ADVANCING COAL RESEARCH AND DEVELOPMENT FOR A SECURE ENERGY FUTURE

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

THURSDAY, OCTOBER 13, 2011

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CONTENTS

October 13, 2011

ADVANCING COAL RESEARCH AND DEVELOPMENT FOR A SECURE ENERGY FUTURE

THURSDAY, OCTOBER 13, 2011

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 2:22 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Andy Harris [Chairman of the Subcommittee] presiding.

RALPH M. HALL, TEXAS
CHAIRMAN

EDDIE BERNICE JOHNSON, TEXAS
RANKING MEMBER

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Subcommittee on Energy & Environment

Advancing Coal Research and Development for a Secure Energy Future

Thursday, October 13, 2011
2:00 p.m. to 4:00 p.m.
2318 Rayburn House Office Building

Witnesses

Mr. Scott Klara, Deputy Director, National Energy Technology Laboratory

Ms. Janet Gellici, Chief Executive Officer, American Coal Council

Mr. Nick Akins, President, American Electric Power

Mr. David Foerter, Executive Director, Institute of Clean Air Companies

Mr. Stu Dalton, Senior Government Representative-Generation, Electric Power Research Institute

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Advancing Coal Research and Development for a Secure Energy Future

Thursday, October 13, 2011
2:00 p.m. to 4:00 p.m.
2318 Rayburn House Office Building

Purpose

On Thursday, October 13, 2011, at 2:00 p.m. in Room 2318 of the Rayburn House Office Building, the Subcommittee on Energy and the Environment will hold a hearing titled *"Advancing Coal Research and Development for a Secure Energy Future."* The purpose of this hearing is to examine current Department of Energy (DOE) coal research, development, and demonstration (RD&D) activities and identify future coal RD&D opportunities and priorities.

Witnesses

- **Mr. Scott Klara**, Deputy Director, National Energy Technology Laboratory
- **Ms. Janet Gellici**, Chief Executive Officer, American Coal Council
- **Mr. Nick Akins**, President, American Electric Power
- **Mr. David Foerter**, Executive Director, Institute of Clean Air Companies
- **Mr. Stu Dalton**, Senior Government Representative-Generation, Electric Power Research Institute

Overview

According to the Energy Information Administration (EIA), the United States currently generates approximately 45% of its electricity from coal-fired power plants. [1] EIA projects nationwide demand for electricity to increase 31% by 2035, with coal generation growing by 25% during this time. Globally, coal-fired generation currently produces over 40% of electricity,[2] and proven global coal reserves are estimated to be sufficient to last 118 years.[3] In 2010, 11 new coal-fired plants were commissioned in the United States, totaling 6,682 MW.[4]

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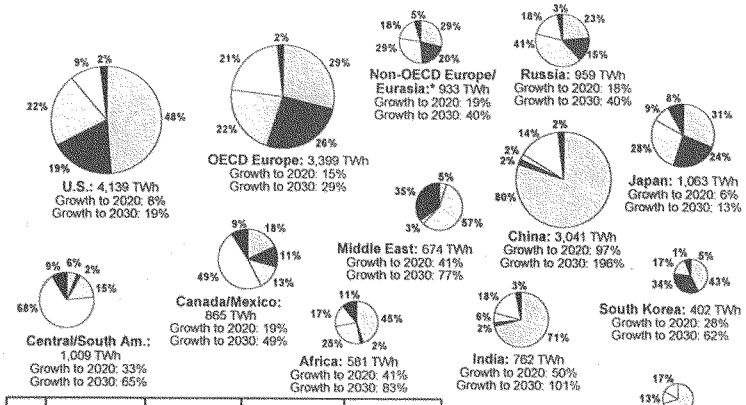
[1] Energy Information Administration, *"Annual Energy Outlook 2011,"* April 2011. Accessible at: http://www.eia.gov/forecasts/aeo/

[2] International Energy Agency, *"2011 Key World Energy Statistics,"* 2011. Accessible at: http://www.iea.org/textbase/nppdf/free/2011/key_world_energy_stats.pdf

[3] World Coal Institute, *"Coal Statistics,"* August 2011. Accessible at: http://www.worldcoal.org/resources/coal-statistics/

[4] National Energy Technology Laboratory, *"Tracking New Coal-Fired Power Plants,"* January 14, 2011. Accessible at: http://www.netl.doe.gov/coal/refshelf/ncp.pdf



	2007	2020	2030
World Totals	18,783 TWh	25,017 TWh (+33%)	31,649 TWh (+68%)
Coal	42%	39%	41%
Nuclear	14%	14%	13%
Gas	21%	20%	20%
Renew/ Hydro	18%	23%	23%
Liquid Fuel	5%	3%	2%

Data Source: U.S. Department of Energy, Energy Information Administration, International Energy Outlook 2010, data as of November 2009; U.S. numbers from Annual Energy Outlook 2011.

Figure 1-1
Electricity Generation by Fuel Type for Major Countries and Regions

5

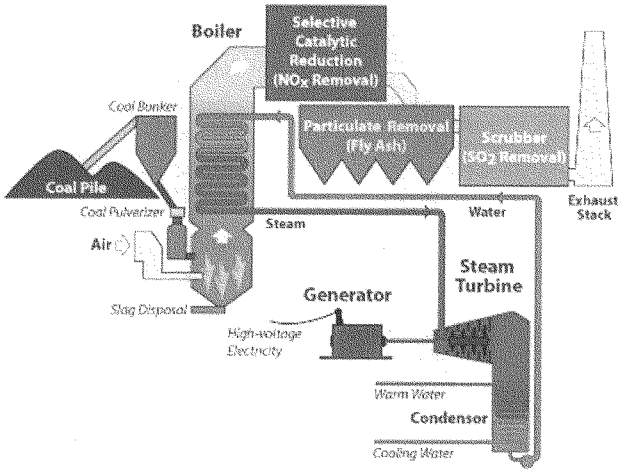
Key Components of Coal-fired Generation Plants

A number of variables contribute to the overall efficiency of a coal power plant. Key factors effecting overall plant performance and efficiency include the type of power cycle, combustion technology, and coal type employed. Typically as plants increase efficiency levels, fuel costs decrease, fewer traditional pollutants (such as SOx, NOx, particulate matter, and mercury) are emitted, less carbon dioxide is emitted, and water use per megawatt hour (MWh) decreases. For example, a gain of two percentage points in plant efficiency reduces the amount of fuel consumed by roughly 5% and provides similar reductions in CO_2 emissions.[6]

[5] Electric Power Research Institute, *"Advanced Coal Power Systems with CO2 Capture: EPRI's CoalFleet for Tomorrow Vision – 2011 Update,"* August 2011. P. 1-2

[6] EPRI CoalFleet for Tomorrow, p. 3-3.

Typical Coal-Fired Power Plant[7]



Steam Power Cycles

Steam power cycles reference the thermodynamic state of steam driving the turbines to produce electricity. As pressure and temperature increase, plants operate more efficiently. Cycles are classified[8] as:

- Subcritical—steam cycles with pressure levels of 2600 pounds per square inch absolute (psia) and steam temperatures of approximately 1000°F (538°C). Approximate efficiency, expressed as higher heating value (HHV): 34.3%[9];
- Supercritical—steam cycles, with steam conditions of 3500 psia and main steam temperatures of 1050°F (565°C). Approximate HHV efficiency: 38.5%;
- Ultra-Supercritical[10]—steam cycles with steam pressure greater than 3625 psia and steam temperatures greater than 1100°F (595°C). Approximate HHV efficiency: 43.3%. and
- Advanced" Ultra-Supercritical[11] with steam temperatures up to 1400°F (760°C). Approximate HHV efficiency: 47%.

Combustion Technologies

Many different approaches are used to combust coal to boil water, which generates steam. Combustion technologies include:

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[7] Partha Das Sharma, 2008.
[8] As defined by the EPRI CoalFleet for Tomorrow, p. 2-3.
[9] Massachusetts Institute of Technology, *"The Future of Coal,"* 2007. Accessible at: http://web.mit.edu/coal/The_Future_of_Coal.pdf
[10] A limited number of Ultra-Supercritcial plants are under construction globally.
[11] No current material exists resilient enough to withstand the high temperatures for sustained periods of time.

- Pulverized coal (PC) boilers, which are the most common combustion technology in existing plants and can be used with all steam power cycles currently in existence. PC boilers burn ground coal in a furnace for rapid combustion;
- Fluidized bed combustion (FBC), which burn coal in a bed of particles suspended in motion by combustion air;
- Circulating fluidized-bed combustion (CFBC), which build on FBC technology to accommodate higher heat and pressure steam cycles;
- Oxy-combustion boilers, which use separated oxygen to mix with recirculated flue gas to increase CO_2 concentrations. The CO_2-rich flue gas can be captured and easily compressed. No oxy-combustion commercial plants have yet been commissioned; however a number of oxy-combustion projects are under consideration.

Additionally, approximately ten integrated gasification combined-cycle (IGCC) plants are in operation globally. IGCC plants pair a gas turbine combined-cycle with a gasification unit to produce syngas from coal. Combined-cycle generation recovers heat from the hot exhaust of a gas turbine and produces steam to produce additional power.

Coal Types

Three types of coal are burned to produce electricity: bituminous, sub-bituminous, and lignitic. Each coal type has unique burn characteristics, which are matched with a specific coal-fired unit. Furnace size, boiler designs, and other power plant systems must align to optimally burn coal and produce power efficiently.

New Generation[12]

Technology Listings	**Operational (Since 2000)***	**Progressing (Permitted, Near, and Under Construction)***	**Announced***	**Total Proposed***
PC Subcritical	31	5	10	15
FBC	12	4	9	13
PC Supercritical	7	7	4	11
IGCC	1	5	13	18

*As of December 2010

Coal Research, Development & Demonstration Technology Issues

Areas of opportunity for RD&D exist throughout the entire generation system. Technological challenges and opportunities related to individual components typically impact an entire plant's operation and performance and thus must be pursued with the overall system in mind.

Carbon Capture and Sequestration

Current coal RD&D is primarily focused on efforts relating to carbon capture and storage (CCS). CO_2 can be captured using a variety of methods and either pre or post-combustion. Once CO_2 is

[12] NETL, *"Tracking New Coal-Fired Power Plants."*

captured, it must be condensed, transported, and stored in a geologic formation for an indefinite time period. According to DOE:

> "Existing CO_2 capture technologies are not cost-effective when considered in the context of large power plants. Economic studies indicate that carbon capture will add over 30 percent to the cost of electricity for new integrated gasification combined cycle (IGCC) units and over 80 percent to the cost of electricity if retrofitted to existing pulverized coal (PC) units. In addition, the net electricity produced from existing plants would be significantly reduced - often referred to as parasitic loss - since 20 to 30 percent of the power generated by the plant would have to be used to capture and compress the CO_2."[13]

DOE's current goal is to limit the additional cost of electric generation on a pulverized coal CCS plant to 30 percent, and 10 percent for an IGCC CCS plant.[14] Further, water use per MWh is expected to increase by 30-90% when a CO_2 system is installed.[15] Each portion of the CCS process needs additional RD&D to effectively demonstrate CCS technologies.

Enhanced Oil Recovery

CO_2 has been effectively used in a process known as enhanced oil recovery (EOR). EOR injects CO_2 into a previously depleted oil well, forcing additional pressure into the formation to extract oil unrecoverable using traditional extraction methods. A number of projects are underway in which a coal plant is sited near depleted oilfields for the sole purpose of providing CO_2 for EOR. EOR provides economic value for captured CO_2 and offers a potential revenue stream to offset some of the additional costs incurred in a coal-fired CCS system.

Efficiency

A significant hurdle to increasing plant efficiency is the lack of advanced materials resilient enough to withstand the high heat conditions for extended time periods. Various metal composites, such as nickel-based alloys and certain types of steel, have the necessary characteristics to allow higher firing temperatures, however such alloys are currently cost prohibitive. Further advances in materials research are needed to move beyond current plant efficiency limits.

Another opportunity to increase output of coal-fired plants rests with improving turbine efficiency. Larger blade sizes, new material, and gas turbine design optimization can result in increased output at greater efficiency rates. Incremental gains in turbine efficiency have significant impacts on the fleet of coal-fired plants, due to the size of each plant.

Water

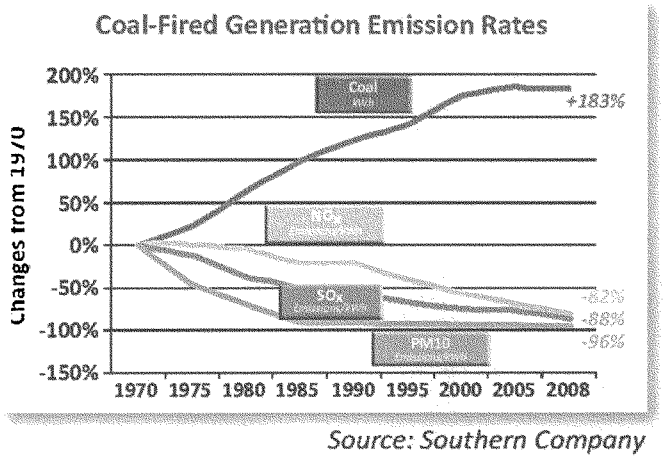
Water availability is of growing concern in certain regions of the United States and RD&D opportunities exist to reduce overall water impact. Supercritical PC plants use over nine gallons of water per minute for each MW of output (gpm/MW). That number rises to over 17 gpm/MW

[13] Department of Energy, "Retrofitting the Existing Coal Fleet with Carbon Capture Technology." Accessible at: http://fossil.energy.gov/programs/powersystems/pollutioncontrols/Retrofitting_Existing_Plants.html
[14] Department of Energy, "Carbon Capture and Storage R&D Overview." Accessible at: http://fossil.energy.gov/programs/sequestration/overview.html
[15] EPRI CoalFleet for Tomorrow, p. 7-1

if CCS is included.[16] IGCC units consume between six and ten gpm/MW which can increase to 16 gpm/MW with CCS. RD&D opportunities exist to reduce impact on water supply through various technology development. For example, optimizing steam cycles or using cooler condensers to lower steam backpressure would reduce water use.

Pollutant Control

While coal use has increased considerably in the last thirty years, traditional criteria pollutant emissions have significantly decreased due to increased effectiveness of pollutant control systems. The reduction in pollutants has been driven by the availability and installation of a number of pollutant control systems, such as flue gas desulfurization systems (commonly known as "scrubbers") to remove SO_2, post-combustion control technologies to remove NOx, or fabric filters (baghouses) to limit particulate matter. Technological advances in these areas could enable cost-effective compliance with continually tightening coal-related environmental regulations.



More broadly, a wide range of related RD&D can advance the use of coal, lessen the associated environmental impact, and improve plant efficiency. Engineered coal fuels consist of pre-treated coal to increase the energy content of the fuel, reduce the total amount of flue gases to be remove pollutants, and improve power plant efficiency. Opportunities also exist to improve system modeling to enable development of computational tools aimed at improving integration of system components and optimizing plant performance.

[16] EPRI CoalFleet for Tomorrow p. 7-2

Department of Energy's Coal Research and Development Activities

The Department of Energy funds a variety of coal research, development, and demonstration activities. DOE's Office of Fossil Energy (FE) is the primary office supporting coal RD&D. DOE's coal program mission is to "ensure the availability of near-zero atmospheric emissions, abundant, affordable, domestic energy to fuel economic prosperity, strengthen energy security, and enhance environmental quality."[17]

DOE Coal RD&D Budget (in thousands)

DOE Coal Programs and Subprograms	**FY 10 Appropriated**	**FY 11 CR**	**FY 12 Request**	**FY 12 House Approps Subcommittee Mark**	**FY 12 Senate Approps Subcommittee Mark**
Fuels and Power Systems Program Total	**403,078**	**400,165**	**0**	**n/a**	**n/a**
Innovations for Existing Plants	*52*	*64.8*	*0*		
Advanced Integrated Gasification Combined Cycle	*63*	*52.9*	*0*		
Advanced Turbines	*32*	*30.9*	*0*		
Carbon Sequestration	*154*	*142.0*	*0*		
Fuels	*25*	*12.0*	*0*		
Fuel Cells	*50*	*49.8*	*0*		
Advanced Research	*27.078*	*47.6*	*0*		
CCS and Power Systems Program Total	**0**	**n/a**	**291,358**	**338,762**	**291,358**
Carbon Capture	*0*	*n/a*	*68,938*		
Carbon Storage	*0*	*n/a*	*115,477*		
Advanced Energy Systems	*0*	*n/a*	*64,193*	*105**	
Cross Cutting Research	*0*	*n/a*	*42,750*	*49,347*	
TOTAL: Coal	**403,078**	**400,165**	**291,358**	**338,762**	**291,358**
TOTAL: Fossil Energy Research and Development	**672,383**	**444,528**	**452,975**	**476,993**	**445,471**

* Of this amount, the recommendation includes not less than $25 million to continue RD&D of solid oxide fuel cell systems, $5 million for High Performance Materials, and $10 million for the Coal and Coal-Biomass to Liquids Program. The recommendation also includes $8 million for continuing activities improving advanced air separation technologies, found within Gasification Systems, a subprogram of Advanced Energy Systems.

[17] Department of Energy, *"Department of Energy's Office of Fossil Energy: Budget in Brief FY12,"* February 2011. Accessible at: http://fossil.energy.gov/aboutus/budget/12_budget_in_brief_fy2012.pdf

In Fiscal Year (FY) 2011, FE received $444 million, of which $400 million was directed to coal RD&D. A recent study by Management Information Systems estimated FE's RD&D program would result in a benefit of $111 billion between 2000-2020, a 13 to 1 return for each dollar spent.[18]

The National Energy Technology Laboratory (NETL) is the primary energy research facility for FE. NETL conducts a broad spectrum of fossil energy research and administers FE's coal RD&D activities. NETL's coal RD&D programs fall into three categories: "technologies that enable existing coal power plants to cost-effectively meet environmental requirements, technologies for coal power plants of the future with dramatically improved performance, and clean coal demonstration projects."[19]

FE's coal RD&D consists of the Clean Coal Power Initiative (CCPI), which fund demonstration projects, and the Fuels and Power Systems program. The Fuels and Power Systems program currently consists of seven subprograms: Innovations for Existing Plants (IEP), advanced integrated gasification combined cycle, advanced turbines, carbon sequestration, fuels, fuels cells, and advanced research.

The Administration proposes to restructure the coal RD&D program in the FY 2012 budget request. FE explains:

> The proposed budget structure change reflects the increased focus of the program on Carbon Capture and Storage technologies. The new budget structure aligns the existing work of the Clean Coal program with four key sub-program research areas: Carbon Capture, Carbon Storage, Advanced Power Systems, and Cross-cutting Research.[20]

The program restructuring would shift the IEP subprogram to the carbon capture subprogram and the turbines, fuels, and fuels cells activities will be conducted by the advanced power systems subprogram. The cross-cutting research subprogram would consist primarily of the computational system dynamics ($11.8 million requested) and computational energy science ($13.4 million requested). The full explanation of the restructuring is included in Appendix A.

Additionally, the budget request proposes to eliminate or significantly reduce a number of coal RD&D activities. The proposal requests $973,000 for high performance materials research, down from $8.8 million in FY10. Hydrogen turbines funding request is $14.5 million, less than half the $31.2 million received in FY10. The budget request seeks to eliminate the coal and coal-biomass to liquids, solid oxide fuel cells, water management, and fine particulate control/air toxics programs.

FE currently is funding a portfolio of eight CCS demonstration projects. The American Recovery and Reinvestment Act (ARRA) provided $3.4 billion for CCS, of which the vast

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[18] Department of Energy, "*Fossil Energy Research Benefits,*" June 2011. Accessible at: http://www.fossil.energy.gov/aboutus/history/researchsuccesses/ReturnInvest_FC_HRes_draft2.pdf

[19] National Energy Technology Laboratory, Coal and power Systems. Accessible at: http://www.netl.doe.gov/technologies/coalpower/index.html

[20] Department of Energy 2012 Congressional Budget. Accessible at: http://fossil.energy.gov/aboutus/budget/12/FY2012_Coal_Budget_Structure.pdf

majority ($3.2 billion) was for nine large-scale demonstration projects. These demonstrations included carbon capture from coal-fired power plants (five), industrial sources (three), and FutureGen 2.0 (one). Typically, cost-sharing for these demonstration projects is 50-50 between DOE and industry. Currently, all of the projects are still in initial stages and are conducting engineering and technical activities. The full list of these projects is included in Appendix B.

Funding for CCS extends beyond FE. The Advanced Research Projects Agency – Energy (ARPA-E) issued a Funding Opportunity Announcement titled "Innovative Materials & Processes for Advanced Carbon Capture Technologies" (IMPACCT) in April 2010. IMPACCT seeks to reduce the costs associated with CCS through new materials research, improvements to existing processes, and demonstration of new capture processes. Fifteen awards totaling $30.6 million were disbursed (Appendix C).

The Administration has focused on CCS issues throughout multiple agencies. On February 3, 2010, President Obama established an Interagency Task Force on Carbon Capture and Storage, consisting of 14 Executive Departments and Federal Agencies. The Task Force issued their "Report of the Interagency Task Force on Carbon Capture and Storage" in August 2010. The Executive Summary noted:

> While there are no insurmountable technological, legal, institutional, regulatory or other barriers that prevent CCS from playing a role in reducing GHG emissions, early CCS projects face economic challenges related to climate policy uncertainty, first-of-a-kind technology risks, and the current high cost of CCS relative to other technologies. Administration analyses of proposed climate change legislation suggest that CCS technologies will not be widely deployed in the next two decades absent financial incentives that supplement projected carbon prices. In addition to the challenges associated with cost, these projects will need to meet regulatory requirements that are currently under development. Long-standing regulatory programs are being adapted to meet the circumstances of CCS, but limited experience and institutional capacity at the Federal and State1 level may hinder implementation of CCS-specific requirements. Key legal issues, such as long-term liability and property rights, also need resolution. [21]

The Environmental Protection Agency (EPA) also has taken action to facilitate the development of CCS. For example, EPA recently proposed a rule to exclude CO_2 streams from EPA's hazardous waste regulations under the Safe Drinking Water Act.[22]

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[21] *"Executive Summary: Report of the InteragencyTask Force on Carbon Capture and Storage,"* August 2010. Accessible at: http://www.fe.doe.gov/programs/sequestration/ccstf/es_ccstf_2010.pdf

[22] Environmental Protection Agency, *"EPA Takes Action on Reducing Barriers to the use of Carbon Capture and Sequestration Technologies,"* August 4, 2011. Accessible at: http://yosemite.epa.gov/opa/admpress.nsf/0/FDE8D083AF16268E852578E10080F49B

Appendix A

New Budget Structure for Clean Coal Program The Office of Fossil Energy's Clean Coal program has a new budget structure for FY 2012. The changes better reflect the increased focus within the Clean Coal program on carbon capture and storage technologies. The new budget structure will align the existing work of the Clean Coal program to four key areas: Carbon Capture, Carbon Storage, Advanced Clean Energy Systems, and Cross-cutting Research. A comparison of the old and new budget structures is shown below.

Old Structure
CLEAN COAL POWER INITIATIVE
FUELS AND POWER SYSTEMS
INNOVATIONS FOR EXISTING PLANTS (IEP)
CO2 Carbon Capture and Storage
Fine Particulate Control/Air Toxics
By-Products and Water Management
CARBON SEQUESTRATION
Greenhouse Gas Control
Focus Area for Carbon Sequestration Science
IGCC
Gasification Systems Technology
Systems Analysis/Product Integration
ADVANCED TURBINES
Hydrogen Turbines
FUELS
Hydrogen from Coal
Coal and Coal-Biomass to Liquids
FUEL CELLS
Innovative Systems Concepts/SECA
ADVANCED RESEARCH
Coal Utilization Science (CUS)
Sensors and Controls - Novel Innovations
Computational System Dynamics
High Performance Materials
Coal Technology Export
Bioprocessing of Coal
Environmental Activities
Technical & Econ. Analyses
International Prog. Support
Focus Area for Computational Energy Science
University Coal Research
HBCUs, Education & Training

New Structure Beginning in FY 2012 New Program (*Old Program*)
CCS DEMONSTRATIONS *(CCPI, FutureGen 2.0, Industrial CCS)*
CCS AND POWER SYSTEMS *(Fuels and Power Systems)*
CARBON CAPTURE
Post-Combustion Capture *(Innovations for Existing Plants)*
Pre-Combustion Capture *(Sequestration)*
CARBON STORAGE
Regional Carbon Sequestration Partnerships/Storage Projects *(Sequestration)*
Geologic Storage Technologies *(Sequestration)*
Monitoring, Verification, Accounting, and Assessment *(Sequestration)*
Carbon Use and Reuse *(Sequestration)*
Focus Area for Carbon Sequestration Science *(Sequestration)*
ADVANCED ENERGY SYSTEMS
Advanced Combustion Systems *(IEP and Advanced Research)*
Gasification Systems *(IGCC)*
Hydrogen Turbines *(Advanced Turbines)*
CROSS CUTTING RESEARCH
Fine Particulate Control / Air Toxics *(IEP)*
By Products / Water Management *(IEP)*
Sensors and Controls *(Advanced Research)*
Systems Analysis/Product Integration *(Advanced Research)*
Coal Utilization Science
Computational System Dynamics *(Advanced Research)*
Computational Energy Science *(Advanced Research)*
Energy Analyses
Bioprocessing of Coal *(Advanced Research)*
Environmental Activities *(Advanced Research)*
Technical & Econ. Analyses *(Advanced Research)*
International Activities
International Prog. Support *(Advanced Research)*
Coal Technology Export *(Advanced Research)*
University Training and Research
University Coal Research *(Advanced Research)*
HBCUs, Education & Training *(Advanced Research)*

Appendix B

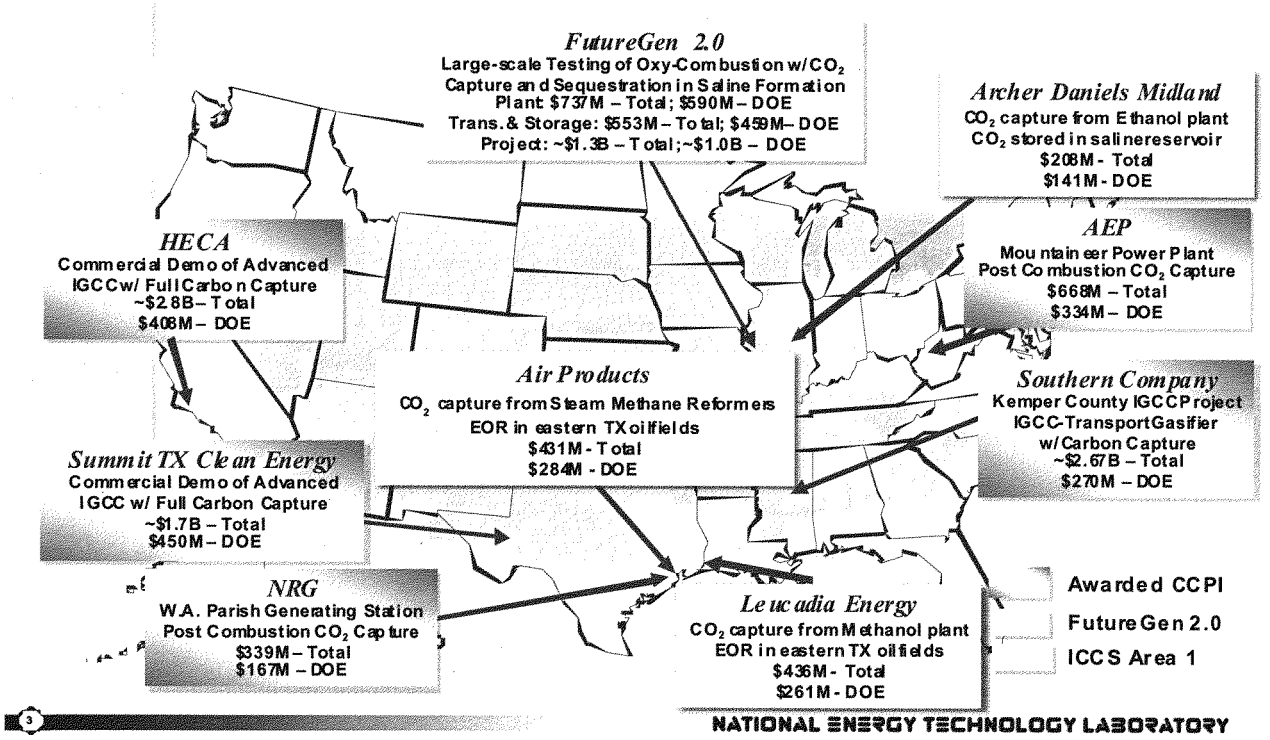
DOE CCS Projects and Costs (in Thousands)

Current as of June 2011

Program	Project	Recipient	CO2 Capture Technology	Sequestration	DOE Share	Non-DOE Share	Total Cost	Start Date
CCPI-2	Kemper	SCS	Selexol	EOR	$293,750	$1,331,332	$1,625,082	2014
CCPI-3	WA Parish	NRG	Fluor Econamine FG Plus	EOR	$166,804	$166,804	$333,608	2014
CCPI-3	TCEP	Summit	Rectisol	EOR	$450,000	$1,276,628	$1,726,628	2014
CCPI-3	Mountaineer	AEP	Chilled Ammonia Process	Saline	334,000	$334,000	668,000	2015
CCPI-3	HECA	HECA	TBD	EOR	308,000	$2,531,577	$2,839,577	TBD
ICCS	SMR H2 Production	APCI	VSA	EOR	284,012	146,636	$430,648	2012
ICCS	Fermentation CO2	ADM	Dehydration	Saline	$141,405	$66,536	207,942	2013
ICCS	Methanol from Petcoke Gasification	Leucadia Energy, LLC	Rectisol	EOR	$261,382	$174,204	$435,587	2014
FuturGen	Futuregen 2.0	Ameren, FGA	Oxycombustion with CO2 Purification	Saline	$1,000,000,000	$300,000	$1,300,000	2016

*CCPI = Clean Coal Power Initiative *ICCS = Industrial Carbon Capture & Storage

CCS Demonstration Projects
Locations & Cost Share



Appendix C
ARPA-E: Innovative Materials & Processes for Advanced Carbon Capture Technologies (IMPACCT)[23]

Coal-fired power plants generate approximately 45 percent of electricity for the United States. While coal is a cheap and abundant natural resource, continued use of coal as an energy source will lead to increasing levels of greenhouse gases as carbon dioxide is released into the atmosphere. Capturing the emitted carbon dioxide and storing it would enable the continued use of domestic coal resources while reducing greenhouse gas emissions into the atmosphere. The primary challenge is the current cost of capturing carbon dioxide from a coal power plant, which is unacceptably high.

