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Thank you Mr. Chairman and Members of the Committee. I appreciate this opportunity to provide testimony on the Department of Energy's (DOE's) Clean Coal Research and Development (R&D) Program.

The economic prosperity of the United States over the past century has been built upon an abundance of fossil fuels in North America. The United States' fossil fuel resources represent a tremendous national asset. Making full use of this domestic asset in a responsible manner enables the country to fulfill its energy requirements, minimize detrimental environmental impacts, and positively contribute to national security.

Given current technologies, coal prices, and rates of consumption, the United States has approximately a 250-year supply of coal available. Coal-fired power plants supply about half of our electricity and are expected to continue to do so through mid-century. Because electricity production increases at a rate of about 2% per year, the rate of coal use will increase proportionally. However, the continued use of this secure domestic resource will be dependent on the development of cost-effective technology options to meet both economic and environmental goals, including the reduction of greenhouse gas emissions.

ENERGY ISSUES FACING THE UNITED STATES

Several overarching issues characterize the current energy situation in the United States. Their resolution depends in part on designing and implementing a timely and properly tailored research, development, and demonstration strategy, which could help sustain economic growth in the United States. The major issues are energy affordability and supply security, and environmental quality.

ENERGY AFFORDABILITY AND SUPPLY SECURITY

The availability of affordable energy has been instrumental in helping establish the United States' economic engine. The relatively recent escalation in energy prices, particularly in oil and natural gas, stem, in large measure, from the global competition for these energy resources. In particular, as economies in China, India, and other countries in the developing world expand to meet the demands of their huge populations, their impact on world markets will increase through increased competition for oil and gas supplies. Further complicating this issue are socio-political and other influences that can affect the energy market.

Despite gains in energy efficiency and projected conservation, stemming in part from higher prices, the Energy Information Agency (EIA) projects that the U.S. will require increasing amounts of energy through 2030, the last year that EIA models. Even after accounting for growing contributions from renewable energy and nuclear, our domestic coal resources will be required to provide an affordable portion of our growing needs.

ENVIRONMENTAL QUALITY

All fossil fuels incorporate carbon and all contain, to greater or lesser degrees, undesirable components, such as sulfur, nitrogen, and other trace elements, that can potentially harm the earth's biota.

It has long been recognized that coal-fired power plants emit sulfur and nitrogen containing compounds that combine with the moisture in the atmosphere to produce acid rain, and even acid snow. The generation of acid rain is not limited to local regions around the power plant. These acid forming emissions are often carried over hundreds to thousands of miles by wind currents where they are deposited to earth through rain or snow. In addition to sulfur and nitrogen compounds, coal power plants are also known to emit particulates that can, if unmitigated, lead to harmful health effects.

Air toxics is a term used to describe atmospheric pollutants that, if unmitigated, can also cause serious health effects. Air toxics include heavy metals, volatile organics, dioxins, and mercury. Relative to fossil fuel use, mercury has been the focus of recent attention and regulatory action. Mercury health effects are still being investigated but have, thus far, been linked to neurological, cardiovascular, and respiratory illnesses.

Currently, there is growing consensus that increased levels of greenhouse gases in the atmosphere, primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons, are linked to climate change. In this connection, fossil fuel use has been identified as a major source of anthropogenic greenhouse gas emissions, particularly carbon dioxide, into the atmosphere. Slowing the growth of anthropogenic greenhouse gas emissions has become an important concern.

The production of electricity using fossil, nuclear, and renewables requires large quantities of water and produces waste byproducts. In the United States, thermoelectric power plants utilize more than 130 billion gallons of water per day. With water supply and availability issues becoming more acute across the major growth areas of the United States, the energy industry will need to take bold steps to conserve water, while meeting all environmental

requirements. Coal-fired power plants also produce more than 120 million tons of solid waste byproducts each year. While 40% of these are re-used in various markets, the remainder is deposited into landfills and requires careful management and monitoring to prevent harmful environmental impacts.

Ensuring environmental quality is not a simple matter. Environmental requirements are becoming increasingly stringent and require new technologies to address the challenges of regulatory compliance. The use of fossil fuels is clearly essential for the foreseeable future. Therefore, industry, and where appropriate in collaboration with the public sector and others, must reduce the environmental impact of utilization of these fuels.

