U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

HEARING CHARTER

FutureGen and the Department of Energy's Advanced Coal Programs

Wednesday, March 11, 2009
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On Wednesday, March 11th at 10:00 a.m. the House Committee on Science and Technology, Subcommittee on Energy and Environment will hold a hearing entitled **"FutureGen and the Department of Energy's Advanced Coal Programs."** The purpose of the hearing is to receive testimony on near-term and long-term strategies to accelerate research, development and demonstration of advanced technologies to help reduce greenhouse gas emissions from new and existing coal-fired power plants.

The Subcommittee will hear testimony from five witnesses who will speak about advanced coal technology projects ongoing in the United States as well as new initiatives under consideration here and around the globe. Witnesses will also address the technical challenges and policy hurdles confronting the wide scale deployment of carbon capture and storage systems.

Witnesses

1. **Mr. Victor Der:** Acting Assistant Secretary for the Department of Energy's Office of Fossil Energy will discuss the status and goals of the Department's advanced coal programs. He also will describe the Department's plans for expenditure of funds allocated under the American Recovery and Reinvestment Act of 2009 and explain the Department's role to facilitate international collaboration regarding CCS technologies.

2. **Mr. Mark Gaffigan:** Director, Natural Resources and Environment Team at the U.S. Government Accountability Office (GAO). Mr. Gaffigan will summarize the GAO's report on the restructured FutureGen program and the conclusions to be drawn for a path forward on CCS policy decisions.

3. **Dr. Robert J. Finley**: Director, Energy and Earth Resources Center for Illinois State Geological Survey with specialization in fossil energy resources. He is currently heading a regional carbon sequestration partnership in the Illinois Basin aimed at addressing concerns with geological carbon management. Dr. Finley will provide an update on activities at the Midwest Geological Sequestration Consortium and provide information about the injection site selection process and strategies for monitoring the site.

4. **Mr. Larry Monroe**: Senior Research Consultant at Southern Company. Mr. Monroe will discuss carbon capture and storage projects his company has underway and some of the technical challenges and other barriers to the deployment of CCS systems on a commercial scale.

5. **Ms. Sarah Forbes:** Senior Associate, Climate and Energy Program at the World Resources Institute. Ms. Forbes will discuss the World Resources Institute's ongoing activities to establish guidelines and recommendations for the deployment of carbon capture and storage technologies. She will describe ongoing activities and new initiatives underway to facilitate international collaboration on advanced coal technologies and the benefits and challenges associated with widespread demonstration and commercial application of CCS programs.

Background

The Department of Energy (DOE) manages a number of different programs designed to research and develop technologies to meet the goal of reducing greenhouse gas emissions from our nation's coal-fired power plants and other industrial sources. The Department's programs include the Clean Coal Power Initiative, FutureGen, Innovations for Existing Plants Program, the Advanced Turbines Program, the Advanced Integrated Gasification Combined Cycle Program, and the Carbon Sequestration Regional Partnerships to name some of the specific programs that aim to improve power plant efficiencies, advance the development of carbon capture and storage technologies and reduce the costs of these technologies. In addition, the Department leads U.S. government participation in the Carbon Sequestration Leadership Forum that was established in 2003 and is comprised of twenty-one countries and the European Commission. Its goal is to facilitate the development of cost-effective technologies and strategies for CO_2 separation, capture and long-term storage and to make these tools broadly available around the globe.

It is well known that approximately 50 percent of the electricity generation in the United States comes from coal. On a global scale, approximately 41 percent of the electricity production is from coal.[1] It is also well understood that the burning of fossil fuels contributes significantly to greenhouse gas emissions. The International Energy Agency (IEA) 2008 report states, "The CO_2 concentration in the atmosphere is 385 ppm, and is rising by about 2 ppm per year."[2] The IEA further states that "[S]tationary CO_2 sources associated with fossil-fuel energy use produce the bulk of the world's CO_2 emissions." Specifically, the IEA report finds that electricity and heat production produced 9.6 Gt of CO_2 in 2005 out of a total 26.3 Gt.[3]

As we move to adopt policies to reduce greenhouse gas emissions in the United States, the electricity generating sector of our economy certainly will be one target to achieve those emissions reductions. While the details of a national climate change program are unknown at this time, there is much discussion about the suite of practices we must adopt and the portfolio of technologies we must deploy to meet the daunting challenge of climate change. As part of that

[1] International Energy Agency, *World Energy Outlook 2007: China and India Insights*, pp. 593.
[2] International Energy Agency, *Energy TechnologyPerspectives* 2008: *Scenarios & Strategies to 2050* , pp. 52.
[3] OECD/IEA, *CO_2 Capture and Storage: A Key Carbon Abatement Option,* 2008, pp. 46.

discussion there is growing interest in determining how significant a role carbon capture and storage systems can play in managing greenhouse gas emissions from coal-fired power plants.