The IMPACCT program seeks to reduce the cost of carbon capture significantly through a combination of new materials, improvements to existing processes, and demonstration of new capture processes. Fifteen high-risk, high-reward projects are underway among a group of universities, businesses, and national laboratories. IMPACCT is pushing the boundaries of carbon capture research through technologies such as new liquid chemistries that dissolve carbon dioxide and a capture system inspired by jet engines that transforms carbon dioxide from a gas into pellets of dry ice. If successful, the IMPACCT program will secure the continued use of America's coal infrastructure without further increases in harmful greenhouse gas emissions.

Awardee	Amount	Technology
Codexis Inc.	$4,657,045	Solvents / Catalysts
Texas A&M	$1,019,874	Sorbents
Massachusetts Institute of Technology	$1,000,000	Sorbents
University of Kentucky- Center for Applied Energy Research	$1,955,078	Membranes / Solvents
GE Global Research Center	$3,017,511	Phase Change
Lawrence Livermore National Laboratory	$3,665,000	Solvents / Catalysts
Lawrence Berkeley National Laboratory	$3,663,696	Sorbents
Georgia Institute of Technology	$1,000,000	Membranes
Notre Dame University	$2,559,563	Phase Change
ATK	$1,000,000	Phase Change
Columbia University	$1,014,707	Solvents / Catalysts
University of Colorado at Boulder	$3,144,646	Membranes
Oak Ridge National Laboratory	$987,547	Sorbents
Research Triangle Institute	$2,000,000	Solvents

[23] From Funding Opportunity Announcement II – April 29, 2010. Accessible at: http://arpa-e.energy.gov/ProgramsProjects/IMPACCT.aspx

Chairman HARRIS. The Subcommittee on Energy and Environment will come to order. Good afternoon. Welcome to today's hearing entitled, "Advancing Coal Research and Development for a Secure Energy Future." In front of you are packets containing the written testimony, biographies, and truth in testimony disclosures for today's witness panel.

I now recognize myself for five minutes for an opening statement.

I want to welcome everyone to this afternoon's hearing on, "Advancing Coal Research and Development for a Secure Energy Future."

According to the Department of Energy, coal delivered 45 percent of America's electricity supply in 2010, totaling 22 quadrillion BTUs of energy. This output is expected to grow an additional 25 percent by 2035. Dependence on coal is similar outside the U.S., representing 40 percent of global electricity generation.

Coal delivers plentiful, affordable, and reliable electricity to millions of homes and businesses every day. It provides power to the industrial and manufacturing sectors that drive our economic engine. Rarely, however, has a beneficial, life-improving resource upon which we depend so heavily been so maligned.

Despite steadily improving efficiency and significantly cleaner processes, coal suffers from a reputation that leads many to think wrongly that we would be better off without it.

This animus seems to be at an all-time high. In recent weeks, this Committee has spent considerable time examining the pending onslaught of regulations aimed at energy producers but particularly at coal energy producers. The review has highlighted the immense challenges facing the coal sector in light of EPA's dogged and scientifically questionable efforts to order major changes to our electric generation system.

The widespread negative impact of EPA's forthcoming regulations are acknowledged even at senior levels of the Obama Administration. An analysis by the Federal Energy Regulatory Commission found that 40 gigawatts of coal-fired power generation could be forced into retirement, and that "could have drastic consequences for many parts of the country." Similarly, DOE Deputy Assistant Secretary for Fossil Energy Jim Wood has estimated that EPA rules could force up to 70 gigawatts of coal offline, adding:

"Number one, electric rates are going to go up. Number two, whether or not construction jobs in the green industry are created, I think there are virtually no manufacturing jobs that are likely to be created from the replacement of coal. Three, transmission grid stability is likely to emerge as a major issue, both because of the shutdowns and because of the intermittency of renewables."

The impact of Administration policies on electricity prices and coal plant shutdowns should come as no surprise. On the campaign trail in 2008, then candidate Obama said openly and clearly that his regulatory regime would bankrupt coal companies and necessarily cause electricity prices to skyrocket.

Fortunately, the President's wildly expensive vision for cap and trade was also wildly unpopular with the American people and, in fact, soundly rejected by Congress.

These concurrent events, the death of cap and trade and EPA's bonanza of new air regulations, beg the fundamental question be-

fore us at today's hearing. Does it make sense for DOE to continue to focus its $400 million R&D effort almost exclusively on carbon capture and sequestration, particularly in light of the need for and potential of advanced technologies to significantly increase coal utilization efficiency and thus benefit the environment?

This exclusive focus certainly doesn't make sense to me. Considering that DOE's goal is to find carbon capture and sequestration technology that "only" increases electricity costs by 30 percent, I have to question whether we should be investing taxpayer dollars on a technology that likely never will be commercially viable in the absence of carbon constraints that Congress has already rejected. Perhaps instead of exclusively pursuing what appears to be an expensive and inefficient technology, we could facilitate the development of technologies with greater thermal efficiency that could achieve lower pollutant emissions.

To this end, I look forward to hearing witness recommendations on potential coal technology R&D opportunities that are not currently being addressed by DOE and how best to prioritize those opportunities within the current budget environment. I also hope to learn more about the status of, outlook for, and lessons learned from the $3.4 billion in Stimulus-funded coal sequestration, CO_2 sequestration demonstration projects.

I now yield back the balance of my time and recognize Mr. Miller for his opening statement.

[The prepared statement of Mr. Harris follows:]

PREPARED STATEMENT OF CHAIRMAN ANDY HARRIS

I want to welcome everyone to this afternoon's hearing on Advancing Coal Research and Development for a Secure Energy Future.

According to the Department of Energy, coal delivered 45 percent of America's electricity supply in 2010, totaling 22 quadrillion BTUs ("quads") of energy. This output is expected to grow an additional 25 percent by 2035. Dependence on coal is similar outside the U.S., representing 40 percent of global electricity generation.

Coal delivers plentiful, affordable, and reliable electricity to millions of homes and businesses every day. It provides power to the industrial and manufacturing sectors that drive our economic engine. Rarely, however, has a beneficial, life-improving resource upon which we depend so heavily been so maligned.

Despite steadily improving efficiency and significantly cleaner processes, coal suffers from a reputation that leads many to think—wrongly—that we'd be better off without it.

This animus seems to be at an all-time high. In recent weeks, this Committee has spent considerable time examining the pending onslaught of regulations aimed at energy producers. The review has highlighted the immense challenges facing the coal sector in light of EPA's dogged—and scientifically questionable—efforts to order major changes to the electric generation system.

The widespread negative impact of EPA's forthcoming regulations are acknowledged even at senior levels of the Obama Administration. An analysis by the Federal Energy Regulatory Commission (FERC) found that 40 gigawatts of coal-fired power generation could be forced into retirement, and that "could have drastic consequences for many parts of the country." Similarly, DOE Deputy Assistant Secretary for Fossil Energy Jim Wood has estimated that EPA rules could force up to 70 gigawatts of coal offline, adding:

> "Number one, electric rates are going to go up. Number two, whether or not construction jobs in the green industry are created, I think there are virtually no manufacturing jobs that are likely to be created from the replacement of coal. Three . . . transmission grid stability is likely to emerge as a major issue, both because of the shutdowns and because of the intermittency of renewables."

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said openly and clearly that his regulatory regime would bankrupt coal companies and necessarily cause electricity prices to skyrocket.

Fortunately, the President's wildly expensive vision for cap-and-trade was also wildly unpopular with the American people, and soundly rejected by Congress.

These concurrent events—the death of cap and trade and EPA's bonanza of new air regulations—beg the fundamental question before us at today's hearing: does it make sense for DOE to continue focusing its $400 million coal R&D effort almost exclusively on carbon capture and sequestration (CCS), particularly in light of the need for, and potential of, advanced technologies to significantly increase coal utilization efficiency and benefit the environment?

This exclusive focus certainly doesn't make sense to me. Considering that DOE's *goal* is to find CCS technology that "only" increases electricity costs by 30 percent, I have to question whether we should be investing taxpayer dollars on a technology that likely never will be commercially viable in the absence of carbon constraints that Congress has already rejected. Perhaps instead of exclusively pursuing what appears to be an expensive and inefficient technology, we could facilitate the development of technologies with *greater* thermal efficiency that could achieve lower pollutant emissions.

To this end, I look forward to hearing witness recommendations on potential coal technology R&D opportunities that are not currently being addressed by DOE, and how best to prioritize those opportunities within the current budget environment. I also hope to learn more about the status of, outlook for, and lessons learned from the $3.4 billion in Stimulus-funded CCS demonstration projects.

I yield back the balance of my time and recognize Mr. Miller for his opening statement.

Mr. MILLER. Thank you, Mr. Chairman. In this Congress, my colleagues on the other side of the aisle pound the drum on a handful of themes they believe are consistent with conservative dogma expressed in phrases like "regulation kills jobs," "climate change is an unproven theory," "government shouldn't pick winners and losers." But, just repeating something over and over does not really make it true. This hearing gives us an opportunity to put a finer point on those issues.

First, to have a stronger economy we do not have to sacrifice cleaner air and a healthier and more productive workforce. We will hear from Mr. Foerter—is that a correct pronunciation—okay—the often-ignored perspective from the side of the power industry that designs, manufactures, and installs pollution control equipment.

Second, when it comes to DOE programs on emerging clean energy technology: solar, geothermal, electric vehicle, batteries, smart grid, efficient technologies, bio-based fuels, and all the things that may one day make for a cleaner and more sustainable energy economy, my Republican colleagues do not hesitate to cry foul at any federal support that they consider to be an inappropriate government intrusion into the energy marketplace. To them these are mature industries in which free market forces alone should push the frontiers of innovation, and the Department of Energy investments in research just crowd out what the private sector would otherwise do.

They say it is not the job of government to pick winners and losers, and they say that government should never pick winners and losers except sometimes. New renewable and efficient technologies do not warrant government support, they say, but conventional energy industries do. When it comes to the most established and powerful industries in the world, the same free market principles that my colleagues relentlessly espouse apparently have no place.

More important I have some issues or some questions about the manner in which this Committee conducts its hearings. We—the reason we do these hearings, we have legislative hearings, is to de-

velop a factual record to support the decisions that Congress has to make, and we need reliable, factual information.

Last week my colleagues on the other side of the aisle accused me of behaving inappropriately when I asked a witness about his financial interests, the extent to which his income was derived from the industry whose interests were at the center of that hearing.

I ask those questions because that is the kind of information that is necessary to evaluate anyone's testimony. I think legislators should take a cue from the courts that have for centuries recognized the importance of that information in evaluating a witness's testimony. The questions I asked were fundamental to our legal system, the federal rules of civil procedure required that expert witnesses disclose any compensation they get for their testimony not just in court but outside of court. Those rules and principles are in place because that information about financial interest is relevant and essential to evaluating testimony and reaching a sound decision.

Mr. Chairman, it is not accusing a witness of lying to say they had a financial interest, but it may create a bias. It may color how they see the world, how they see the facts, and we are entitled to know that. We are entitled to know that as Congress, and the American people are entitled to know that, and this is an issue that I have raised from the first meeting of this Committee. I raised questions about the financial disclosure form, the truth in testimony form, and whether that adequately discloses financial interest. Chairman Hall assured me then that he would work with me. Mr. Rohrabacher, a Member of this Subcommittee, said that I could use my five minutes of questioning to raise those issues, and I said I would rather use my five minutes to ask about the substance of witnesses' testimony, not about their financial interest.

I later wrote a letter along with Ms. Edwards to Chairman Hall about working with us on financial disclosures, and he wrote back and said that upon reflection he decided that the disclosures were perfectly fine, but I could use my five minutes to ask about those financial interests. And then last week I did, and leading the attack were Mr. Rohrabacher and Mr. Hall, Chairman Hall, the very Members who had said I should use my five minutes to inquire about witnesses' financial interest.

I do not plan today to ask those questions orally in my five minutes, but I will submit questions for the record, written questions afterwards, and in future hearings I may well ask questions about financial interests in my five minutes orally, but I intend to make it my practice to ask those questions after the hearing in questions for the record.

And with that I yield back my time. It was one second when I said that.

[The prepared statement of Mr. Miller follows:]

PREPARED STATEMENT OF RANKING MEMBER BRAD MILLER

Opening Statement
Ranking Member Brad Miller
October 13, 2011
Hearing: Advancing Coal Research and Development for a Secure Energy Future
U.S. House Committee on Science, Space, and Technology
Subcommittee on Energy and Environment

Thank you, Chairman Harris.

As I have other matters to dispense with before moving on to witness testimony, I will keep my comments on this hearing brief.

In this Congress my colleagues on the other side of the aisle tirelessly pound the drum on a handful of high-level themes they believe are consistent with conservative dogma, captured in catch-phrases such as "Regulations kill jobs", "Climate change is an unproven theory", and "Government shouldn't pick winners and losers."

But, just repeating something over and over does not make it true. As is too often the case in politics, my friends fail to acknowledge that punch lines are inherently inadequate for addressing issues as complex as defining the role of government in protecting the environment and public health and spurring technological innovation in the most powerful economy in the world. In fact, environmental damage is a classic "externality" that honest conservative theorist concede may cause market failure and justify government action.

This hearing gives us the opportunity to put a little finer point on these issues.

First, to have a strong economy we do not have to sacrifice cleaner air and a healthier and more productive workforce. We will hear from Mr. Foerter the often-ignored perspective from the side of the power industry that designs, manufactures and installs pollution control equipment. Companies like Alstom, Babcock and Wilcox, BASF, Cormetech, Hitachi, Mitsubishi, Nalco, Praxair, Rockwell Automation, Siemens, and Teledyne and dozens of other companies that do not invest in the pollution control sector out of idealism and benevolence. Nor do these companies suffer for a lack of ingenuity or technological sophistication. They coordinate with regulators and generators to define what is technologically and financially possible, and then set their workforce lose to make it a reality.

Second, when it comes to DOE programs on emerging clean energy technologies – solar, geothermal, electric vehicle batteries, smartgrid, efficiency technologies, bio-based fuels, and all of the things that may one day make for a cleaner, more sustainable energy economy - my Republican colleagues do not hesitate to cry foul at the federal support that they consider to be inappropriate government intrusion in the energy marketplace.

To them, these are mature industries in which free market forces alone should push the frontiers of innovation, and DOE investments in research merely crowd out what the private sector would otherwise do. After all, it's not the job of the government to pick winners and losers.

And they say that is always true, except sometimes. For instance, the oil and natural gas industry lacks the resources and technological capacity to unlock hydrocarbon reserves in the deep water and unconventional shale formations. They need a $50 million a year research program and billions in tax breaks.

Ditto for the nuclear industry. They need $850 million a year in taxpayer-funded research, tens of billions in government-backed liability insurance, and multi-billion dollar loan guarantees. But, otherwise, keep the government out of their business.

And, coal. Well, that's why we are here. Republicans say the DOE needs to redirect its R&D program from dealing with the false threat of climate change to develop technologies for the coal industry to meet new tightening emissions standards and stay profitable and competitive in the energy marketplace. Forget about that picking winners and losers, interfering in the free-market nonsense. These poor companies need our help.

So new renewable and efficiency technologies do not warrant government support, but conventional energy industries do? When it comes to the most established and profitable industries in the world, where are these free-market principles my colleagues so steadfastly stand by?

Last week my colleagues across the aisle accused me of behaving inappropriately by asking a witness about his financial interests relating to the subject matter of our hearing. I asked these questions because this type of information is necessary to evaluate the testimony provided. The witnesses we should rely on for technical expertise often have a dog in the fight.
I think legislators should take a cue from the Courts, and the Courts universally recognize the importance of this line of questioning.

In fact, the questions I asked are fundamental to our legal system. Courts have consistently recognized the validity of examining witnesses' pecuniary interests in evaluating their testimony and objectivity. The Federal Rules of Civil Procedure require that expert witnesses disclose compensation so that their testimony may be weighed. These rules and principles are in place because information about conflicts of interest is relevant and essential to evaluating testimony and reaching a sound decision. We as legislators should also consider witnesses' financial conflicts of interest to make sound policy decisions.

This is something that folks on both sides of the aisle have recognized. Senator Grassley, for example, proposed legislation during the 111th Congress requiring witnesses before a committee hearing to "file a disclosure form indentifying substantial financial interests or compensation from an organization or company directly related to the subject of the hearing."

The disclosure of this information is critical to make our hearings transparent and credible. This is a well established practice in our legal system, and it should be in our legislative system as well.

Chairman HARRIS. Thank you very much, Mr. Miller. I will just urge you to take a look at the witness list, and it is not hard to figure out that if someone is the president of American Electric Power, they are probably employed by them, and if someone is from the American Coal Council which represents coal producing companies, they are probably employed by them.

So with regards to this particular——

Mr. MILLER. And——

Chairman HARRIS. Excuse me. With regards to this particular panel I think it is pretty clear.

Mr. MILLER. Perhaps with respect to this panel and that is why I don't plan to ask questions, but we earlier had a witness who listed his occupation as a professor at the University of Houston. Upon questioning, his salary at the University of Houston is $1 a year, and he makes $1 million a year as a consultant to the very industries whose interests were at issue in that hearing.

Chairman HARRIS. And again, I don't know about the past. This panel it is pretty clear, and you know, as a physician, you know, if somebody wants to know about obstetric anesthesia, they are going to have to get someone, you know, they might consult with me because you have to go to someone who actually does it to be an expert on it as you can imagine. So a lot of times it is pretty transparent, and I think it is pretty transparent today.

But if you have any questions about that, of course, please submit them, and thank you.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I would like to introduce our witness panel. Our first witness is Mr. Scott Klara, Deputy Director of the National Energy Technology Laboratory. Mr. Klara has over 25 years of engineering and management experience that spans a broad spectrum of technology areas including electric power generation, advanced separation processes, coal conversion processes, and simulation systems analysis.

Our second witness will be Ms. Janet Gellici, Chief Executive Officer of the American Coal Council. Prior to her work with the ACC she served as Communications Director of the Colorado School of Mines Management Institute and is Public Information Director of the Western Governors' Association.

Our third witness will be Mr. Nick Akins, President of American Electric Power. From 2006 to 2010, he was Executive Vice President for generation responsible for all generation activities of AEP's approximately 40,000 megawatts of Generation resources. Previously he was President and Chief Operating Officer for Southwestern Electric Power Company, serving 439,000 customers in Louisiana, Arkansas, and Northeast Texas.

Next we have Mr. David Foerter, Executive Director, Institute of Clean Air Companies. He has several decades of experience advising the public and private sector on environmental legislation, policy, rules, and technology issues with a focus on air pollution control for stationary and mobile sources. He is also currently a member of EPA's Clean Air Act Advisory Committee and the Deputy of

Commerce's Environmental Technologies Trade Advisory Committee.

And our final witness today will be Mr. Stu Dalton, Senior Government Representative for Generation of the Electric Power Research Institute. He joined EPRI in 1976, focusing on SO_2 control and later led this area for 20 years, additionally working on integrated emission controls for NOx, mercury, and particulates. Before joining EPRI Mr. Dalton worked at Pacific Gas Electric evaluating new generation options, coal gasification and conventional coal, refuse biomass firing, and NOx control refits—retrofits.

Thank you all for appearing before the subcommittee today. As our witnesses should know, spoken testimony is limited to five minutes each, after which Members of the Committee will have five minutes each to ask questions, but we do have your complete written testimony in front of us.

With that I now recognize our first witness, Mr. Scott Klara, Deputy Director of the National Energy Technology Laboratory.

STATEMENT OF MR. SCOTT KLARA, DEPUTY DIRECTOR, NATIONAL ENERGY TECHNOLOGY LABORATORY

Mr. KLARA. Thank you, Chairman Harris and Members of the Subcommittee. I appreciate the opportunity to discuss the Department of Energy's coal research and development activities.

DOE continues to play a leadership role in the development of clean coal technologies. The Clean Coal Research Program is designed to enhance our energy security and reduce environmental concerns over the future use of coal by developing a portfolio of revolutionary clean coal technologies.

The Clean Coal Program in partnership with the private sector is focusing—focused on maximizing efficiency in environmental performance while minimizing the cost of these new technologies. In recent years the program has been restructured to focus on clean coal technologies with carbon capture and storage. The program pursues the following two strategies. The first strategy is capturing and storing greenhouse gases, while the second strategy is improving the efficiency of fossil energy systems.

The first strategy aims to eliminate the concerns over the emissions of greenhouse gases from fossil-fueled energy systems. The second strategy seeks to improve the fuel-to-energy efficiency of these systems, thus reducing the pollutant emissions, water usage, and carbon emissions on a per-unit energy basis. Collectively, these two strategies form the Clean Coal Program within the Department of Energy.

More specifically, the Clean Coal Program is addressing the key technical challenges that confront the development and deployment of these technologies through research on such things as cost-effective capture technologies, monitoring verification and accounting technologies to ensure permanent storage, permitting issues, and the development of advanced energy system. Research is focused on technology options, for example, that dramatically lower the cost of capturing carbon dioxide from these fossil-fueled energy systems. This research can be categorized into three pathways: what we call post-combustion, which is pretty much standard PC technology,

pre-combustion, which is emerging gasification technology, and oxy-combustion.

Another facet of the Clean Coal Program is the regional carbon sequestration partnerships that were created in 2003. The partnerships were designed to address a range of issues associated with the geologic storage of carbon dioxide. The Clean Coal Program has been performing capture and storage field tests focused on things like monitoring verification, accounting, and other aspects of geologic storage for many years. And the seven regional carbon sequestration partnerships are critical to this effort. These partnerships represent more than 400 unique organizations in 43 states and four Canadian provinces. Together the partnerships form a network of capability, knowledge, and infrastructure that we believe will help enable geologic storage technology to play a role in future energy strategies.

These partnerships represent regions encompassing 97 percent of coal-fired CO_2 emissions, 97 percent of industrial CO_2 emissions, 96 percent of the total land mass of the United States, and essentially all the geologic storage sites which could be potentially available for geologic storage.

The success of the Coal Program also hinges upon whether these technologies get deployed, and what we use for that is we—the Clean Coal Program relies on commercial scale demonstrations to help industry understand and overcome technology issues such as start up, component integration, early learning, commercial experience, et cetera, and some of the panelists here have experience working with us in these various programs.

Another aspect, important aspect of the Clean Coal Program is what we call CO_2 utilization. The program recognizes that technologies such as mineralization, chemical conversion to useful products, algae production, enhanced oil recovery, and enhanced coalbed methane recovery could play an important role in pushing the technologies forward.

Other than enhanced oil recovery, the CO_2 reduction potential of these technologies is often limited due to such factors as cost and market saturation of salable byproducts, but even so these approaches are logical first-entry candidates for validating this emerging technology.

So in conclusion, today nearly three out of every four coal-burning power plant in this country is equipped with technologies that can trace its roots back to the DOE Program. For example, NO_X control, SO_X control, particulate matter control and mercury control as we go forward. These efforts helped accelerate the production of these cost-effective compliance options to address these legacy environmental issues associated with coal use.

Additionally, as I mentioned, these utilization technologies are logical first market entry candidates to help get the technology commercially ready. Enhanced oil recovery particularly of the CO_2 utilization options will be the dominant option into the near future and has a lot of potential as I have indicated in my testimony.

I applaud the efforts of this Committee and the Members to take on these important industry—these important issues and look forward to responding to questions when we get to the Q and A. Thank you.

[The prepared statement of Mr. Klara follows:]

PREPARED STATEMENT OF MR. SCOTT KLARA, DEPUTY DIRECTOR, NATIONAL ENERGY TECHNOLOGY LABORATORY

Thank you Chairman Harris and members of the Subcommittee; I appreciate the opportunity to discuss the Department of Energy's (DOE) coal research & development activities.

Interagency Task Force on Carbon Capture and Storage

Before I discuss the Department's Clean Coal Research Program, I will briefly review the conclusions from the Interagency Task Force on Carbon Capture & Storage (CCS). In August 2010, the final report from the Task Force was issued summarizing the Administration's efforts to develop and deploy CCS technologies, and proposed a plan to overcome the barriers to the widespread, cost-effective deployment of CCS within ten years, with a goal of bringing five to ten commercial demonstration projects online by 2016. This report is the collective work of 14 executive departments and Federal agencies, which were tasked with developing a comprehensive and coordinated Federal strategy to speed the commercial development and deployment of clean coal technologies. The task force concluded that while there are no insurmountable technological, legal, institutional, regulatory or other barriers that prevent CCS

from playing a role in reducing GHG emissions, early CCS projects face economic challenges related to climate policy uncertainty, first-of-a-kind technology risks, and the current high cost of CCS relative to other technologies.

Clean Coal Research Program

DOE continues to play a leadership role in the development of clean coal technologies with a focus on CCS. The Clean Coal Research Program – administered by DOE's Office of Fossil Energy and implemented by the National Energy Technology Laboratory – is designed to enhance our energy security and reduce environmental concerns over the future use of coal by developing a portfolio of revolutionary clean coal technologies. The Program is well positioned to help overcome the technical challenges associated with the development of clean coal technologies.

The Clean Coal Program, in partnership with the private sector, is focused on maximizing efficiency and environmental performance, while minimizing the costs of these new technologies. In recent years, the Program has been restructured to focus on clean coal technologies with CCS. The Program pursues the following two major strategies:

1) capturing and storing greenhouse gases; and
2) improving the efficiency of fossil energy systems.