HOW IS DOE RESPONDING TO THE ISSUES

The Office of Fossil Energy (FE) recognizes the complex energy challenges facing America today. Its programs are directly responding to the issues laid out above, as well as to the direction provided by Congress and the Administration. To ensure a secure energy future for the United States, the Nation must commit to energy efficiency and renewable energy, but it also must promote the cleaner and more productive use of domestic energy resources, including coal, oil, and natural gas. The following key thrusts in Fossil Energy's research portfolio will lead the way in enhancing energy security from fossil fuels.

Near-Zero Atmospheric Emissions Energy – DOE is spearheading an R&D effort called FutureGen that will utilize technology developments from the core R&D program to provide near-zero atmospheric emissions clean coal power plants – including carbon capture and sequestration – that could ultimately be built at costs comparable to current day technology. Together with its supporting technologies for reducing all criteria pollutants, FutureGen will help to ensure that coal-fired power plants meet the most stringent environmental requirements.

Climate Change – DOE conducts R&D that contributes to expanding the options for meeting near-term greenhouse gas intensity goals, set by President Bush in the Global Climate Change Initiative. By meeting the near-term intensity goals, the longer-term goal of atmospheric greenhouse gas stabilization will become more achievable. Federal investment in climate change mitigation technologies has one overriding benefit: a broad suite of such technologies can expand the menu of future policy choices, both domestically and internationally. Without technology advances, the choice of future greenhouse-gas-reducing technologies may be limited to those that are either prohibitively expensive or require massive overhauls to existing infrastructure.

ROLE OF PUBLIC INVESTMENT IN R&D

America's fossil fuel industry is a mature industry made up of thousands of small companies and major corporations. The strategic role of the Federal Government in FE R&D is to develop technology options that can benefit the public by addressing market failures. More specifically, FE carries out high-risk, high-value R&D that can:

Accelerate the development of new energy technologies beyond the pace that would otherwise be dictated by normal market or regulatory forces.

Expand the slate of beneficial energy options beyond those likely to be developed by the private sector on its own.

Potentially result in revolutionary "breakthrough" technologies that achieve environmental, efficiency, and/or cost goals well beyond those currently pursued by the private sector.

The Federal R&D program is working to provide advanced technology options that are significantly more effective and affordable than today's limited set of fossil energy technologies.

The success of this activity could not only benefit current power stations but also strengthen the technical foundation for the next generation of coal-fueled power plants – serving to preserve energy diversity and strengthen domestic energy security. The Federal presence in this type of R&D may also provide scientifically sound data for future governmental regulatory and policy decisions.

Similarly, the current uncertainty regarding future regulation of CO_2 is not conducive to significant private-sector investment in greenhouse gas mitigation technologies. The Federal R&D program, therefore, is developing a wide range of potential carbon mitigation approaches – such as carbon sequestration – that can be used by the private sector for future investment opportunity.

Every year, DOE conducts a benefit analysis to quantify and highlight the significant economic- and energy-sector benefits attributable to R&D programs. Estimated impacts on oil and gas production, oil imports, power generation technology market penetration, carbon intensity, and fuel prices are the basis for estimating economic, environmental, and energy security benefits from FE's R&D programs.

PRIVATE-SECTOR R&D ISSUES

Within the electric power industry, R&D investments have been historically modest. The National Science Foundation estimates utility-funded R&D at $114 million in 2001. Nationally, the production of electricity consumes over 40 quadrillion British thermal units of energy a year. Sixty-nine percent of this energy is contributed by fossil fuels and coal is the largest single such contributor of all the fossil resources. However, over 65% of that potential energy in that coal is lost in the process of generation. Thus, the Nation has an obvious interest in increasing the efficiency of electricity generation, and thereby reducing harmful emissions

while allowing the continued use of its most abundant fossil resource – coal. The regulations of the Clean Air and Water Acts, as well as the goals of the Clear Skies Initiative, as embodied in the Clean Air Interstate Rule and the Clean Air Mercury Rule, give utilities the incentives to provide the necessary level of R&D needed to achieve these goals. Where the incentives do not exist, government may have a role.

CLEAN COAL TECHNOLOGY

DOE's Office of Fossil Energy is devoted to ensuring that the Nation can continue to rely on clean, affordable energy from traditional fuel resources. This mission is accomplished through a mix of internal and external R&D efforts that concentrate the expertise and talents of thousands of public- and private-sector scientists, engineers, technicians, and other research professionals. The Department is developing a portfolio of cost-effective near-zero atmospheric emissions technologies, including greenhouse gases, for the future fleet of coal-based energy plants. The RD&D Program is divided into a demonstration component and a core R&D program.

