_2 concentration in flue gas from a coal-fired IGCC turbine is about 9 percent and from a natural gas-fired turbine about 4 percent. The flue gas in these systems approaches ambient pressure, and thus the CO_2 partial pressure of the gas is low, indicating that a very large volume of gas needs to be treated.

For a modern PC power plant or a natural gas combined cycle (NGCC) power plant, current post-combustion capture systems would typically employ an organic solvent such as monoethanolamine (MEA). Aqueous amines are the state-of-the-art technology for CO_2 capture for PC power plants. Analysis conducted at the NETL shows that CO_2 capture and compression using amines raises the cost of electricity from a newly-built supercritical PC power plant by about 85 percent, from 4.9 cents/kWh to 9.0 cents/kWh. The goal for advanced CO_2 capture applied to PC systems is that CO_2 capture and compression added to a newly constructed PC power plant increases the cost of electricity by no more than 20 percent, compared with a no-capture case.

- *Pre-Combustion Systems*

Pre-combustion systems process the primary fuel in a reactor with steam and air or oxygen to produce a mixture consisting mainly of carbon monoxide and hydrogen (‘synthesis gas’) at high pressure. This is the technology used in IGCC plants. Additional hydrogen, together with CO_2, is produced by reacting carbon monoxide with steam in a second reactor (a ‘shift reactor’). The resulting mixture of hydrogen and CO_2 can then be separated into a CO_2 gas stream, and a stream of hydrogen. If the CO_2 is stored, the hydrogen is a carbon-free energy carrier that can be combusted to generate power and/or heat. Although the initial fuel conversion steps are more elaborate and costly than in post-combustion systems, the high concentrations of

CO_2 produced by the shift reactor and the high pressures often encountered in these applications are more favorable for CO_2 separation. The advantage of this type of system is the higher CO_2 concentration (partial pressure), and thus the lower volume of gas to be handled resulting in smaller equipment sizes and lower capital costs. Energy penalties and costs for CO_2 sequestration in a pre-combustion setting are significantly less compared with that from a pulverized coal combustion plant. Pre-combustion would be used at power plants that employ IGCC technology.

The state-of-the-art for CO_2 capture from an IGCC power plant is glycol-based Selexol sorbent. Analysis conducted at the NETL shows that CO_2 capture and compression using Selexol raises the cost of electricity from a newly built IGCC power plant by 25 percent, from 5.5 cents/kWh to 6.5 cents/kWh. The goal for advanced CO_2 capture and sequestration systems applied to an IGCC is to raise the production cost of electricity by no more than 10 percent. The goal for IGCC is more stringent than for PC because the conditions for CO_2 capture are more favorable in an IGCC plant.

- *Oxycombustion Systems*

Oxycombustion systems use oxygen instead of air for combustion of the primary fuel to produce a flue gas that is mainly water vapor and CO_2. This results in a flue gas with high CO_2 concentrations (greater than 80 percent by volume) and some excess O_2. The water vapor is then removed by cooling and compressing the gas stream. Oxycombustion requires the upstream separation of oxygen from air, with a purity of 95–99 percent oxygen assumed in most current designs. Further treatment of the flue gas may be needed to remove air pollutants and noncondensed gases (such as nitrogen) from the flue gas before the CO_2 is sent to storage.

- *Collaboration*

The Carbon Capture Program collaborates with other Federal Government agencies, state and local agencies, non-governmental organizations, private industry, and international organizations, as appropriate, in areas of relevance to the program. These collaborative efforts play an important role in the continued development and success of the program. For example, collaborations with these potential partners could help leverage R&D funding dollars, expand the portfolio of technologies, address key technical and economic barriers, or identify new areas of research emphasis.

- *Specific Accomplishments within Carbon Capture Portion of Program*

The Carbon Capture Program has played a vital role in the overall Carbon Sequestration Program during the past decade, with several successes. A sampling of some of the successful developments and interactions of the Program are:

- Sorbent Achieves 99 Percent CO_2 Removal: Laboratory experiments by NETL researchers have demonstrated that a NETL-developed regenerable sorbent can remove 99 percent of the CO_2 in a simulated coal combustion flue gas. Additional research will test the sorbent in bench-scale reactors and evaluate the feasibility of preparing the sorbent for large-scale units.

- Integrating Carbon Capture with Oxygen-fired Circulating Fluidized Bed Technology**:** Test results at a 2.9 MW project performer site show that no significant roadblocks are foreseen for integrating the carbon capture component to oxygen-fired circulating fluidized bed technologies that are being developed.

- Separation of Hydrogen from Carbon Dioxide: A project team has investigated the use of CO_2 hydrates as a way to capture CO_2. The process has shown potential to reduce the energy requirement for CO_2 capture and the capability to capture greater than 75 percent of the CO_2.