The first strategy aims to eliminate concerns over emissions of greenhouse gases from fossil fueled energy systems. The second strategy seeks to improve the fuel-to-energy efficiencies of these systems, thus reducing pollutant emissions, water usage, and carbon emissions on a per unit of energy basis. Collectively, these two strategies comprise the Clean Coal Program's

approach to ensure that current and future fossil energy plants will have options to meet all emerging requirements for a safe and secure energy future.

Core Research and Development Activities

The Clean Coal Program is addressing the key technical challenges that confront the development and deployment of clean coal technologies through research on cost-effective capture technologies; monitoring, verification, and accounting technologies to ensure permanent storage; permitting issues; and development of advanced energy systems. As an example, today's commercially available CCS technologies would increase the cost of electricity by 80 percent for a new pulverized coal plant (equivalent to about $45 per ton CO_2 captured), and increase the cost of electricity by 35 percent for a new integrated gasification combined cycle plant (equivalent to about $32 per ton CO_2 captured).[1] The Program is aggressively pursuing developments to reduce these costs to less than a 35 percent increase in the cost of electricity for pulverized coal energy plants (about $20 per ton CO_2 captured) and less than a 10 percent increase in the cost of electricity for new gasification-based energy plants (about $10 per ton CO_2 captured).

Research is focused on developing technology options that dramatically lower the cost of capturing carbon dioxide (CO_2) from fossil fueled energy plants. This research can be categorized into three technical pathways: post-combustion, pre-combustion, and oxy-combustion. Post-combustion refers to capturing CO_2 from the stack gas after a fuel has been

[1] Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity, U.S. Department of Energy/National Energy Technology Laboratory, DOE/NETL-2007/1281, Final Report, May 2007.

combusted in air. Pre-combustion refers to a process where a hydrocarbon fuel is gasified to form a mixture of hydrogen and carbon dioxide, and CO_2 is captured from the synthesis gas before it is combusted. Oxy-combustion is an approach where a hydrocarbon fuel is combusted in pure or nearly pure oxygen rather than air, which produces a mixture of CO_2 and water that can easily be separated to produce pure CO_2. Collectively, research in each of these technical pathways is exploring a wide range of approaches such as membranes; oxy-combustion concepts; solid sorbents; advanced gas/liquid scrubbing technologies; and advanced hybrid concepts such as liquid membrane contactors. These efforts cover not only improvements to state-of-the-art technologies but also development of several revolutionary concepts, such as metal organic frameworks, ionic liquids, and enzyme-based systems. Coupling these developments with other advances in efficiency improvements and cost reduction from developments in gasification, turbines, and fuel cells, will help provide a technology base for commercial deployment of fossil energy systems integrated with CCS.

The Department is the primary supporter of the National Carbon Capture Center (NCCC), which is a joint partnership between DOE and industry. The NCCC is a one of a kind, world class facility which offers an opportunity to validate capture technologies on actual gas from a coal-fired power plant or gasification facility. Because of the ability to operate under a wide range of process conditions, research at the NCCC can effectively evaluate technologies at various levels of maturity for many different applications.

Regional Carbon Sequestration Partnerships

The Regional Carbon Sequestration Partnerships were created by the DOE in 2003 through a competitive solicitation. The Partnerships were designed to address a range of issues associated with geologic storage of CO_2. The Clean Coal Program has been performing CCS field tests focused on injection, monitoring, verification, accounting and other aspects of geologic storage for many years, and the seven Regional Carbon Sequestration Partnerships are critical to this effort. These Partnerships are comprised of state agencies, universities, and private companies. They represent more than 400 unique organizations in 43 States, and four Canadian Provinces. Geographic differences in fossil fuel use and potential storage sites across the United States dictate the use of regional approaches in addressing CCS, so each Partnership is focused on a specific region of the United States and Canada that holds similar characteristics relating to CCS opportunities.

Together, the Partnerships form a network of capability, knowledge, and infrastructure that will help enable geologic storage technology to play a role in the clean energy economy. They represent regions encompassing 97 percent of coal-fired CO_2 emissions, 97 percent of industrial CO_2 emissions, 96 percent of the total land mass, and essentially all the geologic storage sites that can potentially be available for geologic carbon storage.

Regional Partnerships are drilling wells and injecting small quantities of CO_2 to validate the potential of key storage locations throughout the country. To date, the Regional Partnerships have injected over 1 million tons of CO_2 at 18 small scale injection projects throughout the United States and Canada. These tests have helped to validate storage at a small scale to

understand the fate of CO_2 in different depositional systems containing saline water, oil, and natural gas. Several large scale projects are also underway that will inject several million tons of CO_2 over the life of the projects. One of these projects has safely and securely injected over 3 million metric tons of CO_2. Several more large-scale field tests will begin later this year.

Over the course of these initiatives, DOE and the Partnerships are addressing key infrastructure issues related to permitting, pore space ownership, site access, liability, public outreach, and education. We are also jointly developing Best Practice Manuals on topics such as site characterization, site construction, operations, monitoring, mitigation, closure, and long-term stewardship. These manuals will serve as guidelines for a future geologic sequestration industry in their regions, and help transfer the lessons learned from DOE's Program to all regional stakeholders. The first editions of the Best Practice Manuals are available on DOE's reference shelf[2] and the Manuals will be periodically updated as lessons learned from the large scale field tests are realized. Finally, DOE and the Partnerships continue to work closely with the Environmental Protection Agency (EPA) and other Federal and state agencies in developing CCS regulatory strategies, which will provide additional certainty for future CCS deployments.

Demonstrations at Commercial-Scale

The success of the Clean Coal Program will ultimately be judged by the extent to which emerging technologies get deployed in domestic and international marketplaces. Both technical and financial challenges associated with the deployment of new "high risk" coal technologies must be overcome in order to be capable of achieving success in the marketplace. Commercial-scale demonstrations help the industry understand and overcome start-up issues, address

[2] http://www.netl.doe.gov/technologies/carbon_seq/refshelf/refshelf.html

component integration issues, and gain the early learning commercial experience necessary to reduce risk and secure private financing and investment for future plants.

The Department is implementing large-scale projects through the Regional Partnerships, the Clean Coal Power Initiative (CCPI), and FutureGen. Phase III of the Partnerships is focused on large-scale field tests of geologic carbon sequestration on the order of 1 million metric tons of CO_2 per year, and are addressing the liability, regulatory, permitting, and infrastructure needs of these projects. As described previously in this statement, the Partnerships have brought an enormous amount of capability and experience together to work on the challenges of these large projects.

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. 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.

The CCPI program received an additional $800 million from the 2009 American Recovery and Reinvestment Act (Recovery Act) which, in combination with base funding, was used to fund

four CCPI Round III projects, two pre-combustion and two post-combustion capture projects. In addition, a CCPI Round II project, with Southern Company Services, has been modified to demonstrate CCS at a new integrated gasification combined cycle power plant. Having completed all design and National Environmental Protection Act (NEPA) activities, this project began construction in 2010 and is scheduled to be operational in 2014.

We are working closely with the project developers to comply with NEPA, air and water regulatory requirements, and complete initial Front End Engineering & Design (FEED) studies for each of the CCPI projects. The CCPI project with Summit Texas Clean Energy, LLC, completed FEED in June 2011 for the new IGCC power plant, and the NEPA Record of Decision was issued in September 2011, clearing the way for the project to meet financial agreements with its investors. Construction is expected to begin in early 2012 with operations expected to start in 2014. The Hydrogen Energy California (HECA) CCPI project with Hydrogen Energy International was restructured in September 2011 to acknowledge sale of the project by BP and Rio Tinto to SCS Energy, LLC. Also, as a result of the ownership change, the project was modified to augment the IGCC-CCS concept to include poly-generation of electric power, carbon dioxide for enhanced oil recovery, and urea and urea ammonium nitrate fertilizers. The project began FEED for the poly-generation facility in September 2011 and is expected to begin operations in 2017. American Electric Power (AEP) announced in July 2011 that they were placing their CCPI Round III post-combustion capture project on hold until economic and policy conditions create a viable path forward. Consequently, AEP requested a termination of their DOE award, concluding all project activities after the completion of FEED in September 2011. Following the results of FEED for their CCPI post-combustion capture project, NRG

Energy determined that a scale increase was desired to improve project economics and make the project more financially sound. As a result, FEED is currently underway for the larger scale project and is expected to be complete, along with the NEPA Record of Decision, in early 2013 and operational in 2015.

The FutureGen Project intends to conduct novel large-scale testing to accelerate the deployment of a set of advanced oxy-combustion power production technologies integrated with CCS. This project will be the first advanced repowering oxy-combustion project to store CO_2 in a deep saline geologic formation. On August 5, 2010, Secretary of Energy Steven Chu announced an award totaling $1 billion in Recovery Act funding to the FutureGen Alliance; and Ameren Energy Resources along with their partners: Babcock & Wilcox, and Air Liquide Process and Construction, Inc., to repower an existing plant with advanced oxy-combustion technologies. Together, these two awards comprise the FutureGen 2.0 project for clean coal repowering with CCS. On February 28, 2011, the FutureGen Alliance selected Morgan County, Illinois, as the preferred location for the FutureGen 2.0 CO_2 storage site, visitor center, and research and training facilities. In addition to the CCPI and FutureGen 2.0 projects, the Recovery Act has also helped fund more than 80 additional projects, which includes three large scale Industrial CCS demonstrations, 10 geologic site characterizations, 43 university research training projects, seven CCS research training centers, six Industrial CCS projects focused on CO_2 reuse, and 14 projects focused on accelerated component development in the core research program.[3]

[3] Details about all of the Fossil Energy projects funded by the Recovery Act can be found here: http://www.fossil.energy.gov/recovery/index.html.

CO_2 Utilization Technologies

The coal research and development program has supported research on CO_2 utilization technologies for more than a decade. When the Carbon Storage Program (formerly named the Sequestration Program) was initiated in the mid-1990s, it was recognized that technologies such as mineralization, chemical conversion to useful products, algae production, enhanced oil recovery (EOR) and enhanced coalbed methane recovery could play an important role in mitigating CO_2emissions. Other than EOR, the CO_2 emissions reduction potential of these approaches is limited, due to factors such as cost and market saturation of salable byproducts. Even so, these approaches are logical "first-market entry" candidates for greenhouse gas mitigation, due to their ability to produce revenue from use of the CO_2 that could be used to offset the costs for these "early adopters." Hence, these options provide a technology bridge and smoother transition to the deployment of the large-scale, stand-alone geologic sequestration operations that will ultimately be needed to achieve the much larger reductions that would be required to approach stabilizing greenhouse gas concentrations in the atmosphere.

EOR represents the most near term and most commercially attractive utilization option for CO_2 storage that could produce substantial quantities of oil while permanently storing the CO_2 in geologic formations. The Department has recognized the importance of CO_2 EOR for more than 40 years, though the focus has shifted from increased incremental oil production to monitoring, verification, and accounting of geologically stored CO_2 as part of a climate change mitigation strategy. As early as the 1970s, DOE-funded projects were developing concepts to improve the effectiveness and applicability of CO_2 EOR. Currently, most EOR projects have been strategically located near cheap sources of naturally occurring CO_2 or along pipelines from such sources. If research into reducing the cost of CO_2 capture from power plants proves successful,

anthropogenic sources of CO_2 may become readily available for EOR projects. The Intergovernmental Panel on Climate Change has estimated a worldwide technical capacity for CO_2 storage in EOR applications at 61 to 123 billion tons of CO_2.[4] Estimates by Advanced Resources International (ARI) have shown that the technology limit for CO_2 storage associated with EOR in the United States is 20 billion tons. Of that quantity, ARI estimates over 10 billion tons could be economically stored with existing EOR technology and the cost of carbon capture technology is significantly reduced.[5] If these potentials can begin to be realized, incremental oil produced via EOR using CO_2 flooding could help offset the costs of CO_2 capture, and the prospect of relatively low-cost supplies of captured CO_2 in widespread areas of the country could, in turn, provide the impetus for a national re-evaluation of the EOR potential in many mature fields. The proximity of sources of captured CO_2 to oil reserves amenable to EOR is an important consideration, because transportation of CO_2 over long distances is expensive and can affect the economics of EOR. Most important to the Clean Coal Research Program, the use of EOR for carbon sequestration will involve permitting issues, liability issues, monitoring and verification technologies to ensure permanent storage, and public outreach. While conventional EOR is a commercial process, CO_2 capture from coal power systems is not yet commercial at the large scale required for deployment in power plants. Continued evolution of EOR and transformational advances in development and deployment of CO_2 capture from coal power

[4] 2005 IPCC Special Report on Carbon Dioxide Capture and Storage; http://www.ipcc-wg3.de/publications/special-reports/.files-images/SRCCS-Chapter5.pdf. The storage capacity values from the IPCC report represent the potential storage global capacity as assessed by the IPCC for existing oil fields using business as usual practices. The IPCC recognized that storage capacity in oil and gas reservoirs could be and order of magnitude higher if 2nd generation enhanced recovery practices were utilized and undiscovered assets were included in future assessments.

[5] "Improving Domestic Energy Security and Lowering CO_2 Emissions with "Next Generation" CO_2-Enhanced Oil Recovery(CO_2-EOR)," DOE/NETL-2011/1504, July 2011 http://www.netl.doe.gov/energyanalyses/refshelf/PubDetails.aspx?Action=View&PubId=391. Estimates and work performed by Advanced Resources International (ARI) for the report.

could help realize this synergy between the coal/power industry and the oil industry. Utilization of the CO_2 in EOR will impart knowledge that will be instrumental in the Department's continued R&D in other geologic storage formations such as saline that has a larger storage potential for CO_2.

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 DOE's advanced coal technology program. These efforts helped accelerate production of cost-effective compliance options to address legacy environmental issues associated with coal use. CCS and related clean coal technologies can play a critical role in mitigating CO_2 emissions under many potential future carbon stabilization scenarios. CO_2 utilization technologies with salable byproducts are logical "first market entry" candidates for greenhouse gas mitigation due to their ability to produce revenue from the use of CO_2. EOR will be the dominant utilization opportunity in the near term and will impart additional experience that will be useful in the Department's continued longer-term R&D in other promising storage formations. Nevertheless, challenges remain to achieving cost-effective commercial deployment of CCS. The Department's research programs are a vital step to advancing the readiness of these emerging clean coal technologies.

I applaud the efforts of this Committee and its Members for taking a leadership role in addressing these timely and significant issues.

Chairman HARRIS. Thank you very much, Mr. Klara.

I now recognize our second witness, Ms. Janet Gellici, Chief Executive Officer of American Coal Council, and I just ask you to take just 15 seconds to describe the American Coal Council so that Mr. Miller understands where you are coming from.

Ms. GELLICI. Sure.

Chairman HARRIS. Thank you.

STATEMENT OF MS. JANET GELLICI, CHIEF EXECUTIVE OFFICER, AMERICAN COAL COUNCIL

Ms. GELLICI. Thank you. My name is Janet Gellici. I am CEO of the American Coal Council. The ACC represents coal industry interests from the hole in the ground to the plug in the wall, so we represent companies that include coal producers, transporters, and consumers of coal.

I would like to frame my remarks today based on two facts. First, we have more coal in the United States than any other country in the world, which means we have access to a 200-year supply of affordable, reliable domestic energy.

Second, we have some of the most admirable and lofty environmental goals of any nation on this planet. There are two facts here. They are not at odds. It is not a matter of picking one over the other. What we need is to bridge these two facts, and that bridge is technology. Other nations are investing heavily in building cleaner coal plants and in increasing their use of coal resources. Here in the United States 44 percent of our electricity comes from coal, but rather than upgrading existing plants or building new clean ones, U.S. utilities are planning to shut down their coal plants.

Projected retirements are now on the order of 50 to 100 gigawatts, representing 15 to 30 percent of our current coal generation. These retirements are due in large part to an inability to meet environmental regulatory requirements. They will likely result in higher costs to consumers and manufacturers and the potential to lead to generation shortfalls.

So we are imposing more environmental regulations on coal consumers, but we seem unwilling to commit the resources needed to actually achieve those objectives. There is an interesting conundrum going on here. Over the past few years our efforts to enact environmental regulations have actually been hampered by the lack of viable technology. The development and commercialization of technologies will actually help us facilitate environmental rulemaking.

You know, if we were to set down rules for our kids and did not provide them with the time, training, and tools to follow those rules, we would be called bad parents. Imposing regulatory objectives without providing the time, training, and technologies to meet them is just bad governance.

The good news is that we do have a history of success in meeting environmental objectives through RD&D efforts. We have installed advanced emission controls on 75 percent of U.S. coal plants and achieved an average of 90 percent reduction in criteria pollutant emissions. The National Academy of Sciences reports that feder-

ally-funded RD&D provides a public benefit that well exceeds the cost of RD&D, including much needed job creation.

We need to focus our RD&D coal efforts going forward in four areas: advanced energy systems, carbon capture and storage, water use technologies, and demonstration projects. I have addressed these in detail in my written testimony but would like to highlight a few points.

Advanced energy systems can increase the thermal efficiency of power plants from today's average of 33 percent up to 40 percent or more, and with each two percent increase in efficiency we can reduce the cost—we can reduce fuel use and CO_2 emissions by five percent. So more R&D will obviously advance technologies that can help us achieve these levels of efficiency in environmental gains, and this can be done both at existing plants and at new power plants. In fact, I believe we can extend the life of our current low-cost power plants in ways that are economic and environmentally sound.

One way to do that is through the use of engineered coal fuels. These are technologies that can be applied prior to combustion that clean coal. They help remove pollutants, and they improve the heat rate of coal so we don't have to burn as much.

Now, I understand that given the uncertainty in Congress right now that there will be any climate legislation passed in the near future, it might be tempting to curtail funding for carbon capture and storage. The reality is that while greenhouse gas legislation may not be eminent, greenhouse gas regulation is proceeding, and we need the technologies to meet those long-term needs.

To be successful RD&D funding needs to be stable and consistent. Curtailing CCS program technologies could have potentially negative gains, could negate the gains that we have had up to this point in time.

I get at least three to four calls a month from inventors and entrepreneurs who think they have the be-all solution to reducing CO_2 emissions and coal plant emissions, and I don't know where to send these people. I suggest they go to DOE or NETL, and they tell me they have already done that. There is no interest there, there is no money, and they are probably not all viable technologies, but I often hang up the phone wondering if I have just hung up the phone on the next inventor of penicillin for the global warming issues.

So we have a lot of coal, we have admirable environmental goals, and I think we have a lot of innovators out there ready to shine. I don't think the responsibility for effective regulation ends once we publish the rule in the Federal Register.

So I look forward to your questions.

[The prepared statement of Ms. Gellici follows:]

PREPARED STATEMENT OF MS. JANET GELLICI, CHIEF EXECUTIVE OFFICER, AMERICAN COAL COUNCIL

Introduction

This statement is submitted on behalf of the American Coal Council (ACC), a trade association dedicated to advancing the development and utilization of American coal as an economic, abundant, secure and environmentally sound fuel source. The ACC (www.americancoalcouncil.org) represents the interests of 170 U.S. coal suppliers, coal consumers and coal transportation companies. We represent the coal

industry from the hole in the ground to the plug in the wall. The ACC welcomes the opportunity to present a perspective on how to advance coal research and development to ensure our nation's energy needs are met in an economic and environmentally sound manner.

Coal is Vital to U.S. Economy

Our nation's domestic coal resources are critical to our economic well being, to ensuring our energy reliability and security, and to meeting our environmental goals. Today, coal generates nearly 44% of our nation's electric power; 36 states obtain at least 25% of their electricity from coal and 26 states obtain at least 45% of their electricity from coal. The Energy Information Administration (EIA) forecasts that U.S. coal generation will increase by 25% between 2009 and 2035, with coal's share of the total generation mix remaining steady at 43% in 2035. [1]

U.S. coal provides low-cost electric power and price stability compared with other fuel resources. Between 2000 and 2009, natural gas prices ranged from $3.10/million Btu (mm Btu) to $12.41/mm Btu. During that same time period, coal never exceeded $2.28/mm Btu. Those states that rely on coal for a majority of their electric power are the states that have the lowest cost of electricity for their residents and industries.

High energy costs disproportionately impact low income and fixed income families. In 2001, the 50% of U.S. households making less than $50,000/year spent an average of 12% of their after tax income on energy costs. Today, those families are now spending 20% of their household income on energy expenses. [2]

Industrial consumers are more likely to be price responsive than any other customer group. There is a strong correlation between the cost of electricity and the number of manufacturing jobs in the United States. Between 2000 and 2008, industrial electric prices increased from 4.6 cents/kWh to 7.2 cents/kWh. Over that same time period, manufacturing jobs decreased from 17.3 million to 13.4 million. [3] Low-cost electricity directly contributes to the competitiveness of America in international markets.

Studies show that new coal plants create more construction and permanent employment jobs than any other electric generation options. Coal jobs created per billion dollars invested equal 9,166, versus 7,640 for natural gas and 1,053 for wind generation. One recent study details the prospective loss of 1.24 million jobs as a result of new coal power plants NOT being built. The National Mining Association report details how the Sierra Club's "Beyond Coal" campaign has targeted for destruction 116,872 permanent jobs and an additional 1.12 million construction jobs represented by the proposed power plants that have been prevented from being built. [4]

The U.S. has 29% of the world's recoverable coal reserves—more than any other nation. Our nation has a 200 year supply of coal at current annual production rates of about one billion tons. Globally, coal is the fastest growing fuel source. World coal consumption is projected to increase 50% from 139 quadrillion BTUs in 2008 to 209 quadrillion BTUs in 2035. U.S. coal suppliers expect to take a greater role in international markets, welcoming the opportunity to contribute to improvements in our nation's balance of trade. In 2010, U.S. coal exports were up 36%, from 60 million tons in 2009 to 81 million tons in 2010. The forecast for 2011 coal exports is in the range of 100-105 million tons. [6]

The growing demand for clean energy technologies for the world's emerging economies will also provide U.S. technology transfer and export opportunities if we are willing to invest now in clean coal technology research development and deployment (RD&D). While other nations are increasing their use of coal resources and their installation of clean coal power plants, U.S. utilities are shutting down their coal facilities. Currently, 23 GW of coal power generation is slated to be shuttered in the next decade. Projected retirements are on the order of 56-101 GW, representing 15-30% of current coal power generation capacity. These retirements are due primarily to an inability to meet environmental regulatory requirements at reasonable costs within acceptable rate structures, as well as to economic demand destruction, aging fleet attrition and competition from natural gas fuels.

Meeting national environmental objectives continues to be coal's greatest challenge, a challenge that has been in the past and can be in the future addressed with

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[1] U.S. Energy Information Administration, Annual Energy Outlook 2011.
[2] Eugene M. Trisko, Esq. for American Coalition for Clean Coal Electricity, January 2011.
[3] Shively & Ferrare 2008 Enerdynamics.
[4] Energy Ventures Analysis, "Employment Impacts Associated with Electric Generation Options" for National Mining Association, September 2011.
[6] Cloud Peak Energy presentation, ACC Coal Market Strategies Conference, August 23, 2011 & Fitch Ratings, U.S. Coal Producers Outlook, August 17, 2011.

technology applications. Significant progress has been made over the past 3-4 decades to reduce air emissions. Since 1970, coal use has increased 183% while criteria pollutant emissions have decreased 90% on average, including NO_x reductions of 82%, SO_2 reductions of 88% and PM10 reductions of 96%. [7]

The U.S. cannot achieve its economic, energy security and environmental objectives without coal and the advancement of clean coal technologies.

Opportunities to Advance the Use of Coal

The benefits of clean coal technology include cleaner air, reduced pollution, increased energy efficiency, support for U.S. manufacturing, increased U.S. exports, enhanced national security and job creation. The role of the Federal government in RD&D is to develop technology options that can benefit the public good. The U.S. Department of Energy's Fossil Energy group carries out high-risk, high-value RD&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.
- Produce revolutionary "breakthrough" technologies that achieve environmental, efficiency and/or cost goals well beyond those currently pursued by the private sector.

Federally funded RD&D provides public benefits in excess of the cost of RD&D. A National Academy of Sciences report noted that the economic benefits in real dollars provided by Fossil Energy research between 1986 and 2000 equaled $7.4 billion versus an investment by DOE of $4.5 billion. [8] The study noted that 600,000 jobs were created in the U.S. power equipment industry, resulting from the more than 700 patents awarded through the Fossil Energy research program. Between 2000 and 2020, investments in coal RD&D are expected to create nearly 1.2 million jobs, with an average of 60,000 jobs created on an annual basis. [9]

DOE's clean coal technology programs have resulted in over 30 successfully completed projects; more than 20 of the technologies have achieved commercial success, including the installation of advanced pollution controls on 75% of U.S. coal plants at one-half to one-tenth the cost of older systems. A detailed overview of DOE Fossil Energy RD&D technology achievements since the 1970s is attached. [10]

Given the success of the Fossil Energy RD&D program in terms of economic and environmental benefits realized, it is disturbing that investments in clean coal technology are not supported at levels commensurate with other energy resources. A recent study by the U.S. Energy Information Administration (EIA) estimated the value of federal support for direct expenditures, tax expenditures, R&D funding, and loans and loan guarantees for various energy resources. It noted that in FY2010, renewable energy resources, which produce less than 5% of U.S. power generation, received 45% of Federal electricity production incentives. Coal, which produced 46% of U.S. electricity in 2010, received just 10% of Federal electricity production incentives. [11]

During the past several years, the primary focus of DOE's coal RD&D program has been on Carbon Capture and Storage (CCS). The coal industry supports continued RD&D in this area. The U.S., however, faces additional energy and environmental challenges that would benefit from collaborative coal RD&D by the government and private sector. These challenges are more immediate than CCS.

There needs to be a greater balance between support for CCS initiatives and those for other coal RD&D projects that can advance coal generation efficiency and enhance environmental compliance.

Our environmental rulemaking and legislative efforts of the past few years have been hampered, in part, by the lack of economic, commercial and technologically viable solutions. Environmental regulations need to be supported by technologies that enable industry to meet target objectives in a timely and economic manner. The de-

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[7] "Benefits from Investments in Advanced Coal Technology," Coal Utilization Research Council, National Mining Association, Edison Electric Institute, et. al. fact sheet attached hereto.

[8] National Academy of Sciences, "Energy Research at DOE, Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000." 2001.

[9] "Benefits of Investments in Clean Coal Technology" Management Information Services Inc., October 2009. Prepared on behalf of The American Coalition for Clean Coal Electricity.

[10] "Benefits from Investments in Advanced Coal Technology"– Fact Sheet Coal Utilization Research Council, et. al.

[11] "Direct Federal Financial Interventions and Subsidizes in Energy in FY2010" U.S. Energy Information Administration, July 2011.

velopment of viable technologies will facilitate the establishment of regulations to help us achieve our environmental objectives. Regulations and technology development go hand in hand.

It is counterproductive to decrease Federal investment in coal RD&D at a time when our nation needs low-cost electricity to support our citizens and industries, at a time when we need all available means to increase the competitiveness of America's goods in the international marketplace and at a time when the security of domestic energy sources is a high priority.

Current programs should be maintained and additional resources appropriated to ensure utility and industrial compliance with both an increasing number of environmental regulations and increasingly strict targets for environmental objectives. We continue to impose more environmental regulations on coal consumers but seem unwilling to commit more resources to actually achieving those objectives. This is akin to setting ground rules for our children but not providing them with the tools and training to be able to obey the rules we set.

Why are we so amazed that coal generators are shutting down their power plants because they can't meet environmental objectives? Why are some folks gleeful about that? Where is the satisfaction in having our nation's largest electric power providers shut their doors, stop producing low-cost electricity, fire their employees, and still not reach our environmental objectives?

There can be only one conclusion—that the real objective is not to reduce emissions—that we are really not concerned with meeting environmental objectives. It would appear that other agendas are in play here, agendas to eliminate coal generation from our energy portfolio simply because it is based on coal.

DOE's recently released Quadrennial Technology Review (QTR) notes that the U.S. needs to be a leader in the development of a clean energy economy and that "our challenge is to provide electric power in environmentally responsible ways that strengthen U.S. competitiveness and protect the climate." These objectives can clearly be met through the use of our nation's vast domestic coal resources in conjunction with the advancement of clean coal technologies.