DEMONSTRATION PROGRAM

The success of Clean Coal R&D will ultimately be judged by the extent to which emerging technologies get deployed in domestic and international marketplaces. The technical and financial risks associated with the deployment of new coal technologies are key factors determining whether they will achieve success in the marketplace.

In 1985, the Congress authorized DOE to initiate the Clean Coal Technology Demonstration Program to provide additional impetus to move technology from the laboratory to the marketplace. The purpose of the program was to develop and demonstrate, at commercial scale, a family of innovative technologies that would help industry to meet the strict environmental requirements that were ultimately contained in the Clean Air Act Amendments of

1990. The Program was developed as a Government/industry cost-shared partnership and DOE's cost share was limited to a maximum of 50% of the funding for each participating project.

The first projects were started in 1987. These projects were selected in the first of five rounds of competition. Over the course of the program, 34 projects have been completed. The total cost of these five rounds was approximately $3.3 billion, with DOE contributing approximately $1.3 billion. In 2001, a solicitation for a follow-on to the original five rounds was issued. This program was called the Power Plant Improvement Initiative (PPII), and it resulted in six projects, of which four are finished, one is still active, and one was withdrawn. The total value of the five implemented PPII projects was approximately $71 million, with DOE contributing approximately $32 million.

The program that followed PPII is the Clean Coal Power Initiative (CCPI). Solicitations issued in 2002 and 2004 resulted in a total of 10 projects, eight of which are active, one is not yet started, and one was withdrawn. The value of the CCPI projects is approximately $2.7 billion, with the DOE contribution set at $530 million. The CCPI and the earlier programs are referred to collectively as the Clean Coal Technology Demonstration Program (the Program).

More than 20 technologies from the Program have achieved commercial success in technologies related to low-NOx burners, selective catalytic reduction, flue gas desulfurization, and fluidized-bed combustion. It is difficult to determine how much commercialization of these technologies would have happened absent the DOE assistance.

FUTURE DEMONSTRATION PROGRAM

Announcement of the third solicitation under CCPI is planned in FY 2007. Its focus is on carbon capture and storage technologies. This current round specifically targets advanced coal-

based systems and subsystems that capture or separate carbon dioxide for sequestration or for beneficial uses. Round 3 is also open to any coal-based advanced carbon capture technologies that result in co-benefits with respect to efficiency, environmental, or economic improvements potentially capable of achieving CCPI coal technology performance levels specified in Title IV of the Energy Policy Act of 2005.

DOE is interested in demonstrating advanced technologies not currently deployed in the marketplace – specifically technologies capable of producing electricity alone or in any combination with heat, fuels, chemicals, or hydrogen. Prospective projects must, however, ensure that coal is used for at least 75% of the fuel energy input to the process and that electricity is at least 50% of the energy-equivalent output from the technology demonstration.

DOE is currently developing large-scale field tests of geologic carbon sequestration, on the order of 1 million metric tons of CO_2 per year, and is looking for the best way to structure the requirements of the current announcement to allow demonstration projects under CCPI to integrate with the sequestration field tests.

CORE COAL R&D PROGRAM

The Office of Fossil Energy's core coal R&D program provides for the development of new cost- and environmentally-effective approaches to coal use, approaches at pre-demonstration scale. It includes Advanced Research, Advanced Turbines, Carbon Sequestration, Fuel Cells, Gasification, Hydrogen and Fuels, and Innovations for Existing Plants, which are described in more detail below.

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 power- and energy-production systems. Research objectives include resolving the technology barriers that enable improvements to emerging power systems as well as fundamental research on novel technologies that can be utilized in clean energy production. The objective of the program is to support development of critical enabling technologies to make it possible for the line programs to achieve their goals of developing advanced, coal-based power systems for affordable, efficient, near-zero atmospheric emissions power generation. Example developments include high-temperature materials, revolutionary sensors and controls, and advanced computing/visualization techniques.

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. The Program focuses on the combustion of pure hydrogen fuels in MW-scale turbines greater than 100 MW size range and the compression of large volumes of CO_2. Since advanced turbines will be fuel flexible, capable of operating on hydrogen or syngas, they will make possible electric power generation in gasification applications configured to capture CO_2.