Carbon Capture

There are three main technology options for capturing CO_2 from power plants or other industrial facilities: 1) post-combustion capture, 2) pre-combustion capture, and 3) oxy-fuel combustion capture.

Post-combustion processes captures the CO_2 from the exhaust gas through the use of distillation, membranes, or absorption, which can be physical or chemical. These technologies may be used to retrofit existing plants or incorporated into the design of new industrial facilities and electricity generating plants. There are some outstanding issues with these technologies that need to be addressed. One issue is the loss of efficiency. Energy is required to operate these technologies, thus lowering the overall power plant efficiency and increasing power generation costs. A second issue is the energy loss associated with the compression of the CO_2 after it is captured and prepared for pipeline transport. There are commercially available technologies that perform post-combustion capture, but generally, they have not been applied to large volumes of flue-gas streams such as those created by coal-fired power plants.

Pre-combustion capture first reacts the fuel with oxygen in a gasifier to create a syngas consisting of carbon monoxide and hydrogen -- an Integrated Gasification Combined Cycle (IGCC) plant is currently a requirement for the pre-combustion capture of CO_2 for electricity generation. The syngas is cleaned of conventional pollutants (SO_2, particulates) and sent to a shift reactor which uses steam and a catalyst to produce CO_2 and hydrogen. Then, a physical solvent can be used to separate out the CO_2. After the capture process, the CO_2 can be compressed for transportation and long-term storage in geologic formations. The hydrogen is directed through gas and steam cycles to produce electricity. While construction costs for an IGCC plant are higher than those for a pulverized coal plant, IGCC's operate at a higher efficiency and the penalty for the carbon capture technology is considered to be less. There are currently two commercial IGCC plants operating in the United States, and despite the potential for improved environmental performance and greater fuel efficiency of IGCC, higher costs have held back a major breakthrough in the U.S. market.

The oxy-fuel process feeds pure oxygen into the combustion process of the conventional air-fired power plant. This type of technology aims to address CO_2 during the combustion stage by increasing the CO_2 concentration of the flue gas exiting the boiler so that less energy is required to prepare the gas for storage. A main advantage is that the lower the energy penalty, the lower the cost. However, the pure oxygen generally would be provided by an air-separation unit which is energy intensive to operate and a primary source of reduced efficiency. There is ongoing work targeted at improving the efficiency of this air-separation process. There are initiatives in the United States to demonstrate this type of technology, but it has not yet been tested in a large-scale facility.[4]

[4] Department of Energy, *Strategies for the Commercialization and Deployment of Greenhouse Gas Intensity-Reducing Technologies and Practices*, January 2009.

Carbon Storage

Following the compression and transportation (if needed) of the captured CO_2, it would be injected into suitable geological formations for long-term storage. Currently, the most promising reservoirs for storing CO_2 are oil and gas fields, deep saline reservoirs and unmineable coal seams. The geologic formations best suited to trap large volumes of CO_2 and do so without leakage would have characteristics that include open spaces or porosity, sufficient interconnectivity between the open spaces so that CO_2 can flow laterally or migrate within the formations (known as permeability) and a layer of cap rock that is impermeable to prevent the upward flow of CO_2 keeping it underground.

The Department of Energy has made an assessment of the potential sequestration capacity across the United States and parts of Canada and determined there exists sufficient volume to store approximately 600 years of CO_2 produced from total U.S. fossil fuel emissions at current rates. The accuracy of this CO_2 storage capacity estimate will be tested and updated as the Department's seven regional sequestration partnerships continue to conduct injection tests and carry out large-scale injection experiments. For example, the tests conducted by the partnerships will help to confirm the efficiency of the available pore space and evaluate their assumptions about the properties of the geologic formations.

Characterizing geologic reservoirs for the purposes of CO_2 sequestration is an ongoing research effort including the work done by the Department's sequestration partnerships. Information derived from ongoing research and demonstration efforts will provide information that would be used to guide site selection for full-scale CCS operations in the future. This is particularly important for non-oil and gas sites, such as deep saline reservoirs, which do not have the same level of engineering experience.

It is expected that the reservoir characterization process will rule out geologic formations that are risky because they are too shallow, inadequate caprock exists, or they are intersected by permeable faults and fractures and therefore provide pathways for CO_2 to escape. There are also concerns about the potential impacts of injected CO_2 on aquifers used for drinking water or as supplies for agriculture.

There are no federal regulations governing the injection and storage of CO_2 for the purposes of carbon sequestration. However, in July 2008, the U.S. Environmental Protection Agency released a draft rule that would regulate CO_2 injection for sequestration purposes under the authority of the Safe Drinking Water Act, Underground Injection Control (UIC) program. Final regulations are anticipated in the 2010/2011 timeframe.