DOE has a proven track record of facilitating the development of clean coal technologies that are cost-effectively reducing emissions today and hold much promise for continuing to yield similar stellar results in the future. Going forward, we need to focus our RD&D efforts on:

- Carbon Capture and Storage
- Advanced Energy Systems
- Engineered Coal Fuels
- Water Use Technologies
- Clean Coal Power Initiative Demonstration Projects

Coal RD&D Priorities

From an historical perspective, DOE's early clean coal technology programs focused on advancing technologies that would achieve reductions in criteria pollutants regulated under the Clean Air Act (CAA) and Clean Air Act Amendments (CAAA), including SO_2, NO_x and particulate matter. Following many years of RD&D, much success was achieved in reducing these emissions.

We should keep in mind that it was only a few short years ago when the pendulum of DOE funding swung toward advancing carbon management technologies. This was in response to the anticipation of legislation and regulations for greenhouse gas (GHG) management and to the increasing international focus on reducing CO_2. GHG regulations are proceeding and so should these technology development efforts—even though U.S. GHG legislation is not imminent.

It takes substantial time to develop and deploy new technologies—on the order of 10–20 years. We should anticipate a continued need for CO_2 management technologies and stay the course. It is difficult to turn technology development initiatives off and on and still make cost-effective progress. If we shutter CCS or the Clean Coal Power Initiative (CCPI) efforts today and decide in a few years to resurrect them, we will be faced with the prospect of starting all over again at ground zero, negating any earlier gains.

To be successful, RD&D funding needs to be stable and continuous. A funding interruption or extreme swings of the funding pendulum are an inefficient use of Federal funds.

We should avoid the knee jerk impulse to pull back CCS technology development efforts as we refocus on addressing more near-term regulations for energy efficiency improvements and compliance with stricter criteria emissions targets. We should also keep in mind that CCS stands for "carbon capture and storage" not "coal cap-

ture and storage." Development of CCS technologies is not a coal-only program. Our fossil energy colleagues in the natural gas industry will ultimately benefit from CCS developments as well.

Carbon Capture & Storage Priorities – Given the current uncertainty that Congress will pass climate legislation in the near term, it would seem easy to dismiss RD&D funding for CCS. In reality, however, the U.S. EPA is regulating GHG emissions and industry is currently being tasked with meeting compliance objectives for CO_2 reduction. It is, therefore, imperative that RD&D funding support continue. A "no regrets" approach to advancing technologies for carbon capture, carbon storage and carbon utilization today, will ensure that industry can meet current EPA regulations as well as prospective future legislation.

This longer-term technology need must, however, be balanced with RD&D funds to pursue more immediate and near-term environmental objectives with advanced energy technologies. While much work has been done in this area and ASTM code certification is certainly needed to advance commercialization, there still remains opportunities for advances in monitoring and control technologies for advance combustion systems. These technologies can help us produce coal-based electricity more cleanly and more cost effectively. They also have the added collateral benefit of reducing CO_2 when integrated with CCS applications. Additionally, there may be broader applications for high-temperature, high-pressure materials outside of coal generation, e.g., in the aircraft industry.

Advanced Energy Systems Priorities– Advanced technologies are needed to enhance the thermal efficiency of power plants, which today operate at an average efficiency of about 33%. Power engineers can replace our aging coal plants with new clean plants exceeding 40% thermal efficiency. This can be achieved in two ways:

1. Advances in energy systems for new plants including:
   - The development and application of high-pressure, high-temperature materials in boilers and steam turbines for new supercritical and ultra-supercritical power plants. These high performance materials would enhance the efficiency of power plants and reduce emissions of criteria pollutants and GHG emissions.
   - Oxy-firing systems that replace combustion air in coal power plants with pure oxygen to greatly reduce emissions.
   - Integrated Gasification Combined Cycle (IGCC) systems which advance efforts to capture carbon.
   - Advanced turbine systems that can enhance plant efficiency and help meet the demands of IGCC plants with high levels of CO_2 capture.
   - Fuel conversion systems that facilitate the production of liquid transportation fuels from coal and biomass.
2. Efficiency upgrades and heat rate improvements for both existing and new plants. New Source Review (NSR) constraints have curtailed efforts to achieve efficiency improvements. A leading combustion systems engineer, Richard Storm, PE, CEO, Storm Technologies notes that we can achieve a 3–5% efficiency improvement at existing plants by upgrading turbine rotors, installing new high capacity boiler feed pumps and higher efficiency air heaters and ductwork, and by upgrading boilers, condensers and feed water heaters. [12]

Storm notes that operations and maintenance improvements could potentially increase heat rates up to 750 Btu/kWh and achieve fuel savings of $2 million or more. Payback on a $5 million investment would take two years. Capital projects that have a potential to trigger NSR are deemed by industry to be very risky. Better clarity, and potentially guarantees, are needed on what upgrades will not trigger NSR.

Also of note is that capital investments to improve thermal efficiency often compete with non-optional investments for environmental compliance and other energy projects that offer high returns on investment. While not a direct DOE RD&D funding need consideration, these operations and maintenance improvements can provide interim compliance with environmental requirements as we work toward longer term solutions. Efficiency gains in the existing coal power generation fleet can offset significant amounts of CO_2, setting a more achievable bar for us to overcome with advanced technologies.

Engineered Coal Fuels Priorities– DOE's National Energy Technology Laboratory (NETL) has noted that " . . . increasing the average efficiency [of power plants] from

[12] Richard F. Storm, "What can be done to improve the Thermal Performance of the existing coal fleet?", EPRI Heat Rate Conference, January 2011.

32.5% to 36% reduces U.S. greenhouse gases by 175 MMmt/year, or 2.5% of total U.S. GHG emissions in 2008."[13] At NETL's February 2010 Technical Workshop ("Improving the Thermal Efficiency of Coal-fired Power Plants in the United States"), industry and government representatives identified more than 50 opportunities to improve thermal efficiency. One of these opportunities included the "use of low-grade heat for coal drying"—an example of numerous Engineered Coal Fuels technologies available or under development today to improve heat rate, advance power plant efficiency and reduce emissions with prior-to-combustion treatments of coal.

Engineered Coal Fuels (ECF) provide an opportunity to extend the life of existing low-cost power plants in an economic, environmentally sound manner. Given the current state of our economy and waning competitive position in world markets, now is not the time to be shuttering low-cost power plants. As noted earlier, low-cost electricity supports domestic industries and manufacturing jobs, advances the competitiveness of the U.S. in international markets and provides for the well being of our nation's citizens.

ECFs treat and enhance coal prior to combustion, resulting in the following benefits:

- **Reduced Fuel Consumption** – increasing energy content by 30% results in less coal used.
- **Decreased Emissions of Criteria Pollutants** – reductions of SO_2 (10–80%), NO_x (10–50%) and mercury (15–99%).
- **GHG Reductions** – increasing combustion efficiency by 2–4% results is a 5–10% reduction in CO_2 emissions.
- **Increased Capacity** – increased power output and improved heat rate enable higher capacity utilization and efficiency at the point of combustion.

ECFs represent low capital cost investments for utility and industrial companies—an operations and maintenance expense versus an intensive capital investment. Stricter pending regulations on SO_2, NO_x, PM, mercury and HAPs are driving the need for some of these more near-term solutions. There is a vital role here for government to take assisting with the deployment of these technologies through testing and evaluation. This type of a role for government dovetails with the following recommendation from the QTR:

> "The Department [of Energy] needs a professional group that can integrate the major functions of technology assessment and cost analysis, program planning and evaluation, economic impact assessments, industry studies, and energy and technology policy analysis."

A facility with the capability to test a broad range of temperature, pressures, coals and methods would provide an opportunity for companies that have developed advanced combustion systems and engineered coal fuels technologies to verify the benefits and economics of their solutions. It would provide an objective, third party evaluation that would benefit all stakeholders, including industry, policy makers and the environmental community.

In the case of Engineered Coal Fuels, we should also undertake RD&D of coal/biomass fuels that can be used in the existing coal generation fleet without significant power plant modification. DOE has committed to fund coal/biomass development of coal gasification applications. Extending the application to the existing coal fleet for purposes of advancing coal/biomass applications would provide a near-term solution to meeting environmental regulations.

Water Priorities– Water RD&D is critical for all energy technologies, not just coal but nuclear, solar and natural gas as well. We need to devote RD&D funding into technologies that can help us reduce water consumption and increase reuse of water discharge.

A sole focus on basic engineering research will not advance commercial technology to the marketplace. The CCPI demonstration program needs to be continued and adequately funded. Previous lack of funding for demonstration projects resulted in what has become well known as "The Valley of Doom"—a future in which no new coal generation facilities are being planned to be built in the U.S.

Clean Coal Power Initiative (CCPI) Priorities– The Administration has not requested funding for large-scale demonstration projects for three years now. Demonstration programs are critical for the commercialization of advanced coal, Engi-

[13] "Improving the Efficiency of Coal-fired Power Plants for Near Term Greenhouse Gas Emissions Reductions." DOE/National Energy Technology Laboratory, April 16, 2010, DOE/NETL-2010/1411.

neered Coal Fuels and CCS technologies, including the FutureGen project which has received funding through the Recovery Act.

DOE's proposal to increase the use of computer modeling has benefits in terms of reducing the amount of time and money to develop, demonstrate and deploy new technologies. But at some point, we need to build something to see how it actually works in real life. Modeling cannot replace the value of practical demonstrations. Demonstration projects validate the reality of technology applications and confer a higher level of understanding, knowledge and acceptance of new technologies. Computational modeling should be supported only to the extent that it does not come at the expense of funding other RD&D and demonstration activities.

Additionally, the $187 million rescinded from the AEP Mountaineer Project should be reallocated for future demonstration projects.

Going forward, RD&D funding should focus on advancing higher efficiency technologies, reducing capital costs associated with these advanced technologies and increasing the commercial availability of technology solutions. These efforts will help us achieve greater reductions in criteria pollutants, as well as CO_2 and other greenhouse gases.

Appended Materials:

- **"Benefits from Investments in Advanced Coal Technology"** – Fact Sheet Coal Utilization Research Council, et. al. *http://www.coal.org/userfiles/file/FINAL%20Benefits%20of%20Investment%20in%20Coal%20RD&D.pdf*
- **"Retrofit Programs Increase Generation Efficiency and Decrease CO_2 Emissions"** – National Coal Council Fact Sheet. *http://www.nationalcoalcouncil.org/Documents/Advanced—Coal—Technologies.pdf*
- **"Engineered Coal Fuels Fact Sheet"** – American Coal Council *http://www.americancoalcouncil.org/associations/10586/files/pre-combustion—Apr—2011.pdf*

Chairman HARRIS. Thank you very much.

I now recognize our third witness, Mr. Nick Akins, President of American Electric Power.

STATEMENT OF MR. NICK AKINS, PRESIDENT, AMERICAN ELECTRIC POWER

Mr. AKINS. Good afternoon, Chairman Harris, Ranking Member Miller, and distinguished Members of the Subcommittee on Energy and Environment. Thank you for inviting me here today and for this opportunity to offer the views of AEP on advancing research and development for a secure energy future.

We applaud your efforts to examine DOE coal research and development activities to ensure that coal fuel generation remains an important part of this Nation's energy mix. AEP has a long track record of accomplishments with the demonstration of cutting-edge technologies.

In May of this year AEP successfully concluded a demonstration of the world's first integrated CO_2 capture and storage project at an existing coal-fired power plant using Alstom's chilled ammonia process, a 20 megawatt scale carbon capture and storage project captured and permanently sequestered nearly 40,000 tons of CO_2 in deep saline reservoirs from our Mountaineer Power Station in West Virginia. That was such an important accomplishment that AEP has hosted visitors in the thousands from every continent around the globe.

AEP also teamed with DOE to demonstrate the same technologies at commercial scale. While funding challenges caused the project to be suspended following the first project phase, we now have the engineering design for a carbon capture and storage facility that includes extensive geologic characterization and a solid cost

estimate. Robust and affordable choices for CCS will not be available in the market if the technology is not demonstrated. We believe DOE should be bolstered in their efforts to develop viable and affordable technology solutions.

AEP's Turk Power Plant in Southwest Arkansas represents America's first deployment of ultra-supercritical technology, a new high-efficiency design that uses less fuel to produce each megawatt hour of electricity. This plant will go commercial in mid 2012, and will result in a substantial performance improvement over today's conventional sub-critical design. The Turk Plant's efficiency is more than 11 percent greater than the typical sub-critical coal power plant. Other advanced technologies deployed at Turk will compound the benefits of higher efficiency resulting in significantly lower emissions.

This is another case of advanced technology making coal usage cleaner and more efficient. AEP has also completed front end engineering designs for Integrated Gasification Combined Cycle, IGCC technologies, as well.

The above examples illustrate that my company stands firmly behind technology advancement. The DOE has shown its effectiveness in advancing technology to commercial readiness, and AEP's recent partnership with DOE resulted in meaningful and important knowledge. In fact, some of DOE's project management processes have been so effective that AEP has adopted them on other major projects. This has truly been a collaborative relationship.

Of greatest concern to me as I consider leading AEP through unprecedented challenges is the recent regulatory actions of the EPA. We strongly support the Clean Air Act and continued reduction emissions from our power plants, however, AEP believes that the current regulatory track being pursued by the EPA will have damaging impacts on the reliability of our Nation's electric system as well as broad or negative employment and economic implications. Together CSAPR, the Utility MACT, Clean Air Visibility Rule, Coal Combustion Residuals Rule, and Cooling Water Intake Structures Rule will require very large capital investments on a timeline that can only be described as unrealistic.

Among AEP's most pressing concerns include infeasible compliance deadlines, unprecedented capital expenditures, abrupt and significant power plant retirements, electric grid reliability problems, and very high electricity rate increases. We believe that a more reasonable approach to energy and environmental policy is needed and is discussed in greater detail in my written testimony.

DOE is in a unique position to be a part of the solution and should serve as a trusted advisor to the EPA in the rulemaking process. They have the well-informed authority to evaluate the electric power generation system and grid stability and security risks and can assess the timelines needed to deploy technology at the broad scale required under EPA's Program.

In summary, continued research, development, and demonstration must be supported and is essential to solving the complex problems of energy security, climate change, and environmental compliance. We must do more than simply call for it. Private industry must complete their commercial plant demonstrations, and our country must devote adequate financial and technological resources

to this enormous challenge. AEP is committed to being a part of this important process and helping achieve the best outcome at the most reasonable cost and timelines possible.

Thank you again for this opportunity to share these views with you.

[The prepared statement of Mr. Akins follows:]

PREPARED STATEMENT OF MR. NICHOLAS K. AKINS,

PRESIDENT, AMERICAN ELECTRIC POWER

Chairman Harris, Ranking Member Miller, and distinguished Members of the Subcommittee on Energy and Environment of the House Science, Space and Technology Committee, thank you for inviting me here today. I appreciate this opportunity to offer the views of American Electric Power (AEP) on advancing coal research and development for a secure energy future.

My name is Nick Akins, and I am the President of American Electric Power. Headquartered in Columbus, Ohio, we are one of the nation's largest electricity generators—with more than 38,000 megawatts (MW) of generating capacity—and serve more than five million retail consumers in 11 states in the Midwest and South Central regions of our nation. AEP's generating fleet employs diverse fuel sources—including coal, nuclear, hydroelectric, natural gas, oil, and wind power. But of particular importance for the Committee Members here today, AEP is the largest consumer of coal in the United States and, as a result, our company is an industry leader in developing advanced coal-fueled electrical generation and emission reduction technologies, including carbon capture and storage (CCS) and ultra-supercritical pulverized coal (USCPC) technology.

I am here today to discuss AEP's experience with our CCS projects and the development of the USCPC technology through the construction of the J.W. Turk Plant. In addition, I will highlight the near term challenges to new technology development associated with the recently-announced EPA regulations.

AEP'S LEADERSHIP IN TECHNOLOGY DEVELOPMENT

AEP has a long and proud history as a leader in our industry for the development and deployment of new technologies. The first high- and extra-high voltage transmission lines at 345 kilovolt (kV) and 765 kV were developed by AEP and serve as the framework for our interstate transmission system. AEP was among the first to develop large central station power plants and to deploy more efficient supercritical generating technologies. AEP recently celebrated its centennial by reflecting on its century of firsts.

Most recently, we have built upon this history of innovation by focusing our efforts on new clean coal technologies. These technologies will enable AEP and our industry to meet the challenge of reducing greenhouse gas emissions while optimizing the use of our nation's plentiful indigenous coal resources. As concepts for effective CCS from coal-fueled facilities are being talked about and debated around the globe, AEP has been on the cutting edge with an aggressive plan to commercialize advanced CCS technology. With the announcement of its successful completion in May of this year, AEP demonstrated the world's first integrated CO_2 capture and storage project at an existing coal-fired power plant. Based on Alstom's chilled ammonia process, a 20-MW-scale CCS product validation facility at our 1,300-megawatt Mountaineer Power Plant in New Haven, West Virginia permanently sequestered nearly 40,000 tonnes of CO_2 in deep saline reservoirs located 1.5 miles beneath the surface. Just as we were winding down that enormously successful demonstration, AEP and DOE were in the final stages of a commercial-scale engineering study of the same technologies. As a result, we now have a robust front-end engineering design for a CCS facility that includes extensive geologic characterization and a solid cost estimate.

In addition to CCS technology, construction currently is underway in southwest Arkansas on the 600-megawatt J.W. Turk Plant that will employ new ultra-supercritical coal-fired generating technology. Ultra-supercritical technology uses high steam pressure and temperature to increase operational efficiency. The Turk Plant represents a new generation of power plant design that uses less fuel to produce each megawatt hour of electricity. This means that all emissions, including sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury, and carbon dioxide (CO_2), will be lower than conventional coal-combustion processes per unit of electricity produced.

Once operational, the Turk Plant will be the first commercial scale ultra-supercritical plant to operate in the United States.

AEP also has pursued the development of Integrated Gasification Combined Cycle (IGCC) technology. IGCC represents a major breakthrough in efforts to improve the environmental performance of coal-based electric power generation. IGCC technology integrates two proven processes—coal gasification and combined cycle power generation—to convert coal into electricity more efficiently and cleanly than any existing uncontrolled power plant. IGCC also has the potential to be equipped with carbon capture technology at a lower capital cost and with less of an energy penalty than traditional power plant designs, but only after the carbon capture technology has been proven at a commercial scale. We still strongly endorse the advancement of this technology in the future.

AEP'S EXPERIENCE WITH CCS AT MOUNTAINEER

As noted previously, AEP recently completed a CCS validation project at our Mountaineer Power Plant using Alstom's chilled ammonia process. This recently completed project treated approximately 20 MW, or 1.5 percent, of the total plant flue gas flow. The CCS validation project was privately funded by AEP and partners, started capturing CO_2 in September 2009, and initiated CO_2 injection in October 2009. The project was designed with the capability of capturing and storing approximately 100,000 metric tons of CO_2 annually. Captured CO_2 from the project was injected through two onsite wells into two geologic formations (Rose Run and Copper Ridge) located approximately 1.5 miles below the plant site. The project also included three deep wells for direct monitoring of geologic conditions and assessing the suitability of the geologic formations for future storage. Consistent with the Underground Injection Control (UIC) Class V Permit, AEP continues to monitor these wells. The project supplied data to support the design and engineering of the commercial-scale CCS demonstration at the Mountaineer facility and thereby has laid the technical groundwork to enable commercialization of complex technology. Without these demonstrations, there is no chance that CCS will become robust and commercially viable at a reasonable cost for end users of electric power.

The CO_2 capture system proposed for the Mountaineer commercial-scale demonstration project is similar to the Alstom chilled-ammonia system operated at the initial validation project, but at approximately 12 times the scale. As with the initial validation project, the process uses an ammonia-based reagent to capture CO_2 and isolate it in a form suitable for geologic storage. The captured CO_2 stream is cooled and compressed to a supercritical (liquid-like) state for pipeline transport to the injection well sites. The process is designed to remove approximately 90 percent of the CO_2 from the 235 MW slipstream of flue gas.

Subsurface geological investigations of the Mountaineer site and surrounding subregion were conducted during 2010–2011 and built on a large amount of work done at the site over the last eight years under two separate projects. First, from 2002 to 2007, the DOE and others provided funding for Battelle to conduct detailed geologic characterization under the Ohio Valley CO_2 Storage Project, which included a seismic survey and drilling of one well in 2003 followed by reservoir testing, modeling, and conceptual CO_2 injection simulations. Second, AEP hired Battelle in 2007 to construct the geologic sequestration systems for the 20 MW CCS validation project. This included completion of the original well and drilling of four new wells on the Plant site. Extensive evaluation of voluminous data from the projects along with the drilling of an additional characterization well some 2.5 miles south of the validation project site, indicate that the Copper Ridge Formation has significant reservoir storage potential. Additional injection potential has been identified in the Rose Run Sandstone and other zones.

While the success of the Mountaineer Plant validation project proved that CCS is viable at a coal-fired power plant and also demonstrated that CO_2 could be safely injected into deep saline reservoirs in that region, the commercial-scale demonstration has been put on hold. An agreement for DOE funding of the commercial-scale project was finalized in early 2010, allowing for a combination of DOE CCPI Round 3 and American Recovery and Reinvestment Act of 2009 funds to provide 50 percent of the cost of the project up to $334 million. AEP was responsible for securing the other 50 percent of the cost. This seemed very plausible at the time of the grant application due to the House's passage of the Waxman-Markey climate legislation and the Senate's serious consideration of similar legislation at that time. Both bills, as well as other legislative proposals, contemplated significant economic incentives to develop CCS projects and a regulatory justification for approval by State Commissions. However, during the balance of 2010, as the U.S. economy remained sluggish and prospects for climate legislation dimmed, it became clear to AEP that cost re-

covery for the expense of a CCS project would not be approved by state regulatory agencies. Therefore, AEP was unable to move forward with the commercial demonstration and has placed the project on hold. The agreement with DOE was terminated following the completion of project Phase 1 and plans to complete the project are on hold.

Even though the Mountaineer commercial-scale project has been postponed, there is still enormous value in the efforts and investment by AEP and DOE. Prior to this project, much of what has been publically discussed and debated regarding performance and cost was based upon crude estimates and extrapolations from petro-chemical processes that, at best, bore no more than a simplistic resemblance to CCS on coal-fired power plants. Because of the work done through Phase 1 of the commercial-scale project, an engineering package has been developed specifically for a retrofit of post-combustion CO_2 capture installation on a coal-fired power plant. Detailed process understanding and performance knowledge was collected from the validation project and applied at full-scale. Optimization of process elements and individual pieces of equipment has yielded a state-of-the-art design. As a result, we now have a robust front-end engineering package that includes extensive geologic characterization and a solid cost estimate. While certain aspects of the information gained through years of technology development at Mountaineer belong to Alstom as intellectual property, a wealth of knowledge has been publically disclosed at conferences and other venues, with even more to come through relationships with DOE, the Global CCS Institute, and others. Hundreds of tours and literally thousands of visitors have come through Mountaineer Plant over the past several years. Clearly this work has been recognized and appreciated on a global scale.

AEP's work on CCS is a critically vital step, but only the beginning of a long path toward broad deployment of CCS technology. AEP's work has not yet produced a commercial scale demonstration of the technology for capturing and sequestering CO_2 at an affordable cost. AEP's work is merely the first of multiple steps in the maturation of a widely-deployable technology. Much like the power industry's experiences with sulfur dioxide scrubbers in the 1970's, much optimization remains to be done. With real demonstrations, brilliant minds working together will identify improvements and process optimizations that will eventually simplify designs, drive down costs, reduce energy consumption, and make the technology more affordable. Now is not the time to ease up on CCS development and demonstration efforts. On the contrary, the industry, with government support, must continue to march together down the path of progress. The DOE program of technology development and commercial-scale demonstration is critical to making this happen. DOE's technology roadmap and planned demonstration projects are essential for commercial technology advancement.

AEP'S EXPERIENCE WITH ULTRA-SUPERCRITICAL PULVERIZED COAL TECHNOLOGY

The J.W. Turk Plant is a 600 megawatt (MW) net, ultra-supercritical unit designed to fire subbituminous coal. The Turk Plant cycle is classified as advanced coal generation technology primarily because of the use of an ultra-supercritical steam cycle. The ultra-supercritical cycle is a technology advancement of the supercritical steam cycle. The term "supercritical" steam cycle means that the water/steam pressure used in this technology is above critical pressure of water (3,208.2 psi). Water above the critical pressure does not boil, but makes a transition from the properties of liquid water directly to the properties of superheated steam. Superheated steam provides a higher efficiency heat transfer mechanism and serves to increase the overall efficiency of the steam cycle. While a supercritical plant cycle uses high pressure, it uses steam temperatures only as high as 1,050°F–1,080°F. The Turk Plant's main steam temperature will be 1,110°F and its reheat steam temperature will be 1,125°F. These very high temperatures, coupled with operation at these high pressures, produce higher cycle efficiency, and thus the term "ultra-supercritical." In addition, Turk uses advanced equipment design features, such as axial flow air and gas fans, pulse jet fabric filters, spray dryer absorber (SDA) technology, and a steam turbine driven boiler feed pump to drive down auxiliary loads (power used by plant equipment) which also improve the overall efficiency of the generating unit.

AEP led the industry in the deployment of supercritical pulverized coal technology. The first commercial supercritical unit in the world was AEP's Philo Unit 6, built in 1957. Since then, AEP has constructed 20 supercritical units and is currently operating 18 supercritical units. These units range in size from 500 MW to 1,300 MW, with a total generating capacity of over 17,000 megawatts.

The advancement to ultra-supercritical has been made possible by recent ASME-approved, cost-effective high temperature chrome and nickel-based alloys in the

steam generator, piping, and turbine systems. This development signals a degree of maturity which allows for minimal risk in deployment of this advance technology.

The use of high steam temperatures and pressures at the Turk Plant will result in a steam cycle that is one of the most efficient in the industry. In addition, the use of high efficiency equipment allows the Turk Plant to have one of the lowest heat rates in the world. Turk's full load higher heating value (HHV) net heat rate will be 8,992 Btu/kWh, which converts to an overall net efficiency of 38%, HHV. As reported by the DOE Energy Information Administration in January 2009, for 2007 the industry average full load net heat rate is 10,114 Btu/kWh, HHV, or an average efficiency of 33.7%, HHV. The high efficiency of the Turk Plant results in very low emissions per megawatt hour, in comparison with those generating units with average efficiency rates.

To give some perspective, the following is a comparison of Turk Plant's ultra-supercritical benefits when compared with a same-sized unit using conventional subcritical technology, based on an 85% capacity factor, per year basis:

- 180,000 tons less coal consumed (1,500 fewer coal train cars)
- 1,600 tons less lime consumed
- Reduction of 14,000 tons ash and FGD waste
- 360 million gallons less water consumed
- 320,000 tons less CO_2 emitted
- 150 tons less SO_2 emitted
- 100 tons less NO_x emitted

Achieving higher efficiency performance is limited by the available materials to handle extreme temperatures and pressures, and is also limited by approved methods for welding the materials. Simply put, there are no available materials or approved welding procedures in the U.S. that enable higher temperature steam cycles than those installed today at Turk Plant.

The Turk Plant received regulatory approval in Arkansas, Louisiana, and Texas in 2007-2008. Construction of the plant began after AEP Southwestern Electric Power Company (SWEPCO) received the Clean Air Act construction permit in 2008. Since that time, SWEPCO has encountered some challenges to the various permits and regulatory approvals.

Construction of the Turk Plant continues, with key milestones approaching that include the boiler hydro test, followed by the first combustion of coal to take place in late spring of next year. The first planned synchronization of the generator to the electric grid is planned for mid–2012.