Program's Demonstration - Regional Carbon Sequestration Partnerships Program

As mentioned in the previous discussion of the program structure, the largest component of the Program's Demonstration element is the Regional Carbon Sequestration Partnerships Program. Seven Regional Carbon Sequestration Partnerships are examining regional differences in geology, land practices, ecosystem management, and industrial activity that affect the deployment of carbon sequestration technologies. Activities conducted in this Program will help provide the knowledge needed to make CCS a viable GHG mitigation option both domestically and internationally.

Carbon Sequestration Leadership Forum (CSLF)

The Carbon Sequestration Leadership Forum is a voluntary climate initiative of developed and developing nations that account for about 75 percent of all manmade carbon dioxide emissions. The CSLF was established in 2003 and focuses on development of carbon capture and storage technologies as a means of accomplishing long-term stabilization of greenhouse gas levels in the atmosphere. The goal is to improve carbon capture and storage technologies through coordinated research and development with international partners and private industry. This could include promoting the appropriate technical, political, and regulatory environments for the development of such technology.

The CSLF is currently comprised of 22 members, including 21 countries and the European Commission. Members engage in coordinated and cooperative technology development aimed at enabling the early and on-going reduction of the carbon dioxide which constitutes more than 60 percent of such emissions - the product of electric generation and other heavy industrial activity.

Regional Carbon Sequestration Partnerships Background

Geographic differences in fossil fuel use and potential sequestration storage sites across the U.S. must be evaluated in addressing CO_2 sequestration. DOE has created a network of seven RCSPs to help develop the technology, infrastructure, and regulations to implement CO_2 sequestration in different regions and geologic formations within the Nation. Underlying this regional partnership approach is the belief that local organizations and citizens will contribute expertise, experience, and perspectives that more accurately represent the concerns and desires of a given region, thereby resulting in the development and application of technologies better suited to that region.

Collectively, the seven RCSPs represent regions encompassing 97 percent of coal-fired CO_2 emissions, 97 percent of industrial CO_2 emissions, 97 percent of the total land mass, and essentially all the geologic sequestration sites in the U.S. potentially available for carbon sequestration. The RCSPs are evaluating numerous sequestration approaches to assess which approaches are best suited for specific regions of the country and are helping develop a framework to validate and demonstrate the most promising carbon sequestration technologies.

CO_2 injection into different geologic formations, including depleted oil and natural gas fields, unmineable coal seams, saline formations, shale, and basalt formations -- has evolved as the highest priority for near term deployment in a carbon constrained world. Among the seven RCSP regions, geologic storage sites differ in their lithology as well as their locations relative to CO_2 emission sources and pipelines. Some regions have an abundance of different types of geologic formations, while opportunities in other regions are dominated by a specific formation type.

The process of sequestering carbon dioxide involves identifying sources that produce CO_2 and identifying storage sites where the CO_2 can be safely and permanently stored. Based on data assembled for the *2006 Carbon Sequestration Atlas of the United States and Canada*, the aggregate CO_2 sink capacity is estimated to hold several hundred years of total domestic U.S. emissions.

The RCSP Program was initiated in September 2003 through an open solicitation process that required a minimum 20 percent cost share from the prospective awardees. The RCSP Program is implemented in three phases:

- Phase I – Characterization (FY2004 – FY2005)
- Phase II – Validation (FY2006 – FY2009)
- Phase III – Demonstration (FY2008 – FY2017)

As a whole, the seven RCSPs have provided more than 31 percent in cost sharing through the first two phases. Even though the RCSP Program is being implemented in three phases, it should be viewed as an integrated whole, with many of the goals and objectives transitioning from one phase to the next. Accomplishments and results from the Characterization Phase have helped to refine goals and activities in the Validation Phase, and results from the Validation Phase are expected to enhance the Demonstration Phase.

The RCSP Program encourages and requires open information sharing among its members. DOE and the RCSPs sponsor both general workshops and more focused technology area working group meetings to facilitate information exchange. During these meetings, the most effective approaches to problem solving become apparent and are quickly adopted, thus strengthening the overall RCSP Program. Although each RCSP has its own objectives and field tests, cooperation has been a hallmark of the Program to date. These workshops and working group activities were initiated during the Characterization Phase, have continued into the Validation Phase, and will likely be an important aspect of the Demonstration Phase as well.