Carbon Sequestration

The Carbon Sequestration Program consists of a portfolio of laboratory and field R&D focused on technologies with great potential for reducing greenhouse gas emissions. Most efforts focus on capturing carbon dioxide from large stationary sources such as power plants, and sequestering carbon dioxide in geologic formations. The Program also addresses the control of fugitive methane emissions, which is another potent greenhouse gas. Carbon sequestration is a key component of the President's strategy to slow the growth of greenhouse gas emissions, as

well as several National Energy Policy goals targeting the development of new technologies. It also supports the goals of the Framework Convention on Climate Change and other international collaborations to reduce greenhouse gas intensity and greenhouse gas emissions. The programmatic timeline is to demonstrate a portfolio of safe, cost-effective greenhouse gas capture, storage, and mitigation technologies at the pre-commercial scale by 2012, leading to demonstration and substantial deployment and market penetration beyond 2012. These greenhouse gas mitigation technologies could help slow greenhouse gas emissions in the medium term. They also provide potential for ultimately stabilizing and reducing greenhouse gas emissions in the United States.

Fuel Cells

Fuel cells could help support the efficiency and emission targets of future power plants, such as FutureGen. The 50% higher heating value target is challenging, and fuel cells can clearly facilitate achieving this target when used as the main power block, possibly in combination with a turbine. In order to ensure the ability to site future power plants in any state in the country, low emissions of criteria pollutants will be required. Fuel cell emissions are well below current and proposed environmental limits. Fuel cells could play a significant part in energy security. Their modular nature permits use in central or distributed generation with equal ease. Rapid response to emergent energy needs is enhanced by the modularity and fuel flexibility of fuel cells. The ultimate goal of the program is the development of low-cost large (>100 MW) fuel cell power systems that will produce affordable, efficient, and environmentally friendly electrical power from coal with greater than 50% higher heating value (HHV) efficiency, including integrated coal gasification and carbon dioxide separation processes and

capture at least 90% of the CO_2 emissions from the system. The cost goal for fuel cells in coal systems is to achieve a ten-fold reduction in the fuel cell system cost.

FutureGen

FutureGen is a $1 billion Government-industry initiative to design, build, and operate an advanced, coal-based, Integrated Gasification Combined-Cycle (IGCC) power plant to:

- Co-produce electricity and hydrogen;
- Achieve near-zero atmospheric emissions, with geological sequestration of carbon dioxide
- Demonstrate system integration of cutting edge technologies; and
- Chart a technological pathway toward an energy future in which near-zero atmospheric emissions clean coal power plants can be designed, built, and operated at a cost that is no more than 10% above the cost of non-sequestered systems.

Coal continues to face environmental challenges relative to other energy sources. The near-zero atmospheric emissions concept spearheaded by FutureGen is vital to the future viability of coal as an energy resource, particularly in light of growing climate change concerns. Coal is abundant, secure, and relatively inexpensive when compared to other energy sources. With near-zero atmospheric emissions, coal could not only produce baseload electricity, but also help germinate a hydrogen energy economy.

Gasification

Gasification is a pre-combustion pathway to convert coal or other carbon-containing feedstocks into synthesis gas, a mixture composed primarily of carbon monoxide and hydrogen; the synthesis gas, in turn, can be used as a fuel to generate electricity or steam, or as a basic raw material to produce hydrogen, high-value chemicals, and liquid transportation fuels. DOE is

developing advanced gasification technologies to meet the most stringent environmental regulations in any state and facilitate the efficient capture of CO_2 for subsequent sequestration – a pathway to "near-zero atmospheric emissions" coal-based energy. 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, could help reveal the technical pathways enabling gasification to meet the demands of future markets while contributing to energy security.

Hydrogen and Fuels

DOE developed the Hydrogen Posture Plan to integrate and implement the technology needed to achieve the Hydrogen Economy. The Hydrogen from Coal Program was initiated in fiscal year 2004 to support the President's Hydrogen Fuel Initiative, DOE's goals in the Hydrogen Posture Plan, and the FutureGen project. The mission of the Hydrogen from Coal Program is to develop advanced technologies through joint public and private RD&D to facilitate the transition to the hydrogen economy through central production of gaseous hydrogen.

Innovations for Existing Plants

Over the past three decades, the existing fleet of coal-fired power plants has made significant strides in reducing air emissions, minimizing impacts on water quality and availability, and managing solid byproducts. As the coal-based electric utility sector enters the 21st century, it will be faced with additional environmental issues such as mercury, nitrogen oxide, air toxics, and acid-gas emissions control requirements, constraints on water availability needed for plant cooling and other purposes, and decreasing space available to dispose of the solid residues from coal combustion. The Innovations for Existing Plants subprogram supported technology development in anticipation of regulatory limits that are now being implemented

through the Clean Air Interstate Rule and the Clean Air Mercury Rule. These rules were promulgated in 2005, giving the private sector an incentive to develop the technologies required to reduce their pollutant emissions. Because the government role in development of these technologies has shifted to the private sector, the Innovations for Existing Plants subprogram is no longer needed.