AEP'S PERSPECTIVE ON THE RECENT EPA REGULATIONS

AEP strongly supports the Clean Air Act and continued reduction in emissions from our power plants. However, AEP believes that the current regulatory track being pursued by the Environmental Protection Agency (EPA) will have damaging impacts on the reliability of our nation's electric system, as well as broader negative employment and economic implications. Together, the federal Cross-State Air Pollution Rule (CSAPR)—formerly known as the Transport Rule, the Utility Maximum Achievable Control Technology Rule (Utility MACT), the Clean Air Visibility Rule, the Coal Combustion Residuals Rule (CCR) as well as the Cooling Water Intake Structures Rule under section 316(b) of The Clean Water Act (316(b) rule) will require very large utility capital investments on a timeline that can only be described as unrealistic. CSAPR and the Utility MACT alone, according to EPA's own estimates, will impose massive costs within the next 3 to 4 years, the vast majority of which will be borne by coal-fired generators and their customers.

This follows two decades during which generators within these same areas have invested billions of dollars to achieve reductions of over 70 percent in emissions of both SO_2 and NO_x. Electricity rates in states where these investments have been made have already risen. For most coal-reliant states, the CSAPR will require additional substantial emission reductions starting in January of 2012. In several of these states, these represent reductions of more than 30 percent below actual emissions in 2010. Further even more substantial reductions are required in 2014, with Ohio, Pennsylvania, Indiana, Kentucky and Virginia required to make 60–76 percent reductions below 2010 actual levels. This is also the same year EPA proposes to make the Utility MACT effective for sources nationwide. There is simply not enough time to get regulatory approvals, design, permit, and construct scrubbers, SCRs or other major pollution control investments to achieve those levels of reductions. As a result, they will force a large number of premature power plant retirements where investments are uneconomical given the remaining useful life of the

plants. Where such investments are the most cost-effective compliance option, plants may have to be idled or significantly curtail production for two or more years in order to complete installation of the necessary controls. These power plant operational outcomes raise significant policy, economic, and energy issues that Congress should carefully examine.

AEP has achieved very substantial SO_2 and NO_x reductions over the past two decades. Our efforts began with a series of cost-effective measures to cut SO_2 and NO_x emissions in the 1990's under the Acid Rain program, including installing SO_2 scrubbers and NO_x combustion controls, as well as blending lower sulfur coals into the fuel mix at plants that could accommodate such coals. The past decade has seen a continuation of AEP's program to transform our fleet of coal-fired generating units. This transformation included the installation of state-of-the-art control technologies at many of our generating stations in order to meet the steep NO_x reduction requirements of the NO_x SIP Call in the early part of the decade. It has continued with a third wave of emissions controls being installed to achieve additional NO_x and SO_2 reductions required under the Clean Air Interstate Rule (CAIR), which CSAPR would replace. As a result of these efforts, over the last 20 years, our annual SO_2 emissions have declined by about 1.1 million tons (a 73 percent reduction) and our annual NO_x emissions have been reduced by about 450 thousand tons (an 80 percent reduction).

Over that same period, AEP has invested more than $7 billion in emissions control equipment on our coal units to reduce SO_2 and NO_x emissions and to comply with the NO_x SIP Call and CAIR programs. AEP has spent several additional billions of dollars on low sulfur fuel, chemical reagents, and other pollution control operations and maintenance costs. Most of these investments and the emission reductions have occurred in the Eastern portion of the AEP system. About 80 percent of AEP coal-fired capacity is located in AEP's Eastern footprint, which includes coal-fired plants in Virginia, West Virginia, Ohio, Kentucky, and Indiana. Annual SO_2 and NO_x emissions have been reduced at AEP plants in these states by 64 percent and 84 percent, respectively, in the last decade alone. About two-thirds of the AEP Eastern coal-fired fleet is now equipped with the most advanced SO_2 controls—Flue Gas Desulfurization (FGD) which reduces SO_2 emissions by about 95 percent. Similarly, about three-quarters of the AEP Eastern coal-fired fleet is equipped with the most advanced NO_x controls—Selective Catalytic Reduction (SCR) which reduces NO_x emissions by about 90 percent. Two projects were completed in the last 18 months at our Amos Plant, and we are preparing to submit applications for regulatory approvals to install additional controls in Indiana. All of these efforts have also been consistent with an agreement we signed in 2007 with EPA and other plaintiffs to settle an enforcement action under the New Source Review Provisions of the Clean Air Act. But EPA's new rules impose more obligations, sooner than required under that Consent Decree.

We expect this transformation of our coal fleet to continue in the coming decade. Two of our newer coal plants in our Western states were originally constructed with FGD controls, and we expect to reduce SO_2 and NO_x emissions further at units that are regulated under the Clean Air Visibility Rule in Arkansas and Oklahoma. CSAPR will impose additional obligations on our units in Texas, Arkansas, Oklahoma and Louisiana as well.

The EPA Rules Threaten Electric Grid Reliability, Create Higher Unemployment, and Result in Much Higher Electricity Rates for States Reliant on Coal Fired Generation.

Although AEP is committed to working with EPA in the development of future control requirements under its proposed Utility MACT, CCR and 316(b) rules, the final Clean Air Visibility Rule, and the final Cross-State Air Pollution Rule, we nonetheless have major concerns with these new EPA rules, including the following:

1. **Infeasible Compliance Deadlines.** EPA is simply not providing sufficient time to design, permit, and install major emissions control technologies on large amounts of existing coal-fired capacity that are necessary to comply with EPA's Cross-State Air Pollution Rule (beginning in 2012, with more stringent limits in 2014), the proposed Utility MACT Rule (by the end of 2014 or by end of 2015) and the proposed Federal Visibility Rule in Oklahoma (end of 2014).
2. **Multiple Major Regulatory Programs Resulting in Unprecedented Capital Expenditures, Mostly Before 2015.** There would be two to three times as much capital spent in the U.S. to comply with these new EPA rules by 2020, compared with the amounts that were spent cumulatively on all utility air pollution controls during the previous 20 years.

3. **Abrupt and Significant Power Plant Retirements due to the Combination of the High Costs of Compliance and the Infeasible Deadlines.** Recent studies have suggested that between 50 and 110 gigawatts of coal-fired capacity will be forced to prematurely retire due to proposed EPA rules, impacting the reliability of the grid, jobs, taxes, and utility rates. The un-depreciated balances associated with these retirements will place greater pressures on utility rates.
4. **Unanticipated Electric Grid Reliability Problems Particularly during 2014–2016.** Because many generating units provide system security and reliability to the grid (e.g., black start, voltage support, etc.), this impact will be exacerbated by the large number of premature retirements; substantial idled capacity arising from insufficient time to design, permit, and install major emissions controls; and the necessarily wide-scale unit outages required to "tie-in" these major new emission controls. The greatest capacity reductions will occur in the PJM (i.e., Pennsylvania New Jersey Maryland Interconnection) region, a very large power pool which serves the Mid-Atlantic states (NJ, PA, DE, MD), plus several states just to the west (including WV, OH, IN, MI and parts of IL) as well as in the SERC (i.e., Southeast Reliability Coordinating Council) region, which includes most of the Southeastern U.S., with additional localized reliability issues in these regions and ERCOT and SPP (the Electric Reliability Council of Texas and Southwest Power Pool, respectively).
5. **Very High Electricity Rate Increases Due to High Capital Costs of Compliance and New Replacement Capacity.** These rate increases will hit electricity-intensive manufacturing in the Appalachian Region as well as other parts of the Midwest and Southeast particularly hard, leading to industrial plant shutdowns and substantial job losses. They will also be disproportionately borne by consumers in some of the poorest rural counties in these same states where there are many customers who are unemployed or on fixed incomes.

There is Not Enough Time to Comply with EPA's New Rules for Controlling SO_2, NO_x, and HAP Emissions from Power Plants.

EPA's Cross-State Air Pollution Rule and Utility MACT Rule will require installation of a large amount of SO_2 scrubbers and other capital intensive air emission controls. In particular, under the Cross-State Air Pollution Rule, the SO_2 caps become significantly more stringent in 2014 for more than two-thirds of the States covered under the SO_2 portion of the rule.[1] These States are those most reliant on coal and they will bear the major portion of the compliance burden for limiting SO_2 emissions. The SO_2 budget limits in Eastern states, specifically states in the Appalachian Region, are equivalent to an average emission rate of approximately 0.20 to 0.30 lbs SO_2 per million Btu. Such very low emission rates can only be achieved at power plants burning Eastern bituminous coals by adding scrubbers. As such, these limits would require most all of AEP's coal-fired power plant units in these states to either install FGD, switch to natural gas or significantly curtail operations in order to comply.

In addition to the massive SO_2 emission reductions required in 2014, the emission reductions slated for 2012 are very significant as well. These new emission requirements will be enforced less than three months from now, with little advanced notice, as the final requirements of the Cross-State Air Pollution Rule are significantly more stringent than those of the proposed Transport Rule. EPA's proposed revisions just announced last week do not result in appreciable changes in allowance allocations. For example, Ohio, Pennsylvania and Indiana are required respectively to make 46 percent, 33 percent and 31 percent reductions in SO_2 emissions from 2010 levels by next year. Other states outside of the Appalachian and Midwest Regions are also hit hard with stringent SO_2 reduction requirements. For example, Texas, even after EPA's proposed revisions to the budgets, is still required to reduce 2012 SO_2 emissions by 21 percent, as compared to actual 2010 levels.

These "new" reduction requirements in just three months (first known with the issuance of the final rule just two months ago) are particularly problematic because utilities are largely unable to make modifications to existing power plants in this time frame to substantially reduce emissions. Also, as most utilities procure most of their coal on a contractual basis well in advance, a major switch to lower sulfur coals is often not a realistic option. As a result, coal-fired power plants will likely

[1] Specifically, 16 states, out of the 23 states covered under the Cross-State Air Pollution Control Rule program for SO_2, would be subject to more stringent SO_2 reduction requirements starting in 2014.

have to be significantly curtailed. Replacement electricity is likely to come in the form of more expensive gas-fired generation. Additionally, the replacement capacity might not be located in areas critical to transmission reliability, or able to provide voltage support or black start capability, creating further risks to reliability and increasing the costs of maintaining the electric grid.

In addition to the Cross-State Air Pollution Rule, the proposed Utility MACT Rule requires compliance on a plant by plant basis with three separate emission limits (1) a very low mercury limit, (2) a PM limit (as a surrogate for non-mercury metals), and (3) a hydrogen chloride limit (as a surrogate for acid gases, or an optional stringent SO_2 limit as a surrogate at certain units). These limits will have to be met by the end of 2014 with a possible one-year extension allowed to the end of 2015. Based on a thorough review of these limits (when combined with the requirements of CSAPR), we believe AEP will be required to retrofit SO_2 scrubbers on most of the remaining Eastern fleet, and at a minimum, install a combination of baghouses, carbon injection and DSI (dry sorbent injection) at our plants in Texas, Arkansas and Oklahoma. For our Western fleet, some of these same units are affected by EPA's Clean Air Visibility Rule (CAVR), and thus could be required to retrofit scrubbers on the same or a slightly longer schedule.

Compliance with the final Cross-State Air Pollution Rule and proposed Utility MACT Rule, plus the existing Clean Air Visibility Rule, will effectively require AEP to install scrubbers at almost all of its unscrubbed units or retire the plants altogether, and to do so for virtually all of these plants by the end of 2014 (or perhaps the end of 2015 if a one year extension is granted). This allows between 2 ° and 3 ° years for compliance with at most 4 ° years in a few cases. This time frame is completely infeasible to get regulatory approvals, design, permit, fabricate, and install a retrofit scrubber as shown in Figure 1 below:

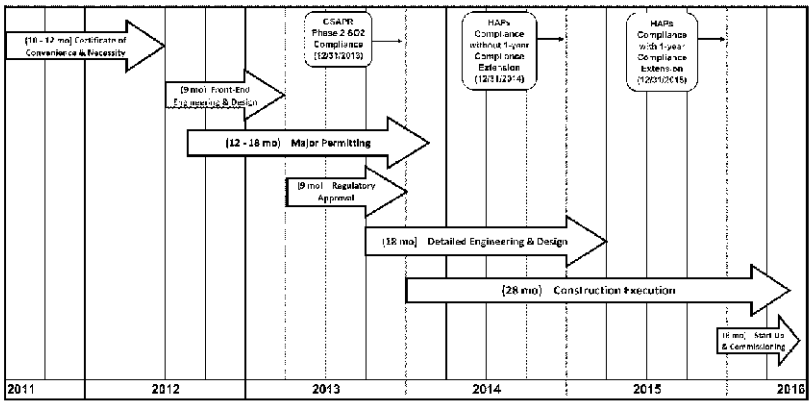

Figure 1

Figure 1 shows that the average time needed from project commencement to completion for a retrofit scrubber is five years for a regulated electric utility. (The time frame is similar if a unit is retired and replaced on site with a new combined cycle gas plant). This figure is based on the actual average time period needed during 2003–10 when AEP added scrubbers at 7,800 MW of capacity or—more installations than anyone else in the industry. Given that the EPA rules will require a greater number of retrofit projects and/or plant replacements and other related environmental investments across our industry within the same three to five year window, compliance with the Utility MACT Rule and Cross-State Air Pollution Rule is simply infeasible within this very short compliance period.

High Costs and Infeasible Deadlines Will Lead to Substantial Coal Plant Retirements and Significantly Compromise Electric Grid Reliability.

Due to the high costs of compliance and infeasible time deadlines, a large amount of coal unit retirements at AEP and across the industry is expected in the 2014–15 time period. In addition, a large number of units that are complying by retrofitting will have to be taken out of service, mothballed, or significantly curtailed during the 2014–16 time period as well.

AEP estimates that in its own coal fleet about 6 GW of its coal fired capacity (or about 25 percent of the company's coal-fired generating capacity) would retire by the 2014–15 time period under the EPA rules. We recognize that certain of our units are also subject to the requirements of our New Source Consent Decree, but only 615 MW is required to comply with those requirements before 2015. Other major coal-fired utilities such as Southern Company and DTE Energy Company have estimated that a similar 20 to 30 percent of their coal-fired capacity would retire in the period before 2015. AEP also estimates that 1.5–5 GW of coal-fired capacity would be temporarily out of service or severely curtailed during 2014–16 as retrofit pollution controls are being completed.

There is A Better Way

The combination of EPA's new rules for power plants will result in a series of relatively inflexible and stringent air pollution and other environmental regulations with infeasible timelines and unnecessarily high compliance costs. In addition to high costs borne by our electricity customers, these new rules could also result in many premature plant retirements and over 1 million net jobs lost in the U.S. [2]

We believe that a more reasonable approach to energy and environmental policy is needed. AEP has been working on these issues with the International Brotherhood of Electrical Workers (IBEW); the United Mine Workers of America (UMWA); and the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers, and Helpers.

A comprehensive analysis of the economic impacts of the proposed regulations as well as the feasibility and timing of their implementation is needed. While we continue to support sound policy aimed at improving air quality and public health, numerous economic studies and modeling analyses have demonstrated that the implementation of these major EPA requirements occurring in the same narrow time period will have major adverse economic repercussions. More time for phasing in the new control requirements is required to smooth the impacts associated with power plant closures and electricity rate increases, as well as to allow for the construction and installation of major environmental retrofit controls. Longer time frames also would enable better planning, ensure electricity grid reliability and avoid many premature plant shutdowns or excessively high costs for pollution controls due to supply constraints.

Given the multi-dimensional nature of major environmental policy initiatives and the immediacy of the compliance deadlines, we believe that Congress must intervene and assure that a sensible multi-pollutant environmental program is developed on a rational schedule and that this schedule is coordinated with the other new EPA rules. We believe that a legislative approach can continue to promote the air quality and public health goals set forth in EPA's regulatory initiatives while ensuring that adequate emphasis is focused on the employment, economic and reliability impacts of the program.

The challenge of EPA's current regulatory approach is not a technology issue requiring the Department of Energy to venture down the path of R&D or major demonstrations. On the contrary, there is simply no time to develop new technologies, demonstrate their viability, and engineer these systems. We believe the technologies exist today to enable AEP and the larger US fleet to comply with increasingly stringent environmental requirements while maintaining a robust and reliable electric power infrastructure. However, timing is the limiting factor in enabling a viable path toward compliance. The role we see for DOE, and it is a vital role indeed, would be to become engaged in a thorough analysis of EPA rules impacts and deployment timelines. In short, DOE should serve as a trusted advisor to the EPA in the rulemaking process.

DOE has expertise in all the areas of power generation and electricity transmission and distribution. They have the well-informed authority to evaluate the electric power generation system and grid stability/security risks and can make a non-biased assessment of the timelines needed to deploy technology at the broad scale required under EPA's program. It is AEP's preference that DOE be engaged in this process.

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[2] NERA (2011). A loss of one job-year is equivalent to a loss of one job for a period of one year. Job-years are commonly used by economists, CBO, OMB and others in reporting employment statistics.

CONCLUSION

In summary, American Electric Power has an established history as an industry leader in technology development and deployment. We were the first in high voltage transmission of electricity and have blazed trails in the development of smart grid technologies. Supercritical steam generation was first put into utility power production by AEP more than a half-century ago, and many of our units operating today represent new benchmarks in performance and efficiency at the time they were commissioned. We carry forward that proud tradition even today with deployment of the nation's first ultra-supercritical unit, which will come on line less than one year from now. We embrace technology as the means to produce and deliver clean and affordable electricity to our customers. We share much of our knowledge with the industry because we believe everybody benefits when technology is allowed to flourish. This philosophy of living on the cutting edge of technology advancement has its risks and uncertainties, as is most evidenced with our extensive work on CCS. While many were hoping and waiting for others to deliver a solution to CO_2 emissions, AEP boldly pursued the path of developing and demonstrating CCS technology. Our shareholders have shown the vision to support this approach by shouldering the burden of extraordinarily-expensive demonstration projects when other means have not been available.

We believe DOE should be bolstered in their efforts to develop viable and affordable technology solutions. While legislative activity on CCS has diminished and some key government-funded demonstration projects, like AEP's, have been cancelled or are currently at risk of being cancelled, now is not the time to divert DOE's attention from further advancement of CCS technology. Robust and affordable choices for CCS will in fact NOT be available in the market for installation on coal-fired power plants if the technology is not demonstrated in the meantime. AEP is ready and eager to reenter the demonstration phase of our CCS program at such a time when adequate funding of demonstrations enables successful completion of projects.

In this same spirit of ingenuity, AEP urges the new EPA rules be structured in a way to allow for cost-effective implementation on a reasonable schedule so as to minimize the impacts on our residential customers, local businesses, and the reliability of the electricity grid. It is also critical that the emissions reduction levels of the program be set at levels that are technically feasible to achieve over the given time frame and are in fact necessary to fulfill the air quality goals and requirements of the Clean Air Act. As a nation, we must ensure our future energy security and reliability by using domestic resources such as coal, while continuing to advance technology. AEP would like to thank the Committee for the opportunity to present our views on the issues of advanced coal research and a secure energy future.

Chairman HARRIS. Thank you very much.

I now recognize our fourth witness, Mr. David Foerter, Executive Director, Institute of Clean Air Companies.

STATEMENT OF DAVID FOERTER, EXECUTIVE DIRECTOR, INSTITUTE OF CLEAN AIR COMPANIES

Mr. FOERTER. Thank you for inviting the Institute of Clean Air Companies or ICAC or Institute to testify and present its perspectives on what motivates the air pollution control and measurement industry to innovate and deploy commercial-ready technologies and enable power generators and manufacturers to operate responsibly and ensure cleaner air to the pollutions they serve.

To provide some perspective about our industry, we are a growing number of technology manufacturing and service companies that have a sustainable industry due to the demand of our technologies and services. And that demand comes from clean air regulations and policies. This industry has great—has matured greatly in the more than a half century ICAC has been its public representative, and we are proud of having met and often exceeded the regulatory control and measurement challenges of the industries we serve.

It should come as no surprise that the air pollution control industry is well prepared with suites of affordable technologies and eager and experienced workforce to achieve the air quality improvements needed to deliver healthy air.

The science of air pollution control and measurement are well understood by our industry, and technologies are continuously refined through healthy competition if the demand is there. Our industry's impact on jobs is well documented, and I have included insights into my written testimony. For brevity I won't go into some of those issues.

Air pollution control and measurement technologies are available to meet the upcoming regulations for hazardous and conventional air pollutants emitted by firing coal, and we are confident that these—that any issues that still exist can be addressed within the framework used to develop regulations and do not require any priority for R&D funding.

Therefore, as an industry largely made up of engineers, we are ready to innovate and build equipment that our clients need in the marketplace.

R&D is best used judiciously to develop and test technologies where none already exist, and this is clearly not needed to effectively address the air pollutant emissions of conventional pollutants such as criteria and hazardous pollutants in the electric power sector. Probably the best example of this is mercury control technology, which about ten years ago didn't exist to an R&D Program that was developed, and it is now probably one of the easiest pollutants to deal with under the Hazardous Air Pollutant Control requirements.

Because of the diversity of control and measurement technologies and the offerings of multiple vendors and mature industry, there are many choices available to sources affected by regulations. For example, some of the largest SO_2 scrubbers may have a large capital cost but also allow sources to take advantage of cost savings and using higher sulfur coal that is often much cheaper, less expensive to use. Therefore, it is possible that for some of the facilities cost savings on coal can cover most, if not all, of the technologies that are being put in place.

But there is also other opportunities because there is less resource and time-intensive technologies are available to be quickly deployed and offers the power generation industry the needed flexibility it may need to comply with upcoming regulations.

For example, direct sorbent injection, another type of scrubbing technology, and circulating and dry scrubbers are technology options with costs and install times less than the larger Wet FGD types of programs.

Today I have in my comments nearly two-thirds of the coal-fired electric power plants are controlled. I am going to have to review that to 75 percent based on two witness testimonies, leaving approximately another 25 percent of the fleet substantially uncontrolled. Decisions to control much of the power fleet generally installed controls on units that were most cost-effective to control.

Plant retirements are inevitable, even in the absence of regulations. Building new plants is problematic, and so I just add that as some of the witnesses already.

As an industry built on innovations, we seek new challenges and opportunities, particularly those that serve the public health and industrial progress. There are certainly challenges for all fossil fuels, particularly coal, which will benefit from well-spent R&D dollars. Chief among those challenges and right for R&D investments is carbon capture as part of a CO_2 control strategy. Here the challenge and the opportunity is to enable coal to be a more sustainable fuel choice whereby emissions are well controlled.

In our industry it is clear that regulations designed to improve air quality for public health is the primary driver for much of the technology development and innovations. For example, as the understanding of particulate control emissions we moved from a very coarse type of particulate control emissions to coarse, fine, and even condensables. In the amount that we have been doing this there has been cost and benefit analysis done, and the benefit-cost analysis prepared by EPA shows that for every dollar spent there was as much as $4 to $20 that comes back to direct public health benefit, and that includes the prevention of pre-mature mortality. From our industry's perspective, this is comforting.

The biggest challenge that we see is not the hazardous and criteria pollutants. It is in CO_2 capture and thermal efficiency. So we look forward to seeing work more in that field, not on criterion, hazardous pollutants.

Thank you.

[The prepared statement of Mr. Foerter follows:]

PREPARED STATEMENT OF MR. DAVID FOERTER, EXECUTIVE DIRECTOR, INSTITUTE OF CLEAN AIR COMPANIES

Dear Chairman:

Thank you for inviting the Institute of Clean Air Companies (ICAC or the Institute) to testify at the October 13, 2011 hearing of the House Subcommittee on Energy and the Environment and present the air pollution control and measurement industry's perspective on coal pollutant control technologies, and industry's capacity to deliver and improve upon technologies used to meet various requirements. Also as requested, we are pleased to describe opportunities and challenges and role of research and development (R&D) on improving the utilization of coal.

ICAC appreciates the opportunity to present its perspective on what motivates the air pollution control and measurement industry (APC) to innovate and deploy commercial ready technologies that enable power generators and manufacturers to operate responsibly and ensure cleaner air to the populations they serve. To provide some perspective about our industry, we are a growing number of technology manufacturing and service companies that have a sustainable industry due to the demand for our technologies and services; and that demand comes from clean air regulations and policies. This industry has matured greatly in the more than half century ICAC has been its public representative, and we are proud of having met and often exceeded the regulatory control and measurement challenges of the industries we serve. It should come as no surprise that the APC industry is well prepared with suites of affordable technologies and an eager and experienced workforce to achieve the air quality improvements needed to deliver healthy air.

The science of air pollution control and measurement are well understood by our industry, and technologies are continuously refined through healthy competition – if the demand is there. The energy of our industry comes directly in response to the certainty of demand for these technologies and services, and without demand, innovation, competition and jobs are lost, adding to an unhealthy economy. This is evident in the documented rise and fall in employment in the boilermaker industry that particularly during the past decade has tracked remarkably well with the demand for control technology installations as a response to major air quality regulations (see attached slide). The APC industry designs, engineers and constructs projects that can use thousands of tons of steel, large quantities of concrete, and specialized equipment such as fans, pumps, motors, rotary mixers, filter bags and cages, and milling equipment, while employing skilled craft labor such as welders, steam fitters, and electrical workers. Because former utility and industrial plant personnel have valuable field experience, these workers often find themselves 'repurposed' in our industry in the work of retrofitting or operating the clean air

technologies on facilities in which they are familiar. Once constructed and operated, the control technologies often depend on supplying and preparing reagents and sorbents such as activated carbon, Trona, lime, limestone, urea and ammonia, as well as other consumables including catalysts and filter bags. Nearly all of the materials and equipment can be manufactured and supplied from the U.S. Manufacturing and installing this equipment creates upstream and downstream employment and economic benefits. For example, during a recent seven year period, the implementation of CAIR Phase 1 resulted in 200,000 jobs in the APC industry, with about 80 percent dedicated to construction and 20 percent for engineering and project management. The workforce from that effort is now highly motivated and eager to apply itself to upcoming clean air regulations.

Air pollution control and measurement (APC) technologies are available to meet upcoming regulations for hazardous and conventional air pollutants emitted by firing coal. To the extent refinements and improvements will be needed, R&D is always helpful; however, a highly motivated and competitive industry generally achieves similar or better innovations and enhancements to their technology offerings. Regulatory requirements are the primary motivation for these technology developments, improvements, and commercial offerings; creating a demand for not just one but many different technologies offered by many technology vendors. As a result, technology offerings like the facilities they are applied to are not monolithic; there is no one size fit all. The biggest challenges we face in the control and measurement of hazardous and criteria pollutants is when any emission limit approaches zero and there is little room for control or measurement error, or for designs that can provide a margin for performance guarantees. However, we are confident that these issues can be addressed with the framework used to develop regulations, and do not require any priority for R&D funding. Therefore as an industry largely made up of engineers, we innovate and build the equipment that serve our clients in the marketplace; in a market fostered by clean air regulations and policies.

R&D is best used judiciously to develop and test technologies where none already exist, and this is clearly not needed to effectively address the air pollutant emissions of conventional pollutants such as the criteria and hazardous pollutants in the electric power sector. History has proven that where markets do not already exist, such was the case for mercury measurement and control in the electric power sector almost a decade in the past, that a well managed R&D program minimizes large uncertainties and builds confidence in new technologies, but the movement to commercial ready technologies offered by multiple vendors relies greatly upon regulations and policies. In the case of mercury control and measurement, in the absence of commercially ready mercury-specific technologies, R&D helped identify the challenges and provide confidence in previously untested technologies. As a result, commercial offerings preceded and even anticipated national regulations although real sustainable markets resulted from federal and state requirements that fed the innovation and competitiveness of our industry. Today, mercury control is widely considered to be one of the easier pollutants to control and measure, and the electric power sector has a broad range of technologies to choose from, and a broad range of vendors competing for their business. Because of state mercury control programs, that operate in the void created by the Court's remand of the federal program (CAMR), the U.S. arguably now has the most accomplished workforce of skilled technology vendors that can meet U.S. demands and spread its innovations across the globe.