Characterization Phase

The Characterization Phase, completed in 2005, focused on characterizing regional opportunities for CCS, identifying regional CO_2 sources, and identifying priority opportunities for field tests. Each RCSP developed decision support systems that house regional geologic data on CO_2 storage sites and information on CO_2 sources to complete source-sink matching models. Each RCSP also researched project tools necessary to model and measure the fate and spread of CO_2 after injection. Combined with public outreach and education programs conducted by the

RCSPs during the Characterization Phase, these activities indicate that CCS is a viable option to mitigate CO_2 emissions. In preparation of the Validation and Demonstration Phases, the RCSPs gathered data necessary to prepare and conduct geologic field tests, and succeed in the following key accomplishments:

- Established a national network of companies and professionals working to advance sequestration technology so that it is viable for commercial deployment. The RCSPs brought an enormous amount of capability and experience together to work on the challenge of infrastructure development. Together with DOE, the RCSPs secured the active participation of more than 500 individuals representing more than 300 industrial companies, engineering firms, state agencies, non-governmental organizations, and other supporting organizations.

- Raised awareness and support for carbon sequestration as a GHG mitigation option. Each RCSP developed creative and innovative approaches to outreach and education. Articles about sequestration have appeared in local newspapers, documentaries have been shown on public television, and RCSP leaders have made appearances on local television programs. All seven RCSPs developed websites that describe their activities and several RCSPs experimented with innovative, internet-based outreach efforts, including a modified chat room for fielding questions about sequestration and town hall style meetings.

- Advanced understanding of permitting requirements for future carbon sequestration projects. To comply with public and regulatory requirements of multiple federal and state programs responsible for addressing possible safety and environmental risks, carbon sequestration projects will likely require specific permits. Working in collaboration with the Interstate Oil and Gas Compact Commission (IOGCC) and the U.S. Environmental Protection Agency, the RCSPs are assessing requirements and procedures for permitting future commercial sequestration deployments. Specifically, DOE and EPA meet on a quarterly basis at a high management level to ensure that Agency efforts are coordinated and communicated to each other effectively. Both DOE and the RCSPs were involved with providing comments for EPA's first Underground Injection Control program guidance related to permitting initial pilot projects as experimental technology wells, giving regulatory agencies enhanced flexibility in expediting these projects.

- Identified priority opportunities for sequestration field tests. The RCSPs identified, within their Regions, high priority opportunities for selected field tests during the Validation Phase.

- Established a series of protocols for project implementation, accounting, and contracts. RCSP activities in this area focused on the development of accounting protocols and support for state or national GHG accounting registries.

Validation Phase

The Validation Phase, initiated in October 2005, focuses on field tests to validate the efficacy of carbon sequestration technologies in a variety of geologic and terrestrial storage sites throughout the U.S. Using the extensive data and information gathered during the Characterization Phase, the seven RCSPs identified the most promising opportunities for carbon sequestration in their Regions and commenced geologic field tests. In addition, the RCSPs are verifying regional CO_2 sequestration capacities, satisfying project permitting requirements, and conducting public outreach and education activities.

The field tests conducted during the Validation Phase address the following goals:

- Validate and refine current CO_2 formation models for various geologic sequestration sites;
- Collect physical data to confirm capacity and injectivity estimates made during the Characterization Phase;
- Demonstrate the effectiveness of Monitoring, Mitigation and Verification (MM&V) technologies to measure CO_2 movement in the formations and confirm the integrity of the seals;
- Develop guidelines for well completion, operations, and abandonment to maximize storage potential and mitigate potential leakage; and
- Develop strategies that can be used to optimize the storage capacity for various sink types.

To achieve these primary Validation Phase goals, each RCSP has established supporting goals and planned actions. Many of these supporting goals and actions were created as a logical continuation of goals completed and/or specific accomplishments attained during the Characterization Phase. For example, initial data collected on CO_2 point sources and potential sequestration sites will be updated during the Validation Phase as additional data and analytical procedures become available. In addition, a common economic modeling approach for CO_2 capture will be developed during the Validation Phase and beyond. It will be based on preliminary economic models of available and emerging capture technologies created during the Characterization Phase. Storage capacity estimates for saline formations will be re-calculated in the Validation Phase and beyond using a common methodology developed by the RCSPs during the Characterization Phase; and instrumentation evaluated and tested during the Characterization Phase to follow CO_2 injection, plume migration, and storage permanence will be field-tested in the Validation Phase.

As I previously mentioned, the U.S. Department of Energy (DOE) is taking a leadership role in the development of CCS technologies. The challenges being addressed through research and development within the Carbon Sequestration Program will allow carbon sequestration to become an effective and economically viable option for reducing CO_2 emissions. Successful research and development will enable carbon mitigation technologies to overcome the various technical, economic and social barriers currently limiting widespread commercial applications, including barriers to cost-effective CO_2 capture, long-term stability (permanence) of CO_2 in underground formations, monitoring and verification, integration with power generation systems, and, most important, that of public acceptance.

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