The terms measurement, monitoring and verification (MMV) are frequently used to describe the plan and tools for characterizing the subsurface reservoir and for detecting changes throughout the injection, closure, and long-term oversight of a geologic storage project. Because the geology varies from site to site, there is no universal agreement on the specific elements that should be included in MMV for all large-scale geologic sequestration projects.

FutureGen:

In 2003, President Bush and the Department of Energy announced their FutureGen initiative. FutureGen was described as the first zero-emission, coal-fired electricity-generating plant that would also produce hydrogen. FutureGen was a major technology initiative to address climate change and to support the administration's hydrogen fuel initiative.

Under the FutureGen program, DOE would oversee a consortium of industrial interests (the FutureGen Alliance) and international partners that would manage the construction of a $1 billion next-generation integrated gasification combined cycle (IGCC) power plant to produce electricity and hydrogen. There were three main components to the original FutureGen program. It would be a state-of-the art demonstration of a 275 megawatt IGCC power plant designed to capture, compress and store carbon dioxide, emit virtually no conventional air pollutants, and produce hydrogen fuel. FutureGen was also intended as the United State's major collaborative effort with international partners (India, Korea, etc.) to demonstrate an integrated CCS system using advanced gasification technology. Finally, FutureGen was to serve as a living laboratory to test advanced coal technologies in order to achieve operational efficiencies and speed deployment of CCS technologies. Between FY 2003 and FY 2008, Congress appropriated approximately $174 million for the FutureGen Initiative.

On January 30, 2008, the Department of Energy announced a major restructuring of the FutureGen program. Rather than build a 275 megawatt IGCC power plant to test CCS technologies and provide for the demonstration of an integrated carbon capture and sequestration system, the Department would support the private sector's investment in IGCC power plants by providing the additional funding needed to add CCS technologies to the construction of multiple commercial power plants being pursued by industry. Although, initially the restructured FutureGen focused on IGCC facilities, the final Funding Opportunity Announcement included other advanced coal power plants. It is important to note, that the restructured program eliminates the hydrogen production and the living laboratory components of the original program.

Since the announcement to restructure FutureGen, DOE issued a Funding Opportunity Announcement for the restructured program in June 2008. The Department has received a handful of proposals and those proposals are under review. In addition, the American Recovery and Reinvestment Act (ARRA) of 2009 includes $3.4 billion for fossil energy research and development and some of these funds could be used for FutureGen. Recently, Secretary Chu testified in the Senate Energy and Natural Resources Committee that he would support the plant with "some modifications."[5] In response to the ARRA, DOE is planning to issue four Funding Opportunity Announcements for improving techniques to clean or capture and store the emissions from coal-fired electric generating plants and other industrial sources. It is still unclear if those funds will be used for FutureGen and what, if any, modifications will be made to the FutureGen program going forward.

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[5] Kindy, Kimberly, *"New Life for 'Clean Coal' Project: Illinois Plant was Abandoned by Bush, Now Its Backers are in Power," Washington Post*, Friday, March 6, 2009.

International Activities:

China is the world's largest coal user, accounting for 63 percent of the country's total primary energy supply.[6] India is the world's third-largest coal user accounting for 62 percent of the country's energy supply and its use is expected to grow rapidly.[7] As stated above, the United States relies on coal for approximately 50 percent of its electricity production. Climate change is a global problem and major world economies see a growing need to work collaboratively to develop and deploy advanced coal technologies.

This past summer at the G-8 Summit in Japan, the G-8 leaders asked the International Energy Agency (IEA) to develop an energy roadmap for CCS technologies. The IEA intends to build the roadmap based on workshops convened in 2006-2007 by the IEA and the Carbon Sequestration Leadership Forum (CSLF). The roadmap will make recommendations for the G-8 in policy areas including financial, legal and international cooperation endeavors to help expand the deployment of CCS strategies. The G-8 Ministers also issued a joint-statement supporting the IEA and CSLF's recommendation to launch 20 large-scale CCS projects globally. Australia has taken steps to create a Global Carbon Capture and Storage Institute to assess CCS and facilitate international research collaboration covering a range of technologies and geologies. The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) was founded in 2005 to ensure CCS is commercialized by 2020. In 2004, the China Huaneng Group led the development of the GreenGen project to build an IGCC plant with CCS. While pieces of an integrated CCS system are being demonstrated at various scales throughout the world, no large-scale integrated CCS project has been conducted on a coal-fired power plant to date. Knowledge transfer of these technologies and investment cooperation may be critical if international goals for greenhouse gas emissions reductions are to be achieved.

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[6] OECD/International Energy Agency, *CO_2 Capture and Storage: A Key Carbon Abatement Option,*" 2008, pp. 154.

[7] OECD/International Energy Agency, *CO_2 Capture and Storage: A Key Carbon Abatement Option,*" 2008, pp.162.