Because of the diversity of control and measurement technologies, and the offerings by multiple vendors in a mature industry, there are many choices available to sources affected by regulations. Looking at our industry now it is easy to see that the broad needs and demands of the market have created an equally broad range of technology choices that can fit into the planning of the electric power sector. For example, some of the largest SO2 scrubbers may have a large capital cost, but also allow sources to take advantage of cost savings of using higher sulfur coal that is often much less expensive. It is possible that for some facilities the cost savings realized from less expensive coal may cover most if not all of the cost of the control technology. Alternatively, lower capital cost technology options allow a facility to minimize capital costs, incurring primarily operation and maintenance costs for only as long as the facility plans to remain viable in the energy market. Therefore the facility can reduce stranding large amounts of capital in a facility that otherwise may be slated for retirement. In general, less resource and time-intensive technologies are available to be quickly deployed and offers the power generation industry the needed flexibility it may need to comply with upcoming clean air regulations. For example direct sorbent injection (DSI), circulating and dry scrubbers are technology options with costs and install times less than with the larger Wet FGD systems that already serve as the backbone of SO2 removal of the previously retrofitted fleet. Today, nearly two-thirds of the coal-fired electric power fleet is being controlled, leaving approximately one-third of the fleet substantially uncontrolled. Decisions to control much of the power fleet generally installed controls on units that were most cost-effective to control. And retirement is inevitable, despite the best engineering, boilers and equipment have a defined and useful life, and that life means fitting into a modern healthier world. Plant retirements are inevitable, even in the absence of regulations.

As an industry built on innovations, we seek new challenges and opportunities, particularly those that serve both public health and industrial progress. And there are certainly challenges for all fossil fuels, particularly coal, which will benefit from well spent R&D dollars. Chief among these challenges is carbon capture as part of a CO2 control strategy. Here the challenge, and the opportunity, is to enable coal to be a more sustainable fuel choice whereby all emissions are well controlled. If we regard post-combustion CO2 capture (carbon capture) as a scaled up flue gas scrubbing technology, we should look historically at how the flue gas desulfurization (FGD) technology market was developed, has grown, innovated, and diversified to the extent that high sulfur, previously regarded 'dirty' coals can now be a sustainable part of fuel choice diversity offering a source of well scrubbed, affordable, and much more energy efficient option. Similarly, carbon capture has large initial hurdles and risks to overcome in preparation for commercial readiness, but the rewards are great. Once these technologies have been adequately vetted, the next step is not technical but rather one of ensuring appropriate policies and regulations are in place to promote more innovation in the marketplace. We are aware of no energy 'map' that does not include fossil fuels, particularly coal, as being essential to a load following, demand responsive, reliable energy strategy. If these maps are accurate, the challenges to deliver clean energy from fossil fuels will only increase, requiring our industry to – innovate – with a reasonable expectation of some payback through demand for these products.

Faced with clean air regulations, now reinforced by judicial decisions, we are hearing the doom and gloom "what if" scenarios of technology availability, energy reliability, and our industry's ability to meet demand for installations. However, as these issues have all been raised

in the past, history shows these predictions be unfounded then, and again will prove to be unfounded. As I remarked earlier, our industry understands the science of air pollution control and measurement, we have a history of successes in meeting the demands of customers for technology options and timely installations, we work well with customers to utilize the compliance flexibility the U.S. Environmental Protection Agency continues to offer in regulations, and we are confident that effective checks and balances are in place to ensure energy reliability.

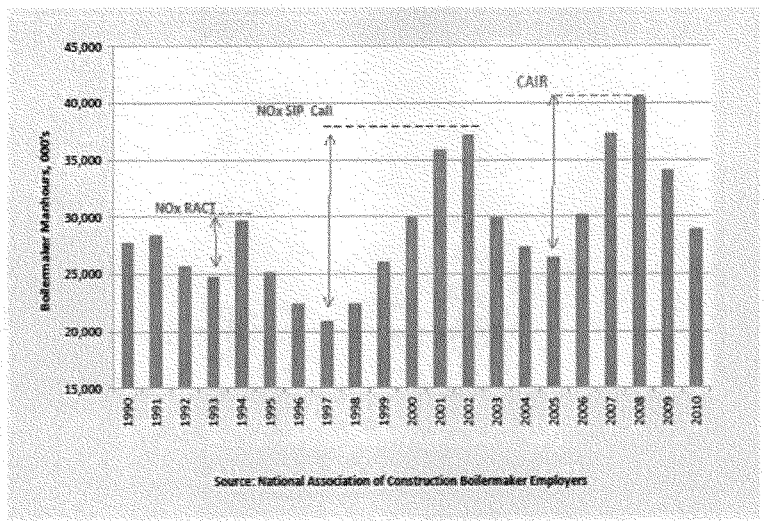
In our industry, it is clear that regulations designed to improve air quality for public health, is the primary driver for much of the technology development and innovations. For example, as the understanding of particulate emissions and regulations to control these emissions have evolved, so to have the science and availability of particulate control and measurement technologies. In this example, we have successfully moved from controlling total or coarse particulates to technologies that now address coarse, fine and even condensable forms of particulates. The robust benefit-cost analysis prepared by the U.S. Environmental Protection Agency continues to show that for every dollar spent on clean air technologies, there are consistently high benefits, on the order of $4 to $20, to direct public health, including prevention of premature mortality. From our industry's perspective, it is comforting to know that the work we do creates jobs and saves lives.

The biggest R&D challenge we see, having effectively addressed hazardous and criteria air pollutants, will be innovating commercial-ready technologies for CO2 capture and reductions. In looking into the future and mapping how fossil fuels can be a sustainable energy resource, innovation needs to come from the private and public sectors, and ideally both to ensure that the skills and tools will be ready when they are needed once again. In regards to hazardous and criteria pollutants, we have all the skills and tools needed, so it is the right time to let our industry get to work.

Sincerely,

David C. Foerter, ICAC Executive Director

Labor Responds to Clean Air Initiatives



Andover Technology Partners

Chairman HARRIS. Thank you very much.

I now recognize our final witness, Mr. Stu Dalton, Senior Government Representative for Generation of the Electric Power Research Institute.

STATEMENT OF STU DALTON, SENIOR GOVERNMENT REPRESENTATIVE-GENERATION, ELECTRIC POWER RESEARCH INSTITUTE

Mr. DALTON. Thank you, Chairman Harris, Congressman Miller, and Members of the Committee. I appreciate the opportunity to give this testimony today.

The U.S. DOE has a significant R&D effort as you have heard, developing technology for coal and a long history of doing that work with an important program in place. We have worked independently as well as collaboratively with the DOE over several decades in many of the areas you have heard talked about today on SO_2, NOx, mercury control, as well as on advanced technologies.

But the changing regulations and demands of the system are requiring or creating new challenges which are, indeed, calling for new R&D, and that is what I will talk about today.

Based on our review there are three major areas that are not sufficiently covered in the current R&D Program. One is high-efficiency combustion plants. We have heard a little talk about that today. Another area is water management, we have also heard that mentioned. The third area is new implications of the recent work on hazardous air pollutants. We have worked on hazardous air pollutants for two decades at least.

These technologies are needed to meet the global challenges in advanced coal-powered technology as well as the domestic regulatory compliance schedules. A fourth area of gasification would also benefit from additional R&D.

The first area involves high-efficiency steam cycles based on American advanced alloy steels that have been developed largely with funding from the DOE. The need is to accelerate the pace from successful component fabrication and testing to in-service boiler and turbine testing that includes operation of a complete integrated demonstration plant. This RD&D would put American technology and suppliers in the lead worldwide for high-efficiency technology and low-emission use of coal.

The DOE has been a major sponsor of this work, along with the Ohio Coal Development Office. They have supported a public, private, federal, and state effort across the U.S. Industry and national lab participants have worked for almost a decade on this area to create, fabricate, and weld these alloys with work done in six states—in Indiana, Ohio, Pennsylvania, Texas, West Virginia, and Wisconsin. We have done work with a number of these organizations.

We have shown that high-temperature materials can work for tens of thousands of hours in the lab. You need to take it to the full scale. The very high-temperature steam pressures and temperatures that are used to get this high efficiency requires some new novel technology. I am holding a report that is actually entitled, "U.S. Department of Energy and Ohio Coal Development Office Report on Advanced Ultra-Supercritical Materials Project for

Boilers and Steam Turbines." This report has a lot more details on the timing and the content of that work.

The second area I would like to mention is water management. We are seeing new barriers to siting plants as well as barriers for continued operation from some of the new regulatory requirements. Water management needs to reduce consumption, accommodate lower water quality supplies, and address more complex waste water treatment. Solid management issues need to be addressed, partly because there are requirements that cover all aspects of water management, not just water but air and solids as well. Use of degraded waters and recovery of water from power are also issues. There are many different ideas out there, and EPRI is working with industry right now to create a water research center in this area.

A third area is in hazardous air pollutants. Not just in capturing Mercury but looking at other compounds like Selenium, Arsenic, Hydrochloric acid, Hydrofluoric acid, and things of that sort that are—that might be cross-media. You catch it from the air, it goes somewhere.

The variety of coal and power plant types, and emission control configurations require different controls because of the new regulations. It is urgent because firms are starting to design and purchase equipment, yet we believe not all these issues are resolved.

The fourth area, gasification is one where DOE has an ongoing program and has been doing a lot of work. We need to accelerate work on synthesis gas cleanup, higher temperatures, larger turbines, lower oxygen costs for the supply, and better plant controls.

Finally, I would like to say that EPRI has been working cooperatively in the area of CO_2 control with the Department of Energy. The heavy focus on CO_2 capture, utilization, and storage we think is worthwhile and now utilization might be possible for enhanced oil recovery to bootstrap CO_2 demonstrations and improve the domestic oil capabilities as well.

We see that the sustained work on integrated demos is important because it is a very broad issue. We thank you for the opportunity to address the Committee.

[The prepared statement of Mr. Dalton follows:]

PREPARED STATEMENT OF MR. STUART DALTON SENIOR GOVERNMENT REPRESENTATIVE, GENERATION ELECTRIC POWER RESEARCH

My name is Stuart M. Dalton. I am the Senior Government Representative, Generation, for the Electric Power Research Institute (EPRI, www.epri.com). EPRI conducts research and development relating to the generation, delivery, and use of electricity for the benefit of the public.

As an independent, nonprofit corporation, EPRI brings together its scientists and engineers, as well as experts from industry, academia, and government, to help address challenges in electricity, including reliability, efficiency, health, safety, and the environment. EPRI also provides technology, policy, and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States, and international participation extends to 40 countries. EPRI's principal offices and laboratories are located in Palo Alto, California; Charlotte, North Carolina; Knoxville, Tennessee; and Lenox, Massachusetts. EPRI appreciates the opportunity to provide this testimony today.

Introduction and summary

EPRI analysis including our Prism/MERGE reports shows multiple future scenarios in which coal will be an important fuel in the US generation mix. In the

wake of recently proposed environmental rules and other regulations, U.S. power producers have estimated that tens of thousands of megawatts of coal-fired power generation capacity could be retired prematurely. At the same time, studies by EPRI, the International Energy Agency and others demonstrate that in order to *reliably* and *affordably* meet the nation's energy needs and environmental goals all types of power plants—from renewables to advanced coal and natural gas to nuclear—are needed to provide a secure energy future.

For coal-based generation to fulfill its potential to contribute to the nation's clean energy supply, new technologies and practices must be developed and demonstrated to address concerns over air, water, and thermal emissions, as well as secure solids disposal and CO_2 storage.

The U.S. Department of Energy (DOE) has excellent research, development, and demonstration (RD&D) programs in place on CO_2 capture and storage and conducts significant work on advanced coal generation technology; these were preceded by a long history of successful RD&D on criteria pollutant, particulate, and hazardous pollutant controls for coal power plants.

RD&D on stronger and more durable high-temperature materials as well as improved integration and process configurations for increased plant efficiency have paralleled environmental control technology development. EPRI has worked independently, as well as cooperatively, with DOE and other government agencies to help attain many of these research objectives.

The needs of the electric power industry are evolving rapidly because of changing emission regulations and power grid system requirements. The continued alignment of RD&D efforts to reflect these latest priorities is necessary to help ensure that the nation's coal-based power plants can continue to supply affordable electricity.

Based on EPRI's analysis, three major areas not sufficiently covered by current DOE coal RD&D need additional support and these areas currently compromise the power industry's ability to meet both global competitive challenges in advanced coal power technology and domestic regulatory compliance schedules. A fourth area is relatively well addressed, but would benefit from additional RD&D on basic gasification and power block technology improvements. These areas are listed below and discussed individually in further detail:

1. Ultra-high-efficiency steam power cycles based on American advanced alloy steels: we need to accelerate the pace from successful component fabrication and testing to in-service boiler and steam turbine testing and a complete integrated demonstration plant
2. Improved water management to reduce consumption, accommodate lower-quality/degraded water supplies, and address more complex wastewater treatment and solid by-product management challenges
3. Workable solutions to proposed hazardous air pollutants (HAPs) emission standards accounting for real-world operational issues, flue gas constituent interactions and cross-media impacts, and measurement capabilities
4. Efficiency and cost improvements for gasification power plants independent of CO_2 capture processes: we need to accelerate scale-up, testing, integration engineering, and demonstration of fundamental improvements in synthesis gas cleanup at higher temperatures, higher gas turbine firing temperatures and larger turbines (and associated blade temperature control), lower-energy oxygen supply technologies, and better plant controls

EPRI would like to stress that these areas are identified as necessary to augment, not supplant, DOE's current RD&D programs focusing heavily on CO_2 capture, utilization, and storage (CCS). Continued and sustained support for CCS development and integrated demonstration is essential to success in this most overarching of issues facing coal power plants.

Advanced ultra-supercritical steam cycle development using nickel-based alloys: In-service test facility and fully integrated demonstration

Higher plant efficiency reduces the amount of fuel consumed and associated emissions and water consumption per megawatt hour of electricity generated. Notably, CO_2 reduction is significant, up to 20–25% per megawatt hour and the avoided cost per ton of CO_2 is estimated both by DOE and EPRI as being one of the lowest avoided costs compared to any technology for CO_2 capture and storage. This is a win-win approach for utility customers and the environment. Thermodynamics dictates that increasing the efficiency of a steam cycle requires hotter and higher pressure steam conditions known as ultra-supercritical (USC) at the turbine inlet. Maintaining boiler, piping, and turbine safety and longevity at steam temperatures of up to

1400°F (760°C) requires a new class of high-nickel-content steel alloys and, in some cases, coatings, several of which have been pioneered in the United States under a research program sponsored by DOE and the Ohio Coal Development Office (OCDO).

Despite this successful record of fabrication and testing of key boiler and steam turbine components by American manufacturers, the program faces federal funding uncertainties at a time when European competitors have advanced to an in-service boiler test loop and Asian firms are looking to move to higher temperature and pressure cycles. To reach DOE and industry goals for improving coal plant efficiency, EPRI recommends a "managed risk" series of demonstration elements embedded in commercial power projects, concluding with a fully integrated plant (dubbed UltraGen) featuring nickel-alloy high-temperature components, superior environmental controls, and CO_2 capture and compression.

The foundation has been laid with earlier DOE/OCDO materials work managed by Energy Industries of Ohio and EPRI (one team focused on boilers, one on steam turbines), with a joint vision for future scale-up and demonstration established by DOE, EPRI, and the Coal Utilization Research Council. The most developed alloys are Inconel 740, a product of Special Metals Corporation in West Virginia, and Haynes 282 alloy by Haynes International, headquartered in Indiana.

Large-diameter pipe extrusions have been made by Wyman-Gordon in Texas, and Haynes alloy 282 castings have been made by MetalTek in Wisconsin and Flowserve in Ohio. The project also conducted powder metallurgy work at Carpenter Technology Corporation in Pennsylvania. Some of these firms are already receiving inquiries for use of these materials overseas. To reap the benefits of this technology research domestically, we need to adequately fund the next stages of development, namely in-service test and demonstration to allow for commercial deployment.

At a cost of about $50M over three years, an in-service component test facility at an existing plant would lay the groundwork for the design and installation of a demonstration unit, possibly in later phases of DOE's Clean Coal Power Initiative or via other risk-sharing mechanisms for first applications in the United States. Under this scenario, advanced USC plants would become commercially available after 2020, following successful operation of a demonstration plant. This recommended path to commercialization and prior work on advanced materials development are described in EPRI brochure 1022770, *U.S. Department of Energy and Ohio Coal Development Office Advanced Ultra-Supercritical Materials Project for Boilers and Steam Turbines (March 2011).*

Such a commitment would return the United States to the forefront in thermodynamic efficiency, building upon the legacy of the world's first plants with USC steam conditions–AEP's Philo Unit 6 in 1957 and Exelon's Eddystone Unit 1, in service from 1960 until its retirement this year. Finally, given the prospect of future CO_2 regulations (and efforts by power producers to demonstrate voluntary CO_2 reductions), the impetus for higher efficiency in future coal-based generation units has gained traction worldwide. Many new coal plant projects announced over the last two years will employ supercritical steam cycles, and several will use high-efficiency "moderate USC" steam conditions, building a logical progression toward advanced USC plants with the help of financiers, state regulators, and other key stakeholders.

Improved water management to reduce water consumption, accommodate degraded water supplies, and address wastewater treatment and solid by-product disposal challenges

Water withdrawals and discharges by the power industry are falling under new regulatory requirements, and are posing new engineering challenges, as the sources and composition of water available to power plants are changing, along with restrictions on its discharge.

Water is the lifeblood of a power plant, serving both as the working fluid that converts combustion heat to turbine shaft power and as the cooling medium that allows high-purity steam cycle water to circulate continuously from boiler to turbine and back. Accordingly, water quality and cost are major factors in plant economics.

Cooling water is a power plant's largest use. There are proven low-water-use cooling options—developed in the arid western states and other locations where power plants have faced water limitations for decades—providing a technical foundation for new innovations. However, these alternative cooling options normally require more space than traditional "once through" river, lake, or ocean water cooling, which can create significant challenges when existing plants are compelled to retrofit recirculating cooling systems in response to Clean Water Act Section 316 rules on intake structures and thermal discharges. Thus, there is an RD&D need for retrofit cooling options, as well as designs for new plants.

Even in areas of the United States with historically adequate water supplies, reducing water use is a growing issue for the power industry, so the need is now national rather than regional. Compounding the challenge is the prospect of future regulations limiting CO_2 emissions. Virtually every type of CO_2 capture technology requires steam use for the process and additional cooling. CO_2 compression for sale or geologic storage also requires additional cooling. DOE research in this area will be especially important if CO_2 capture, utilization, and storage become widespread because power plant cooling demand will increase substantially.

In many cases, power plants are finding the only (or most economic) new source of water is from lower-quality and/or degraded supplies, such as municipal wastewater treatment plant discharge. These less-pure waters require different treatment methods and more blowdown (a slipstream sent to the plant's wastewater treatment equipment) than conventional water supplies.

Wastewater treatment also faces new engineering challenges due to tighter air pollution requirements, which result in greater amounts of trace species such as mercury, arsenic, selenium, and acid gases being removed from flue gases and transferred to wastewater streams. These may need to be treated differently before discharge than under prior practices. The particular wastewater treatment needs and available technology options depend on the coal and boiler type and the type and configuration of air pollution equipment used (e.g., wet vs. dry scrubbing for SO_2, different types of particulate and NO_x controls, and different sorbents or additives for mercury control). EPRI in conjunction with industry is developing an initiative to address plant water management and welcomes further collaboration with DOE.

Additional information is being developed in a draft roadmap by EPRI and the Coal Utilization Research Council. Some of the R&D goals being addressed are:

- Demonstrate reduced water consumption technologies
- Improve wet, hybrid, and dry cooling testing in conjunction with water balance modeling
- Moisture/water recovery
  - Test membrane, liquid desiccants, cyclic reheat and/or other new approaches, as well as low-temperature heat recovery plus water capture on coal gasification/combustion
  - Demonstrate integrated treatment, quality management, and moisture recovery
- Create an industry water research center to demonstrate methods for reduced water consumption and improved water management

Researching solutions to hazardous air pollutants issues in a real-world deployment setting: flue gas constituent interactions, cross-media impacts, and measurement capabilities

In the same manner that tailpipe emissions from new cars are a minuscule fraction of the emissions from cars of the 1960s, new coal-fired power plants are vastly cleaner than plants from a generation ago. In addition, many existing plants have been retrofit with technologies to capture SO_2, NO_x, mercury, and SO_3 and fine particulates.

New regulations have been proposed for hazardous air pollutants and the power industry is currently looking at process and operational alternatives for the coal fired stations as well as weighing options to retire plants where compliance with this plus other pending requirements for criteria emissions, water limitations , and solids management is not practical. In the timeframe required it will also be difficult to plan, permit, fabricate, install and place in service the equipment necessary to meet the U.S. Environmental Protection Agency's Maximum Achievable Control Technology (MACT) rule proposed in 2011, and the Cross-State Air Pollution Rule (CSAPR) rule finalized in July 6, 2011.

As the government, industry, and EPRI have tested the various types of plants and process configurations and their emissions, real-world issues and unintended consequences of HAPs reduction methods have been identified. The issues vary, and the solutions have required additional R&D to resolve concerns about water and solid by-product changes that would make current management practices unsuitable. Conditions can vary widely because coals can contain virtually any of the constituents of the earth's crust. Because coal and ash compositions vary, plants must have different plant configurations, firing equipment, and processes existing on the units to operate properly. Testing, modeling, and limited experience has identified a wide variety of issues. Some of these issues are cross-media (i.e., between air, aqueous, solid release streams) and can cause currently useful materials such as fly

ash or gypsum used in aggregate, concrete, or wallboard to be questioned or to make them unusable. Research is needed in this area to verify and resolve potential impacts to enable reliable, operable units that consistently meet regulations for criteria air emissions, HAPs, as well as water and solids limits, and allows beneficial use of coal combustion by-products whenever possible.

Current emissions controls reduce criteria pollutant emissions to very low levels, and often capture a significant fraction of mercury in the process. Nonetheless, new regulations call for further reductions in NO_x, SO_2, SO_3, fine particulates, and mercury emissions, with an added focus on other HAPs, including selenium. Chief among these regulatory drivers are the utility HAPs MACT and CSAPR rules. EPRI has commented on the HAPs MACT in a submission dated August 4, 2011, and identified some of the challenges in measurement and compliance that make power company compliance difficult within the proposed timeframe and implies urgent R&D is needed. Some of the summary comments related to the need for additional R&D are quoted below, followed by a comment regarding R&D needs. The entire EPRI submission is available to the public at the following site:

http://mydocs.epri.com/docs/CorporateDocuments/SectorPages/Environment/hapsicr/EPRI—HAP s—Comments—08-04-11.pdf

EPRI comments on the difficulty of meeting proposed limits and the issues with data collection

- "No coal-fired EGU (new and existing coal- and oil-fired electric utility steam generating units) tested in the ICR (EPA's Information Collection Request)would likely meet the new unit MACT limits for all three regulated HAPs-total particulate matter, mercury, and hydrogen chloride (or the alternative acid gas surrogate, sulfur dioxide). The new unit limits are very challenging to achieve as few EGUs have multiple ICR measurements that are consistently below the proposed new unit limits. The use of the lowest test series average introduces biases, and EPA should use the average of all ICR data for setting the HAPs standards for both new and existing EGUs."

The proposed regulations for new and existing coal- and oil-fired electric utility steam generating units (EGUs) have very low limits which have been set based on, in many cases, erroneous data and a limited number of data points. Despite the values that are eventually established, additional R&D will be needed to ensure that the new limits can be met on an ongoing basis and for the variety of coals and plant designs in operation.

EPRI comments on dry sorbent injection and the ability to use the technology without power plant impacts in other areas

- "Additional data are required to evaluate the use of dry sorbent injection as a control for removing hydrochloric acid (HCl) and hydrofluoric acid (HF). Based on the limited available data, there are concerns about whether EGUs firing medium- to high-chloride coals can achieve the HCl standard using dry sorbent injection, and whether there would be impacts to balance-of-plant operations."

A number of firms are considering dry sorbent injection to manage hydrochloric acid (HCl) and hydrofluoric acid (HF). Because data are limited it is unclear the range of coals and conditions which may be able to use this control technique and the type of sorbent that will be effective and able to avoid cross media issues after use (not making an air issue into a solid waste or water issue). R&D is needed to test alternate sorbents and their fitness for the purpose of acid gas control and the cost effectiveness of their use.

EPRI comments on the data not representing the range of operating conditions and the ability to comply under all normal and transient conditions.

- "The ICR did not require EGUs to test over the full range of operating conditions, and therefore the ICR data do not represent the entire range of emissions variability from power plants. Additional measurements are needed to adequately characterize the variability of HAPs and surrogate emissions during normal plant operations. Sources of emissions variability include fuels burned, startup and shutdown conditions, partial load operation, and other reasonably foreseeable changes to operating conditions. Limited measurements at one facility indicated that trace metal variability was comparable to the variability of filterable PM measurements."

The EPA's Information Collection Request (ICR) collected data for a number of static conditions but data is not available to assure power plants can comply with a range of operating conditions typical of coal plant operation. In order to retain reliable grid operation and maintain the obligation to serve customers with economic,

secure power, it is normally necessary to vary load from different types of generation sources. Now that more "non-dispatchable" power such as wind is generated in certain areas of the country such as the upper Midwest and Texas, power companies are seeing added requirements to turn down or reduce coal generation periodically and bring it back if those non-dispatchable sources cannot generate. This variation in demand will mean chemical and physical processes may be called on to operate out of their most efficient or effective ranges and it may be difficult to meet the emission standards during transients or at partial loads. R&D is needed to evaluate and test, understand, model and provide guidelines for design and operation in these instances.

As regulations become more sweeping, with less flexibility in terms of time averaging and emissions banking and trading, fuel-specific nuances become magnified in their impact on compliance assurance, as do the relative effects of emissions from transients (startups, shutdowns, and load changes), seasonal variations, effects of one emission control device (or new additive) on another device, and measurement reliability. Compliance timetables are short and coal plant "back ends" are packed with emissions control devices so many strategies for capturing trace toxics involve modifications to existing systems or operations. A major industry concern is unintended consequences that could risk noncompliance or lead to premature corrosion or other failure of emissions control equipment.

In the near term, EPRI notes particular technology development and demonstration needs as follows:

- Controls consistent with 90%-plus mercury reduction for all applications and fuels
- Managing acid gas removal including HCl and SO_2 as surrogates for acid gases
- Model, test, and develop operation and maintenance practices for wet and dry scrubbers which are also used to remove HAPs, and how to best manage cross-media impacts and implications for operations, such as corrosion due to high levels of chlorides or halogens in plant process water
- Selective catalytic reduction (SCR) NO_x control catalyst regeneration strategies, as well as SCR catalyst management systems consistent with year-round system operation at >90% NO_x removal, minimum SO_3 generation, and maximum oxidation of elemental Hg in the flue gas
- Robust, reliable FGD systems for all coals
- More wear-tolerant, low-pressure-drop, ultra-high-efficiency baghouses for control of particulates from a wide range of fuels; improved performance of electrostatic precipitators (ESPs) for applications not suited to baghouses or amenable to upgrading in existing power plants; and demonstrated wet ESPs for acid mist and fine trace metal particulate capture
- Resolution of balance-of-plant issues and long-term operability issues for recently installed environmental controls.

Recent Testimony by J. Edward Cichanowicz an independent consultant based in Saratoga, California before this Subcommittee October 4, 2011 is available on line at the following url (http://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/100411— Cichanowicz.pdf) his testimony identifies issues with the short time for compliance being proposed under MACT and CSAPR. We agree with the concerns addressed by Mr. Cichanowicz and suggest that this creates an urgent need to get DOE support for understanding the HAPs issues and solutions. We need to understand unintended consequences, the ability to comply under all conditions, and the ability of the planned equipment to address varying coals and water compositions. Given the tight schedule the power industry faces for compliance, DOE could best support industry RD&D efforts by building upon previous work for mercury controls, including management of HAPs control processes to minimize water and/or solids contamination. In other words, power plant operators need help identifying and testing approaches to managing HAPs issues holistically for the variety of plant types and conditions. To summarize, specific areas the industry needs support in are:

1. Understanding HAPs control (mercury, HCl, trace metals) balance of plant issues such as corrosion, increased PM emissions, solid by-product disposal/use, leaching, and wastewater treatment
2. Development of lower cost HAPs control options to maintain the viability of coal-fired power plants
3. Understanding the variability of long term HAPs control effectiveness (start-up, shutdown, cycling)

4. Understanding the underlying mechanisms for HAPs formation and control, as well as independent assessments of emerging emission controls

Efficiency and cost improvements for gasification power plants: synthesis gas cleanup at higher temperatures, higher gas turbine firing temperatures and larger turbines, lower-energy oxygen supply technologies, and better plant controls

Gasification technology uses heat and pressure to partially oxidize a carbonaceous fuel to create a combustible "synthesis gas," which can be fired in a highly efficient combined cycle (gas turbine and steam turbine) power block. In the power industry, gasification plants are used with inexpensive solid fuels, such as coal or petroleum coke, or sustainable fuels such as biomass, and in some cases, the plants sell steam or hydrogen as well as electricity. Gasification technology is also offers a relatively lower incremental cost for incorporation of CO_2 capture and compression, relative to other fossil power technologies. However, a "base" gasification combined cycle power plant (i.e., one without CO_2 capture and compression) usually costs more than other types of fossil power plants. Hence there is an RD&D focus on improving gasifier, power block, and auxiliaries performance and cost by equipment improvements and improved integration. DOE has long and active history in coal gasification RD&D, providing a knowledge and experience base to manage an accelerated program of competitiveness-driven gasification combined cycle technology development and demonstration, which would parallel ongoing efforts on integrating CO_2 capture and compression.