CONCLUSION

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 Clean Coal Technology Program.

Approaches demonstrated through the program include coal processing to produce clean fuels, combustion modification to control emissions, post-combustion cleanup of flue gas, and repowering with advanced power generation systems. These efforts helped accelerate production of cost-effective compliance options to address environmental issues associated with coal use. Relative to carbon capture and storage, DOE is making significant progress in developing the technologies and infrastructure needed for deployment of these technologies in a future carbon-constrained world. The following are some examples of clean coal successes that were developed in part with DOE support:

- The current generation of low-NOx burners alone is a major clean coal success story. Nearly $1.5 billion of these burners have been sold. Selective catalytic reduction now costs half what it did in the 1980s and systems are on order or under construction for 30 percent of U.S. coal-fired plants.

- Flue gas scrubbers are a third of their cost in the 1970s, and they are more reliable, less costly and more efficient due to innovations developed and tested in Clean Coal Technology Program.
- Fluidized bed technology developed in the core coal R&D program and first demonstrated in the program has recorded global sales of over $10 billion.
- In Tampa, Florida, and West Terre Haute, Indiana, the first pioneering, full-size coal gasification power plants have opened a new pathway for the next generation of clean, fuel-flexible power plants. This was made possible through demonstration projects under the Clean Coal Technology Program.
- A number of the commercial demonstration projects have received technology achievement awards. These include the Tidd pressurized fluidized-bed combustion project by Ohio Power Company; Babcock & Wilcox Company low-NOx/cell burner project; Pure Air Lake's advanced flue gas desulfurization project; and Southern Company Services' CT-121 flue gas desulfurization project.
- Advanced coal preparation work previously conducted at NETL's onsite research facilities is now standard practice in the energy industry in achieving product quality specifications for sulfur emissions compliance, as well as reductions of other air pollutants including mercury and other trace elements.
- Work sponsored by the clean coal program continues to look at mercury and multi-pollutant controls for coal-fired boilers. Operation of the TOXECON™ process, which could offer coal-fired power plants a low-cost retrofit option for reducing mercury emissions by up to 90%, was initiated at the We Energies Presque Isle Power Plant in

Marquette, Michigan. This project demonstrates the first full-scale commercial mercury-emission-control system for permanent operation.

- The Carbon Sequestration Atlas of the United States and Canada, developed by NETL, the Regional Carbon Sequestration Partnerships (Partnerships), and the National Carbon Sequestration Database and Geographical Information System, contains information on stationary sources for CO_2 emissions, 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 sites.
- CO_2 capture technology is being developed for solvent, sorbent, membrane, and oxy-combustion systems that, if successfully developed, would be capable of capturing 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. Research and systems analysis have identified potential cost reductions of 30-45% for the capture of CO_2. In addition, ionic liquid membranes and absorbents are being developed for capture of CO_2 from power plants. Ionic liquid membranes have been developed at NETL for pre-combustion applications that surpass polymers in terms of CO_2 selectivity and permeability at elevated temperatures.
- 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 perfluorocarbon tracers to track CO_2 movement through a reservoir. DOE-sponsored research has also led to the development of the U-Tube sampler, which was developed for and successfully deployed at the Frio test site in Texas. This novel tool is

used to obtain geochemical samples of both the water and gas portions of downhole samples at *in situ* pressure.

- The Carbon Sequestration Regional Partnerships have brought an enormous amount of capability and experience together to work on the challenge of infrastructure development. Together with DOE, the Partnerships secured the active participation of more than 500 individuals representing more than 350 industrial companies, engineering firms, state agencies, non-governmental organizations, and other supporting organizations.
- The Partnerships are conducting field tests to validate the efficacy of carbon capture and storage technologies in a variety of geologic storage sites throughout the U.S. and Canada. Using the extensive data and information gathered during the initial stages of the project, the seven Partnerships identified the most promising opportunities for carbon sequestration in their Regions and are performing 25 geologic field tests.

In conclusion, DOE's Clean Coal R&D Program has a successful track record and a promising future that will ultimately lead to coal plants with near-zero atmospheric emissions.

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