The synthesis gas, or syngas, produced in a gasifier consists chiefly of CO, with varying degrees of methane and heavier hydrocarbons, hydrogen, water vapor, CO_2, nitrogen, and H2S, COS, and other sulfur compounds. To prevent erosion and corrosion in the gas turbine and associated heat exchangers and ducting, and to limit stack emission of sulfur species, the "raw" syngas is cleaned of particulate matter and sulfur compounds. Traditionally, this is accomplished by cooling the syngas with a water quench and/or a series of heat exchangers, and treating it with sulfur removal processes commonly used in the petrochemical industry. Because cooling reduces the thermodynamic properties of syngas, plant designers would prefer a reliable and effective "warm gas" cleanup process (which is actually quite hot). This has been the subject of numerous DOE RD&D efforts, and new technical options are ready for pilot- and demonstration-scale testing so this needs to be emphasized in the DOE portfolio.

To capture CO_2 from a gasification combined cycle power plant, an additional step (known as water-gas shift) is added to the syngas cleanup train, in which water vapor and syngas react in the presence of a catalyst to form hydrogen and CO_2. Established chemical industry processes can remove the CO_2, leaving a high-hydrogen content that can be combusted in the gas turbine with little CO_2 formation. Emerging technologies, such as membranes, may be able to separate the hydrogen from CO_2 with less energy and in more compact vessels. One promising approach couples the membrane with the water-gas shift reaction, saving additional equipment, space, and cost and could benefit from additional support.

Gas turbines designed specifically to combust high-hydrogen-content syngas are being built, tested, and commercially introduced. These will be essential to reliable and efficient gasification power systems with CO_2 capture and compression. DOE development and demonstration funding has contributed to success in this area. Equally important in EPRI's view is RD&D to move gas turbine technology to higher firing temperatures to improve efficiency and output—for both conventional and high-hydrogen syngas. EPRI economic analyses show larger and more efficient gas turbines to be perhaps the single most important step to improving integrated gasification combined cycle power plant economics. Although the commitment of gas turbine manufacturers is essential to ultimate success in realizing new commercial offerings, advances in the underpinning materials, design concepts and integration engineering can advance with DOE and industry cooperative efforts.

Many gasifier designs use a nearly pure oxygen input to the gasification reaction. That oxygen has traditionally been produced by cryogenic air separation units, which tend to be large, expensive, and large energy consumers. DOE has been funding lower-energy alternative oxygen production technologies, and EPRI has assembled an industry team to participate in one such effort, the scale-up and testing of Air Products' ion transport membrane (ITM) technology. EPRI is assisting in assuring that the product design and test program meet power company "real world" operation and maintenance criteria and also in gasification plant integration engineering.

EPRI believes that this model of cooperative DOE, industry team, and technology developer RD&D speeds the path to successful deployment and attainment of elec-

tricity cost reductions for the American economy. EPRI is also investigating whether a variation in the process can be used for supplying oxygen to future oxygen-fired systems (an early example of an oxygen-fired system is the FutureGen 2.0 project). Additional development and demonstrations in this area can support cost, efficiency and energy security from a variety of coal utilization processes.

Gasification power plants will also benefit substantially from improvements in process measurement and control. For example, durable fast sensors that provide real-time readings of temperatures and gas composition within the gasifier would provide operators with more accurate and timely measurement of syngas heating value, which in turn could be fed forward to power block controls. For the last several years, an EPRI program has been investigating the use of laser-based sensors for this purpose, and scale-up and demonstration funding is still needed.

- For additional information on gasification power plant RD&D opportunities, refer to EPRI publication 1023468, *Advanced Coal Power Systems with CO_2 Capture: EPRI's CoalFleet for Tomorrow Visionr – 2011 Update.*

Sustaining vital DOE RD&D on CO_2 capture, utilization, and storage

EPRI's analysis of options needed for the future validates DOE's high prioritization of RD&D to establish effective, economical, and publicly acceptable technologies to reduce atmospheric greenhouse gas buildup. This supports DOE's work on coal-based technology including CO_2 capture at power plants, cost-effective cleanup and compression for on-site geologic injection or transportation off-site, CO_2 utilization where economical, and secure long-term storage away from the atmosphere. In particular, EPRI identifies the following current work as warranting continued RD&D to achieve the cost and efficiency improvements necessary to allow viable commercial deployment:

1. R&D, scale-up, and integrated operation of coal power systems based on gasification and oxy-combustion technologies (presently through Clean Coal Power Initiative and American Reinvestment and Recovery Act funding, loan guarantees, and other mechanisms plus base program DOE funding)
2. CO_2 capture, compression, and storage RD&D to seek breakthrough innovations for low-cost capture, lower-energy compression, and for larger scale integrated projects, to understand operational flexibility, cost reduction options, and techniques to verify long-term storage
3. CO_2 utilization: because CO_2 used for enhanced oil recovery (or other means of generating revenue) will be essential to jump-starting CCS deployment, and may also help in reducing dependence on foreign oil, additional geologic characterization of areas near concentrations of power plants may be a logical follow-on under the DOE regional carbon sequestration partnerships programs

Chairman HARRIS. Thank you, and I thank the panel for the testimony. Reminding Members Committee rules limit questioning to five minutes.

The chair at this point will open the round of questions, and I recognize myself for the first five minutes.

Mr. Klara, let me just ask a question. The CCS projects that were funded from the first Stimulus Bill, was the total allotted around a little over $3 billion? Is that correct?

Mr. KLARA. The Stimulus Bill provided $3.4 billion but not all that went to demonstrations.

Chairman HARRIS. How much of that——

Mr. KLARA. Probably about a little more than $2 billion went to demonstrations.

Chairman HARRIS. And of that $2 billion how much has been spent in the last year and a half?

Mr. KLARA. The spending on the Stimulus so far is probably in the neighborhood of $500 million.

Chairman HARRIS. So the Stimulus Bill passed a year and a half ago, which was supposed to provide immediate jobs obviously at least $1–1/2 billion of that is sitting around, something that you are waiting to spend.

Mr. KLARA. Well, the——

Chairman HARRIS. Or can be spent but has not been spent, hasn't created a job.

Mr. KLARA. No. There have been some jobs created with——

Chairman HARRIS. Out of that $1–1/5 billion that hasn't been allotted. Is that an accurate representation of the timeline of things?

Mr. KLARA. Yes.

Chairman HARRIS. Okay. Those projects, of the ones that are going to be, that were funded, what is your belief, how many of those will be successfully implemented to the point where all that money will be spent?

Mr. KLARA. Well, we have had one project drop out which was indicated by Mr. Akins.

Chairman HARRIS. Okay.

Mr. KLARA. Our AEP project. We have seven projects currently being funded with Stimulus dollars, and right now all of those projects continue to go forward in a positive direction.

Chairman HARRIS. Now, was there any project further along than the AEP project?

Mr. KLARA. Yes. We actually have three projects that are—have already started construction. One is with Southern Company, another is with Archer Daniels Midland, and another with Air Products. So, yes, three of the projects are actually starting construction, and I would add, too, that the Stimulus requirements were pretty specific on putting a lot of the money on what we call these demonstration projects, and I think what you will hear from members of the panel is when you deal with building demonstration projects, retrofitting a plant or building an entirely new plant——

Chairman HARRIS. Right.

Mr. KLARA. —that the spending profile was such that it takes a couple——

Chairman HARRIS. Yes. They are not shovel ready, are they?

Mr. KLARA. No. Correct.

Chairman HARRIS. Right, and so that is what I thought.

Let me ask a question, Mr. Dalton, I guess if I summarize your testimony, you kind of believe that we really ought to have a diversified approach to research on these coal-related areas.

Mr. DALTON. Yes, Mr. Chairman.

Chairman HARRIS. Okay.

Mr. DALTON. Absolutely. We need all the options, coal, nuclear, renewables, several options.

Chairman HARRIS. So that the movement in certainly with regards to the Stimulus Bill and in the President's budget toward really a concentration on just CCS with really decreased funding to the other areas is probably in your opinion might not be the right direction to go.

Mr. DALTON. Well, we see that the addition of work on very high efficiency, getting that to the——

Chairman HARRIS. Right.

Mr. DALTON. —demonstration stage is critical, and there are new areas that are opening up partly due to regulation, on water and HAPs—that are requiring some additional——

Chairman HARRIS. Right. There might be very useful places for that funding. Yes. I can understand that.

What is the—and a question to Mr. Akins and Ms. Gellici, I mean, what is the future for, the outlook for building new power plants? Mr. Akins, you have said you have one, the ultra-supercritical plant under construction. If I could just ask about how much more does that cost to build than a regular plant in a conventional, I guess we call them sub-critical plants.

Mr. AKINS. Typically a sub-critical plant would probably be on the order of $1.5 billion, maybe $1.6 billion. This one is around $2.1 billion to $2.3.

Chairman HARRIS. And it consumes how much less fuel is your consumption per——

Mr. AKINS. Eleven percent.

Chairman HARRIS. Eleven percent less, and of course, with that it is also less pollution because you are burning less fuel I take it——

Mr. AKINS. Yes. Absolutely.

Chairman HARRIS. —with that. Okay, and so to the rate payer, I mean, what is your estimate of how much that increases the cost of the electricity?

Mr. AKINS. Generated?

Chairman HARRIS. Yes.

Mr. AKINS. For the power plants?

Chairman HARRIS. You go to the ultra-supercritical versus the conventional.

Mr. AKINS. Over the lifetime of the plant——

Chairman HARRIS. Yes.

Mr. AKINS. —it will be relatively negligible compared to the sub-critical.

Chairman HARRIS. Negligible.

Mr. AKINS. And from an environmental standpoint you——

Chairman HARRIS. Beneficial. So the testimony we have heard, and well, I guess we didn't hear it but I was going to ask Mr. Klara actually to substantiate that, is it true that, in fact, a goal is only a 30 percent increase in costs?

Mr. KLARA. Well, we have two pathways.

Chairman HARRIS. Right.

Mr. KLARA. The one pathway is for new plants gasification which would be 10 percent——

Chairman HARRIS. Right.

Mr. KLARA. —and the other is for pulverized coal-based systems, which is what you are talking about with Mr. Akins, and yes, there is a 35 percent increase with the cost of adding——

Chairman HARRIS. For the CCS technology.

Mr. KLARA. Correct.

Chairman HARRIS. Right, but when you are talking about ultra-supercritical, that is not—that has nothing to do with CCS. Right? That is just thermal.

Mr. KLARA. That is correct.

Chairman HARRIS. Right. So, in fact, if what you are looking to do is decrease pollution and keep the costs over the—of the lifecycle of the plant relatively stable, you wouldn't pick a CCS technology, I mean, because, I mean, if our, I mean, I can guarantee that if our research goal is to only increase the cost by 30 percent, it is going to increase at least 30 percent. Is there any reason to believe,

Mr. Klara, that we are going to hit below that target in the next few years for increased costs? Well, we won't know until the demonstration projects are done, I guess.

Mr. KLARA. Well, yeah. You are correct that when you add CCS to a plant that it adds cost. Within our program we are trying to look at a no-regrets path forward, and part of that no-regrets, for example, is that if you could use the carbon dioxide that is captured for valued-added stream back such as enhanced oil recovery, now you can potentially have a scenario where it is——

Chairman HARRIS. Sure. A win-win.

Mr. KLARA. —neutral. Yeah. Win-win.

Chairman HARRIS. Right.

Mr. KLARA. Right.

Chairman HARRIS. Thank you.

Mr. Miller.

Mr. MILLER. Thank you, Mr. Chairman. I was Chair of the Subcommittee on Investigations and Oversight of the Science Committee in the two previous Congresses to this one, and questioned and criticized the Bush Administration for pulling, without explanation, the funding for Future Gen, which was the principal, very ambitious carbon sequestration effort for coal. So I do support R&D for the coal industry.

Mr. Dalton urged DOE to help the coal power industry meet competitive challenges. Ms. Gellici, Ms. Gellici, by the way, I appreciate your using, speaking slowly and using—avoiding big words in your testimony so I could understand it. You said that the sole focus on basic engineering and research will not advance commercial technologies to the marketplace, and the Department of Energy funding of late-stage, large-scale demonstration activities advances the efficiency, reduces capital costs, and increases the commercial availability of the advanced coal technologies.

Do all of you agree with those statements? Do any of you disagree with those statements? I am not seeing any movement at all. Either heads up or down. I assume no one disagreed at least.

Why does, again, I supported research, R&D funding for Future Gen but why is the coal industry not capable of doing that research themselves? The basic research, to applied research, to demonstration on their own. What are the reasons that justify government funding for research that helps that industry?

Mr. Akins.

Mr. AKINS. Sure. I will be happy to answer that. You know, when you start with these technologies, it is basically bench-top scale, and then it moves to more proving the technology. Moving to commercial scale is an entirely different approach where the magnitude of the dollars associated with it are important to be able to deal with from a cost-recovery perspective. In our business we have to be able to recover our costs from someone, and we invested over $100 million dollars on the integrated carbon capture and storage project I talked about, and our shareholders wound up footing that bill.

For—to upscale this project to another CCS project would be on the order of $700 to a billion dollars, and when you talk about that kind of dollar commitment, there has to be some sense of certainty around not only legislation or regulation but also for us to be able

to recover from our costs from the customers. We have to be able to have some requirement to do so.

Mr. MILLER. So the funding for that research and development does not crowd out private investment in innovation?

Mr. AKINS. The funding for the research if the government were to fund it?

Mr. MILLER. Right.

Mr. AKINS. If the government were to fund that type of research, we could advance the technology.

Mr. MILLER. And it wouldn't discourage private investment. It wouldn't crowd out private investment.

Mr. AKINS. I think at the demonstration scale you could have private investors involved with that as well.

Mr. MILLER. Okay.

Mr. AKINS. I think it is a public-private partnership.

Mr. MILLER. All right. Well, do you think that the same arguments apply to the less mature technologies? One of you suggested we should be doing all coal and nuclear and the newer technologies as well. Do the same arguments not apply to them, and if not, why not?

Mr. AKINS. Are you asking me?

Mr. MILLER. Yes, sir. You were—you volunteered earlier so——

Mr. AKINS. Okay. Yeah. I think the advancement of the technology is needed regardless. If we are going to have a secure energy future in this country, it includes all resources, and the government has to be very selective about—and make sure we maximize the value of taxpayer funds to support these kind of investments, but it is clearly important to advance the technologies on all fronts.

Mr. MILLER. Mr. Foerter, the industry often has estimates on what compliance with EPA regulations will cost, and it usually assumes the worst possible case, the most expensive, the most time consuming, retrofits, wet scrubbers, cooling towers. All that will be required. But it appears in most cases there are other technological—there are other technology options that are less costly and can be implemented more quickly.

Could you describe the options the power companies might have and what the biggest factors are in how they choose between technologies, how to proceed, what the technological readiness is of those various options?

Mr. FOERTER. Yes. In fact, that is an astute difference between the difference of trying to predict what is going to go into the marketplace and what the marketplace actually creates. When EPA makes predictions, they use big monolithic type of technologies, and that is where the big costs come out.

But when you get into the marketplace and there is—it is quite different, and quite frankly, our industry moves with that market, what the demands are and what the changes are. Things like ash handling and water cooling issues. All those things start to come in. We start looking towards dryer systems, so a wet scrubber becomes not the favorite, and you start moving down that same chain and looking at dry systems or direct sorbent injection kind of systems. Direct sorbent injection installed in a couple of months. A wet scrubber takes 30 plus months to install it.

So it is very different in that kind of thing. Wet scrubbers, very expensive, direct sorbent injection, relatively inexpensive. Your cost—the biggest cost there is going to be the reagent that you are continually feeding into the system. You turn it on, and you turn it off, and that is where your costs begin and end.

So we have really diversified within our system, and I, when I talk about our pollution control technologies, if I started to move towards saying just wet FGD for scrubbing, you know, there would be a lot of my members who would be very unhappy because they are all out there competing in the marketplace to sell all the different suites of technologies, and the same thing happens with NOx and every other pollutant that is out there.

Mr. MILLER. My time has expired.

Chairman HARRIS. Okay. Thank you. The gentleman from Maryland.

Mr. BARTLETT. The other gentleman from Maryland. Thank you very much.

We use energy in basically two different forms. We use electrical energy for a great variety of things, and we use liquid fuels, and it is hard for us to compare the relative costs of those because they are used in very different domains.

But when we can use them for the same thing like in an electric car, we find that you have about half the cost per mile in the electric car that you do in a car using liquid fuels. So we know that the electric power is much cheaper per unit of power than liquid fuels. The average American should be a big fan of coal because the electricity is so cheap largely because coal is the source of the base load production for most of our electricity.

Ms. Gellici, you said that we have 200 years of coal. Is that a current use rate?

Ms. GELLICI. That is correct. Yeah.

Mr. BARTLETT. Okay. Be careful when you hear somebody say we have so many years of something at current use rates. Do you suspect that we will increase the rate at which we use coal?

Ms. GELLICI. Yeah. The latest projections are that we will probably increase our use of coal by about 25 percent.

Mr. BARTLETT. Twenty-five percent. Wow. Do you know what that does? If you increase the use of coal only two percent——

Ms. GELLICI. Uh-huh.

Mr. BARTLETT. —two percent growth of something, it doubles in 35 years. It is four times bigger in 70 years, it is eight times bigger in 105 years, it is 16 times bigger in 140 years. That means that your 200 years of coal, if we increase its use only two percent, you suggested 25 percent, that dramatically reduces the time. But if the increase is only two percent, that 200 years now shrinks to 70 years. So be very careful when you hear somebody say we have so many years of something at current use rates, because our economy is growing, our use of energy is growing. That is very likely to increase.

You know, that is not a very long time, is it? Seventy years. And then it is all gone if we increase its use only two percent. You said we might increase its use 25 percent, which would dramatically reduce the time that it is available to us.

I would ask to have a couple of slides loaded into our little magic system. I don't know if it did or not but—oh, there they are up there. Okay. Well, I can't read the end of that. Does that say 35 years or 30 years? That one says 35 years. Okay. We are talking about secure energy future, and this is a chart produced by the IEA. This is a creature of the OECD, one of the two best entities in the world tracking the use and predicting the continued production of liquid fuels.

If you look at that, you will see if—I am sure that is—yes, that is the one that ends in '35. They are predicting that by '35, we will have, will be producing only 96 million barrels a day. Now we are producing 84 million barrels a day. Just two years before this their prediction had us in—by 2030, producing 106 million barrels a day.

Notice the dramatic reduction in the production of conventional oil. That is the dark blue on the bottom. It is now plateaued for four years at 84 million barrels of oil a day. That plateau was reached in our country in 1970.

With everything we have done since then since like finding a lot of oil in Alaska and the Gulf of Mexico and drilling more oil wells than all the rest of the world put together, today we produce half the oil that we did in 1970. The United States certainly has to be a microcosm of the world, and you see those two big wedges in there? The medium blue wedge and the light blue wedge, the light blue wedge is oil that we are going to get from fields that we discovered that are too tough to develop like under 7,000 feet of water and 30,000 feet of rock out in the Gulf of Mexico. The medium blue field there is fields yet to be discovered. Those two wedges, if the United States is any indication what will happen, will not occur.

So we are talking about a secure energy future. The production of liquid fuels for the future is going to do in the world what it has done in the United States, and it is inexorable. We could not turn it around with all of our creativity and innovation, and so this is where the world is going, and we are talking about a secure energy future since that was a part of the title of our hearing, I just wanted to use this opportunity to present those graphs to show that we have got some big challenges facing us.

Thank you all for what you are doing to help us have more energy.

[The slides follows:]

SLIDES PRESENTED BY MR. ROSCOE BARTLETT, COMMITTEE ON SCIENCE SPACE AND TECHNOLOGY

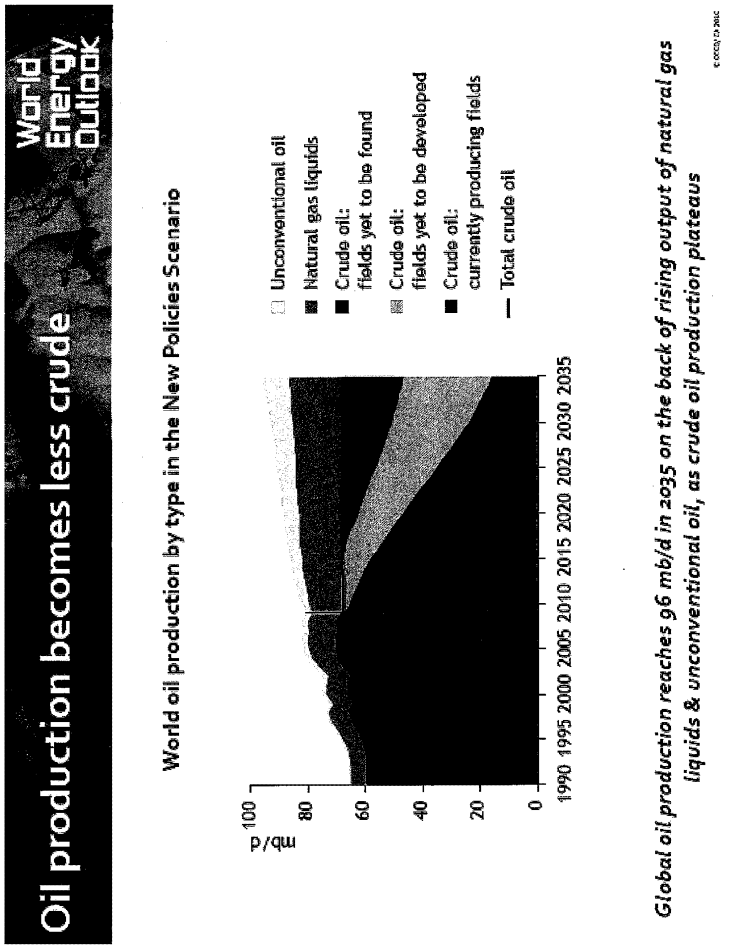
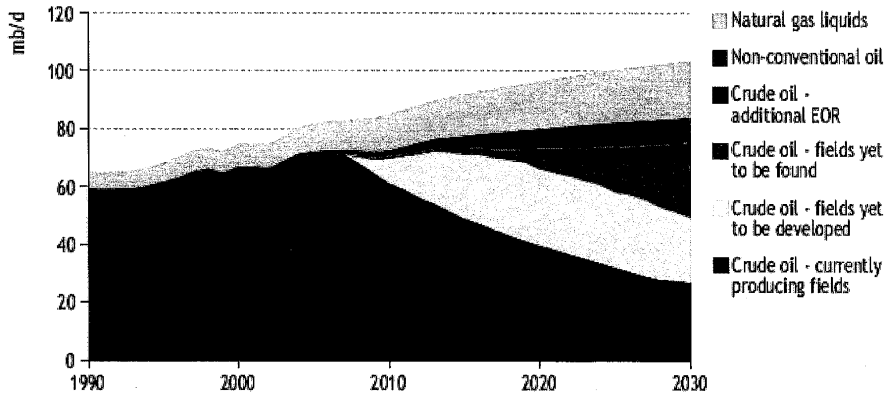


Figure 11.1 • World oil production by source in the Reference Scenario



Chairman HARRIS. Thank you very much.

I recognize the chairman, the gentleman from Texas.

Mr. HALL. I thank you, Mr. Chairman. I want to talk a little about the EPA's war on energy, which is really the President's war on energy, which this Committee and this Chairman has devoted a lot of time and effort to examine over the last few months.

Specifically, with regard to coal, we have looked at the science behind the whole package of Clean Air Act rules EPA's pursuing, and we held a hearing in September on the Cross-State Rule. I don't know if you all know about that or you remember about it or you read the reports within it, which would force the closure of significant coal-fired electricity capacity, even in my State of Texas, as close to me as I know about, and I don't know how much other all over the country. But we would lose 500 jobs in one plant, in one little district there.

EPA announced revisions to this rule last week after some weaknesses in the technical assumptions were exposed and after Dr. Broun and this chairman, Dr. Harris, and other subcommittee chairmen and Congressman Rohrabacher had raised that Billy Graham preaches against all the time on it, and I don't think that is enough. And I have called for EPA to simply scrap the rule and start all over.

My question is this, primarily Mr. Akins, but I welcome thoughts from anybody else that wants to chime in on it. How do the compliance deadlines under mercury MACT and the Cross-State rules compare with the time it takes to install the emissions control equipment necessary to achieve compliance with these rules?

That is a question, and what happens when you can't install equipment in time under these rules?

Mr. AKINS. Chairman Hall, it is something we have done quite a bit of analysis on. It typically takes us about five years to put a scrubber in, and I think EPA had assumed three years. I don't know where their numbers come from. I will let them cover their numbers, but with our numbers they are based upon substantial amount of work done. We spent $7.2 billion in the last—over the last decade putting in scrubbers and SCRs, Selective Catalytic Reduction devices. It typically takes about five years because we have to go through regulatory approvals with the In-State Commissions before we are able to move forward with the projects. And then by the time you get through with engineering, project design, construction, those types of things, a procurement of supplies, you are talking about five years.

So—and as what we have looked at is the staging of all those projects, it is just impossible to get the number of projects done in that amount of time. If we—for AEP it would force the retirement of about 6,000 megawatts of generation. If you impute that, we are about ten percent of the coal-fired capacity in the country. That would be about 60,000, which is right in line of many of the studies that have been done.

So if we can't get the projects done, we either retire the units or we put them on idle. I mean, we just don't run them for a period of time, but then that capacity is not available to customers during peak periods like in Texas over the summer.

Mr. HALL. Well, listening to your figures I think in the Cross-State rule I think they gave from now to the first of the year——

Mr. AKINS. That is right.

Mr. HALL. —to correct that. Just impossible. Absolutely impossible to do that. Impossible even to plan it probably.

Mr. AKINS. That is right.

Mr. HALL. And yes, ma'am.

Ms. GELLICI. Yes. I think this is one of other major differences between the current regulations as proposed and the ones that we had seen in the past. We have much success in meeting the SO_2 and NO_X reduction regulations that have been imposed in the past because we had a five to ten year compliance schedule. The Acid Rain Program was passed in 1980, and we had five years, five to ten years for compliance.

What we are looking at now is extremely truncated compliance deadlines, sometimes three years if we are lucky but oftentimes much shorter. So——

Mr. HALL. Well, thank you for that, and Mr. Akins, another thing. Can you explain how the new EPA rules could threaten the electric grid reliability? Just address that. I think I have——

Mr. AKINS. We have done——

Mr. HALL. —about 30 seconds left.

Mr. AKINS. —an extensive amount of analysis. When you look at the security of the electric grid, these plants are located in particular areas for reasons, and primarily they supply black start which restarts the system in a blackout or voltage support, which supports the voltage so that, basically so power could be delivered where it needs to be delivered.

So you look at these plants in these localized areas, if you truncate all these units at one time, then we are essentially shutting them down, and they are not available to the grid. And in that context you are dealing with serious reliability implications, and we have looked at it on our system in a lot of detail and have confirmed that is the case, and in fact, the regional transmition organizations like ERCOT, Southwest Power Pool, and PJM have verified that.

Mr. HALL. I thank you, and my time is up. I thank you for your service, each of you, and for coming here today, and I thank the chairman for holding this hearing.

I yield back.

Chairman HARRIS. Thank you very much, and we still have time before we have to go to see the President of Korea, so we will have another round of questioning.

I will recognize myself for the first five minutes.

Mr. Klara, let me ask you, is—if those additional projects fail to be—to reach completion, the CCS projects with the Stimulus money, what happens to that money that is not spent? And I guess we can just ask upfront, you know, the AEP project that is not—it looks like it is not going to continue. I mean, is that money going to come back to pay down the deficit, does it—what does it do? What happens to that money?

Mr. KLARA. Well, what we know or what I know is that any of the Stimulus funds will go back to the Treasury. Where it goes

from there is beyond my ability to know, but, yes, any of the Stimulus funding that is not used will go back to the Treasury.

Chairman HARRIS. Okay. So that is your belief. Okay. Very good. I am glad to hear that because we got a little deficit running.

I am going to ask you also, you know, I think everyone kind of acknowledges cap and trade isn't going anywhere, and in the absence of cap and trade, you know, they probably—I would imagine there is really no economic way that you could have carbon restrictions that wouldn't make electricity rates skyrocket.

So given that what is the Administration's position on the future of coal in America? I mean, is it—is CCS really going to be financially viable at all unless you had a cap and trade system? I mean——

Mr. KLARA. Well, we have tried to design the program as a no-regret strategy as I somewhat inferred earlier, and what I mean by that is we have tried to design it such that the key developments that come out of the program are going to be valuable whether there is a carbon——

Chairman HARRIS. Well, let us assume that that is not scalable. Let us just make the assumption that we are not going to grow enough algae to use the CO_2, and we are not going to, you know, that, yes, there will be some secondary oil recovery, but let us assume that that is a minimal benefit. Or is that what the Administration is banking on, that we are actually going to have some incredible breakthrough, and we are going to be able to use every molecule of CO_2 from a burnt piece of coal to do something else?

Mr. KLARA. Well, we believe, looking at the R&D portfolio and if it is successful. So if you make the assumption that it can be successful——

Chairman HARRIS. I know, but Solyndra made the assumption, too, and it is a lot of money and a lot of effort that it goes to the negation of other efforts. It is really the bottom line of the hearing. So—but I think you have answered the question, so thank you for that.

Mr. Foerter, you made the statement that building new plants is problematic, but Mr. Akins sitting next to you said, wait a minute. They just built an ultra-supercritical plant, and it is going to have negligible effect over its lifetime on the cost of energy, and it is going to burn cleaner, it is going to burn more efficiently. Why do you say it is problematic?

Mr. FOERTER. Well, and we agree on the thermal efficiency and it is a better, you know, it has an upfront CO_2 benefit from it as Janet Gellici kind of talked about in the different levels, and if you ask Mr. Akins about how long it took to go through that permit and how problematic that process may have been, it was very, very difficult.

Chairman HARRIS. So it is the regulations you mean?

Mr. FOERTER. It was a process of trying to get—there is no infrastructure right now that allows for power plants to be built without sort of a CO_2 kind of issue. So the real issue comes back to CO_2.

Chairman HARRIS. Right. So if we negated the CO_2 issue, let us say we put it on hold for awhile, we could build plants that actually are more efficient and cleaner and could supply energy from coal.

Mr. FOERTER. Well, the idea was that we were going to build new plants that could be retrofitted with a technology which would be proven, and that that is what AEP and others were trying to do. But building new plants, there is an upfront——

Chairman HARRIS. Let me just clarify something because the plant Mr. Akins is building actually produces less CO_2 per unit of energy.

Mr. FOERTER. But they go through permit processes which are strenuous——

Chairman HARRIS. Right, but it—just so, I mean, there are ways to do it without sequestration I guess is what I am getting to with that.

Mr. FOERTER. Well, up front you do get the reduction. Eventually you are—if you are trying to look to a 70 or 90 percent reduction on the CO_2, you are going to start using like a technology they were trying to demonstrate fully, scale, and that is the chilled ammonia chilled ammonia process which was working well at a smaller scale.

Chairman HARRIS. Right.

Mr. FOERTER. They are getting ready to go to the next level.

Chairman HARRIS. I don't know. It sounds like an ultra-supercritical might be the next level. I mean, your testimony did mention the availability of dry sorbent injection as a technology option, pollution control, but as you know, EPA's proposed utility rule relies heavily on this technological fix.

Which coal-fired units in the United States utilize that dry sorbent injection to capture more than 90 percent of acid gases?

Mr. FOERTER. Well, the dry sorbent injection and EPA's—we even commented on this. We think they have overused the DSI part of it. We think they will go drier systems, which are dry scrubbers and circulating dry scrubbers. We don't think we are necessarily going to see the wet type scrubbers that Mr. Akins was talking about that take five years to put in place. We will see something that takes a lot less install time, permits still have to be found, but we think that EPA, and we have told them we——

Chairman HARRIS. Those permits again. Thank you very much. I am out of time.

Mr. FOERTER. Those permits are always there. Yeah.

Chairman HARRIS. I recognize Mr. Miller.

Mr. MILLER. Thank you, Mr. Chairman.

I have questions that kind of pursue the line of questioning I had earlier for Mr. Foerter. Critics of the EPA regulations say that the regulations will cause, will force a number of coal plants to close and even compromise the reliability of our electric system, but the projections of the number of retirements do vary greatly, and the estimates as Mr. Foerter said of costs also vary greatly. And it appears that some that are supposedly going to close because of EPA requirements were scheduled to retire anyway. That happens. Plants wear out and also technology becomes obsolete. It is replaced by other technologies.

Do any of you see the likely coal plant retirement rates—or, how do you see the likely coal plant retirement rates under current expectations, business as usual, versus that under EPA regulations?

Mr. FOERTER. If I could, if you have been watching, you sort of have a trend of what the announcements are for retirements and what the predictions are. I just saw one yesterday. ICF had said 68 megawatts or gigawatts in retirement, have now revised that down to around 40. There has been—so you start putting more and new information in, including final rules, not proposed rules, information. You start seeing those numbers of retirements come down quite a bit.

But on these plants we have 50 and 60-year-old air pollution control technologies on some of these plants. So, the technologies wear out, the boilers can wear out, the technologies are put on them, wear out. They lack any useful life in them.

So some of these are not even supplied with coal anymore, and so they are just sitting there waiting for a decision to be made, and decisions are starting to be made.

Mr. MILLER. Okay. Can the rest of you kind of roughly describe what plants you think might be retired and how they compare in age and efficiency and the environmental profile compared to the rest of the coal fleet?

Mr. AKINS. Well, typically, I can speak for our system. We have several of the 50, 60-year-old units, and the units continue to operate fine. You have made a lot of capital commitments associated with the continuing operation of those plants.

One thing I wanted to clarify was when we talk about—they were slated to retire anyway, that is true. We plan on retiring several of these units through the 2020 timeframe and beyond. The issue is the compliance time that forces those retirements on an earlier basis.

So if we are talking about 2014, or 2015, you are effectively truncating all of these units at the same time, and that is the part that we have an issue with. These units are going to gradually retire. They are intended to do that. We will make decisions on the scrubber technology, on whatever, dry sorbent injection or whatever, but many of these units will probably not survive, but we know that, and we are making that transformation to a new energy future, I think. My biggest issue is that people need to have the patience to get there. I mean, this is a heavy capitalized industry, and when we talk about retiring units, they are done over time, they are done in the manner to preserve the reliability of the system, and to mitigate cost increases to customers.

So those are the kinds of things we look at.

Mr. MILLER. Do the regulators, in fact, have the authority to disallow closing a plant if it would threaten reliability, electrical reliability?

Mr. AKINS. Yes. They do. The in-state regulator would have to give approval for retirement of the units.

Mr. MILLER. Right.

Mr. AKINS. And reliability of—the priority in that, they have the resource requirements within the state, the regional transmission organizations, they also have the authority which is an extension of FERC, and then obviously if the EPA requires something, then we are stuck between three agencies trying to determine what the heck to do.

Mr. MILLER. Okay. Mr. Foerter, you said that some of the estimates of cost were high because they assume that the most expensive technology would have to be used, but do you think the estimates about forcing plants to close would change when the industry really did look at the technological, regulatory, and financial options available to them?

Mr. FOERTER. Yeah. I think it would change because they were looking at it like the example I would use with Mr. Akins was five years for building this scrubber. Well, we are not building any big scrubbers like that anymore, and for that first 75 percent, we were building lots of big wet scrubbers. I mean, that is what we spent our last five to seven years doing.

As we move into the future, we are moving towards things that have less capital cost, so if you got an old car, and you want to—you try to fix it up a little bit, you are not going to go in there and put a new engine, a new transmission and everything else. You are going to try to do what you can with less capital costs. It might mean you use some fuel additives, some things to keep it going, and that is exactly what is happening, could happen in this industry. We can keep these things running as long as we can.

There was a good testimony in another hearing where they said they tried to close down a power plant, and then they went through this due diligence process, took 29 months for everybody to agree this is how they were going to do a closure on that plant for reliability issues. So it does work really well. We have a lot of confidence. In fact, we have heard that reliability card used many, many times before and it just doesn't happen, and we have done some very, very big capital projects like SCR where the boiler goes out for quite a bit and FGD, where these are much bigger tax construction projects.

So it hasn't happened in the past. I am not exactly sure why I think it is going to happen in the future.

Mr. AKINS. If I could respond to that, is it okay?

Mr. MILLER. Sure. It is up to the chairman. My time has expired.

Chairman HARRIS. Sure.

Mr. AKINS. Okay. The first thing is we have spent $7.2 billion on investments in scrubbers and SCRs. We continue to build large scrubbers and SCRs throughout out system. For 500 megawatt units, for 1,300 megawatt units, and we have achieved over 80 percent reduction in SOx and NOx emissions from our power plants.

To get the other 20 percent or 15 to 20 percent is another $6 to $8 billion, and that is what we are slated to spend in the future on these plants. So, there are smaller, more elegant solutions that are cheaper, that are less efficient, but scrubbers and SCRs continue to be built.

Mr. FOERTER. If it is helpful, as they start building—that means that these units they expect to keep around for a long time, and they are willing to make the large capital investments, and the way that the Clean Air Act is set up and particularly the max standards is there is more time than is provided there. In fact, we have used that more time in many other industries. Someone was telling me about metal smelters. You can't just shut a unit down and not have, you know, you still have to have the capacity.

Same thing happens here. There is lots of flexibility, and EPA has reached as hard as they can finding that flexibility, and I think they have done a pretty good job. No one is going to shut down units that are critical to reliability in the Nation's power.

Chairman HARRIS. Thank you. Let me just take 30 seconds for a follow-up with Mr. Akins.

The—with regards to the dry sorbent technology, is that an answer for a lot of your plants? That is something that you are——

Mr. AKINS. Yeah. We are utilizing dry sorbent technology, but in a lot of cases you get the maximum benefit for scrubber, for removal efficiencies you are going to the larger scrubbers, and for the larger units that is what you put in place.

Chairman HARRIS. The dry sorbent? Not—you can't do it.

Mr. AKINS. We have dry scrubbers, we have wet scrubbers but—and the dry sorbent injection is a smaller, less——

Chairman HARRIS. Smaller scale.

Mr. AKINS. —efficient solution.

Chairman HARRIS. Thank you, and before we—and in the last—if you would in the last minute, I am just going to ask each of you if—we are going to, obviously going to spend money on CCS. We are going to spend research money that is in the pipeline. What should our number two priority be with regards to government-funded coal research?

Just go down the line. Mr. Klara. What do you think? You had a chance, all of you had a chance to look over what you think we—where you think we should be spending the money.

Mr. KLARA. Well, I think many of the things that were mentioned here, for example, water management is a key.

Chairman HARRIS. You think water management.

Mr. KLARA. And you have heard that time and time again.

Chairman HARRIS. Okay. Ms. Gellici.

Ms. GELLICI. Efficiency improvements. I think even just through simple operations and maintenance techniques we can pick up three to five percent efficiencies at our existing power plants. We have got some new source review issues that are preventing us from doing that, but there is still quite a bit of low-hanging fruit out there that we can reduce not just criteria, pollutants, but SO_2 as well.

Chairman HARRIS. Okay. Mr. Akins.

Mr. AKINS. Yeah. I would agree efficiency improvements.

Chairman HARRIS. And including thermal energy——

Mr. AKINS. Yes.

Chairman HARRIS. —improvements?

Mr. AKINS. Yes.

Chairman HARRIS. And Mr. Foerter?

Mr. FOERTER. Yeah. The thermal efficiency of new power plants as I previously had talked about. There is—you need to test these things out. I mean, the TURK Plant is an ultra-supercritical or supercritical, so we want to keep pushing that envelope. You can get up to 50, maybe 51 percent. Those are huge benefits as you get out there. They do need to be tested and maybe not through the public permitting process.

Chairman HARRIS. Mr. Dalton.

Mr. DALTON. All of the above. Actually, efficiency and water both——

Chairman HARRIS. Okay.

Mr. DALTON. —are——

Chairman HARRIS. Listen, thank you very much to the panel for your testimony. It has been very eye opening. If any Members have additional questions for the witnesses, we ask you to submit them, and we are going to ask you to respond to them in writing. The record will remain open for two weeks for additional comments from Members. The witnesses are excused, and the hearing is adjourned.

[Whereupon, at 3:43 p.m., the Subcommittee was adjourned.]

Appendix I:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Scott Klara, Deputy Director,
National Energy Technology Laboratory

QUESTION FROM REPRESENTATIVE HARRIS

Q1. What is the Administration's view of the future of coal in America? Does the Department of Energy believe new coal-fired power plants should be built in the absence of significant carbon controls?

A1. As stated in prepared remarks by Secretary Chu to the House Energy and Commerce Committee on March 16, 2011, "To meet our energy needs, the Administration believes we must rely on a diverse set of energy sources including renewables like wind and solar, natural gas, clean coal and nuclear power." Additionally, the U.S. Energy Information Administration Annual Energy Outlook 2011 projects that coal will continue to be a significant part of the U.S. energy mix in the future.

The Department of Energy believes that industry is best positioned to evaluate market conditions to determine whether new coal-fired power plants should be built in the U.S. to meet the energy demand. DOE continues to support research, development, and demonstration efforts to capture, utilize, and store carbon dioxide emissions from fossil energy plants.

QUESTION FROM REPRESENTATIVE HARRIS

Q2. In discussing the outlook for FutureGen, DOE's nominee for Assistant Secretary for Fossil Energy recently said it is unclear now "whether or not the participants will be capable of moving into Phase II, or frankly, whether the participants will be willing themselves, to move into Phase II." Please provide DOE's outlook on FutureGen and the viability of the project in the absence of private investment. When will a decision be made by participants regarding the transition into Phase II? What factors will drive this decision and how does DOE expect to be involved in it? Please also provide a summary of DOE spending on FutureGen for each fiscal year since its original inception in 2003.

A2. The FutureGen 2.0 program consists of two integrated projects. The first is the repowering of an existing coal-fired power plant with oxy-combustion technology and carbon capture capability. The private participant responsible for this project has been Ameren Energy Resources. The second project is the construction of a pipeline and sequestration facility; this project would transport the carbon dioxide from Ameren's power plant and inject it into an underground geologic formation. The private participant responsible for this project is the FutureGen Alliance.

The Department of Energy remains committed to the FutureGen 2.0 program. We awarded $1 billion in Recovery Act funding to the program because we believe it has the potential to demonstrate innovative technologies for reducing carbon emissions from existing coal-fired power plants and to help the United States remain competitive in the future. The Department is working closely with the participants to complete Phase I of this project, which will conclude in December 2011. At that time we and the participants will assess whether there is the willingness and capability to move into Phase II.

It is DOE's understanding that the participants will announce their formal decisions soon.

The participants must confirm that they are willing to move into Phase II and demonstrate to DOE that they have the financial, technical, management and other capabilities to successfully complete both projects on a schedule that will expend the Recovery Act funds obligated to the FutureGen 2.0 program before they expire on September 30, 2015. DOE must review and approve each participant's application to continue its project into Phase II.

The requested information on FutureGen spending appears in the following table. The amounts shown do not include indirect expenditures such as federal salaries or travel.

Fiscal Year	**Payments**
(Non-ARRA)	
2003	$0
2004	$0
2005	$509,353
2006	$3,804,721
2007	$10,257,461
2008	$14,663,828
2009	$1,065,816
2010	$11,624,105
2011	$2,220,737
2012	$88,575
TOTAL	$44,234,596
(ARRA)	
2009	$0
2010	$0
2011	$19,628,772
2012	$1,923,245
TOTAL	$21,552,017
GRAND TOTAL	$65,786,613

QUESTION FROM REPRESENTATIVE HARRIS

Q3a. Please provide an update on each remaining clean coal demonstration project (including those funded through the Clean Coal Power Initiative as well as others) and DOE's outlook for the success of those projects. What are the key factors and decision points that will determine the success or failure of the remaining projects? Additionally, for each project please provide:

The cost share apportioned within each budget period for each project, including a description of the structure and requirements associated with cost-shares that vary for each phase of a project.

A3a. The Department of Energy remains committed to the demonstration of carbon capture and storage technologies at commercial scale and has been working very hard to make all clean coal demonstration projects successful. The Department has been working closely with all of our industry recipients to complete each of the phases of every project. As each phase concludes, recipients submit Decision Point Applications that are then reviewed by the Department. We review each application for completeness and technical acceptability of required documentation and, if the application represents that sufficient progress has been made, accept the application as a basis for that project to proceed into its next phase. Key factors include technical performance and estimated costs; as new technology projects unfold, engineering details and cost estimates are refined and updated continually. As such, recipients are not authorized to expend additional taxpayer funds until they have proven successful completion of the current phase, are ready to proceed into the next phase, and present a credible plan to successfully execute any remaining future phases.

The table below presents the breakout of funding by budget period for each project within the Clean Coal Power Initiative (CCPI), Industrial Carbon Capture and Sequestration

(ICCS), and FutureGen 2.0 programs. Funding provided to each project by the 2009 American Recovery and Reinvestment Act (ARRA) is also indicated in the table.

Projects selected under the CCPI 3 Funding Opportunity Announcement (FOA) received both ARRA and base funding. All ARRA funding was obligated against Budget Period 1 while all CCPI base funding was obligated against Budget Period 2.

Project Name	Total Project Cost	Govt. Cost Share	Budget Pd. 1	Budget Pd. 2	Outlook
Southern Co. Kemper IGCC Project (CCPI 2)	$2,380,992,148	12.3	$23,518,640 (Non-ARRA)	$270,231,360 (Non-ARRA)	Project is under construction.
Summit Texas Clean Energy Project (CCPI 3)	$1,726,628,229	26.1%	$211,097,445 (ARRA)	$238,902,555 (Non-ARRA)	Project is working towards financial close early in 2012. Off-take agreements signed.
Hydrogen Energy California (HECA) Project (CCPI 3)	$4,008,132,814	10.2%	$275,000,000 (ARRA)	$133,000,000 (Non-ARRA)	Project in FEED. Working towards off-take agreements.
NRG W.A. Parish Post-combustion Capture Project (CCPI 3)	$1,726,628,229 (Cost for 60 MWe project only)	50%	$163,007,179 (ARRA)	$3,797,246 (Non-ARRA)	60MWe FEED complete. 240MWe FEED in progress.
Excelsior Mesaba IGCC Project (CCPI 2)	$2,155,680,783	1.7%	$22,245,505 (Non-ARRA)		This project scheduled to end August 2012.
Air Products Steam Methane Reformer CCS Project (ICCS)	$430,648,802	66%	$721,499 (ARRA)	$283,290,997 (ARRA)	Project is under construction.
Archer Daniels Midland Biofuel CCS Project (ICCS)	$207,942,199	68%	$1,520,656 (ARRA)	$139,885,289 (ARRA)	Project is under construction.
Leucadia Petcoke to Methanol CCS Project (ICCS)	$435,587,194	60%	$390,103 (ARRA)	$260,992,207 (ARRA)	FEED completed. Off-take agreements being negotiated
FutureGen 2.0	$1,289,715,075	81.3%	ARRA - $994,729,000 Non-ARRA - $53,619,112		Phase 1 (Pre-FEED/Project Definition) extended through 12/31/2011

QUESTION FROM REPRESENTATIVE HARRIS

Q3b. Please provide an update on each remaining clean coal demonstration project (including those funded through the Clean Coal Power Initiative as well as others) and DOE's outlook for the success of those projects. What are the key factors and decision points that will determine the success or failure of the remaining projects? Additionally, for each project please provide:

The amounts obligated and spent on each project to date, distinguishing as appropriate Stimulus vs. base-year funding.

A3b. The table below summarizes for each demonstration project the amount of funding obligated to each budget period and the amount spent to date. American Recovery and Reinvestment Act (ARRA) funding is specifically identified in the table below otherwise funds are base.

Project Name	Budget Pd. 1 Obligated	Budget Pd. 1 Spent	Budget Pd. 2 Obligated	Budget Pd. 2 Spent
Southern Co. Kemper IGCC Project (CCPI 2)	$23,518,640 (Non-ARRA)	$23,518,640 (Non-ARRA)	$270,231,360 (Non-ARRA)	$0
Summit Texas Clean Energy Project (CCPI 3)	$211,097,445 (ARRA)	$42,305,158 (ARRA)	$238,902,555 (Non-ARRA)	$0
Hydrogen Energy California (HECA) Project (CCPI 3)	$275,000,000 (ARRA)	$54,941,848 (ARRA)	$133,000,000 (Non-ARRA)	$0
NRG W.A. Parish Post-combustion Capture Project (CCPI 3)	$163,007,179 (ARRA)	$3,492,481 (ARRA)	$3,797,246 (Non-ARRA)	$0
Excelsior Mesaba IGCC Project (CCPI 2)	$22,245,505 (Non-ARRA)	$21,915,505 (Non-ARRA)	$0	$0
Air Products Steam Methane Reformer CCS Project (ICCS)	$721,499 (ARRA)	$721,499 (ARRA)	$283,290,997 (ARRA)	$ (ARRA)
Archer Daniels Midland Biofuel CCS Project (ICCS)	$1,520,656 (ARRA)	$1,520,656 (ARRA)	$139,885,289 (ARRA)	$20,170,77 (ARRA)
Leucadia Petcoke to Methanol CCS Project (ICCS)	$390,103 (ARRA)	$390,103 (ARRA)	$260,992,207 (ARRA)	$7,781,393 (ARRA)
FutureGen 2.0	ARRA - $994,729,000 Non-ARRA - $53,619,112	ARRA - $21,435,549 Non-ARRA - $0	$0	$0

QUESTION FROM REPRESENTATIVE HARRIS

Q3c. Please provide an update on each remaining clean coal demonstration project (including those funded through the Clean Coal Power Initiative as well as others) and DOE's outlook for the success of those projects. What are the key factors and decision points that will determine the success or failure of the remaining projects? Additionally, for each project please provide:

A description of the method in which DOE tracks each project's funding commitments and reserves.

A3c. DOE maintains records of all obligations of federal funds against cooperative agreements utilizing enterprise systems such as STARS and STRIPES. DOE is prohibited from maintaining any funds set aside as "reserve" or "contingency" within the cooperative agreements, and performs rigorous analyses of budget plans submitted by recipients to ensure that work scope exists for every dollar associated with an award. DOE monitors each recipient's progress against its Funding Plan.

QUESTION FROM REPRESENTATIVE HARRIS

Q4. If any additional projects fail, what will happen to the previously obligated funding? Does DOE have the authority to spend such funding (ARRA or non-ARRA) on other projects, and if so, does it intend to use such authority?

A4. Demonstration funding that was appropriated by Congress for major Carbon Capture, Utilization and Storage (CCUS) demonstration projects in the Office of Fossil Energy (FE) is currently being used in the development of those projects consistent with the cooperative agreement signed with each project. Some of these projects are being developed with a combination of annual appropriations and stimulus dollars given to FE as part of the 2009 American Recovery and Reinvestment Act (ARRA). If a project should withdraw or be terminated, the remaining funds on the cooperative agreement would be de-obligated. Any portion of those de-obligated funds that are part of ARRA would be returned to the Treasury in accordance with the law. Any remaining de-obligated funds that were previously appropriated for CCUS demonstration projects from non-ARRA funding will be coded as a prior year de-obligation (PYD) and entered into the PYD account at DOE-FE. DOE may request that OMB authorize a re-apportionment of the base program (non-ARRA) CCPI funds. If OMB approves a re-apportionment, DOE may re-obligate the funds to another award that has the same general purpose for which the funds were originally appropriated.

QUESTION FROM REPRESENTATIVE HARRIS

Q5. What is the status and outlook for the $334 million in DOE funding provided to the now-terminated AEP project? Has the remainder of this funding been returned to the Treasury? If so, when, and how much? If not, why not? Please provide any DOE guidance documents discussing the Department's authorities associated with handling obligated but unspent funds (both ARRA and non-ARRA). According to the DOE Fossil Energy website, "Existing CO2 capture technologies are not cost-effective when considered in the context of large power plants. Economic studies indicate that carbon capture will add over 30 percent to the cost of electricity for new integrated gasification combined cycle (IGCC) units and over 80 percent to the cost of electricity if retrofitted to existing pulverized coal (PC) units. In addition, the net electricity produced from existing plants would be significantly reduced – often referred to as parasitic loss – since 20 to 30 percent of the power generated by the plant would have to be used to capture and compress the CO2." Additionally, the DOE CCS Roadmap states that the program goal is to eventually "reduce these costs to a less than 30 percent increase in the cost of electricity for PC power plants and a less than 10 percent increase in the cost of electricity for new gasification-based power plants."

In light of this economic reality, please explain why DOE continues to focus almost exclusively on a technology that it acknowledges will remain significantly more expensive and less efficient even if program goals are achieved?

A5. The AEP project officially ended on September 30, 2011. However, DOE has not yet been invoiced for all expenses incurred on the project. It is expected that the final invoice for the project will be received early next year. At that time, the Department will de-obligate the remaining funds. Deobligation of the ARRA and non-ARRA funds are handled in different ways. Of the deobligated funds, those that are ARRA funds will be returned to the Treasury, since they expired for obligation at the end of FY2010. As outlined in the response to Question 4 above, reapportionment of the remainder can then be considered, unless Congress directs us differently.

The Department is trying to develop a carbon emissions control technology portfolio that will ultimately serve to lessen compliance costs felt by consumers if carbon legislation is enacted. This is similar to DOE's support of acid rain precursor (SO_2 & NO_x) emission

control technologies in anticipation of the Clean Air Act Amendments of 1990 and subsequent EPA and state-level regulations promulgated in accordance with those amendments. There is no denying that emission control technologies, whether for SO_2, NO_x, or CO_2, carry capital and operating & maintenance (O&M) costs, as well as parasitic power requirements. DOE cannot accurately predict the timing or exact form of carbon regulations, however, given the magnitude, scope and importance of potential CO_2 regulations for both new and existing fossil fuel power plants, DOE recognizes the need to develop, test, and learn from a suitable portfolio of carbon control technologies while carbon control market signals are all but absent. The Department is pursuing advanced technologies and new approaches within its major demonstration projects that have the potential to significantly reduce carbon constrained compliance costs felt by the consumer. Approximately 50% of our nation's electricity is generated from coal-fired power plants, and this is among the lowest cost supplies of electricity on our nation's grid. Industry has reported the need to operate many of these plants in the future, and the Energy Information Administration (EIA) includes these projections in its forecasts. The post-combustion approach, which is being funded in part by DOE and private industry (e.g., NRG) uses an advanced amine capture technology coupled with a gas turbine, and offers a novel approach for CO_2 capture from the existing fleet of coal-fired power plants, will not cause a derate to the plant that the owners have spent years to optimize. Another advanced approach being supported in part by DOE involves an air-blown transport gasifier and other technologies that were developed jointly with Southern Company; these will be demonstrated at the Kemper IGCC project. IGCC polygeneration projects being funded in part by DOE and private industry (e.g., HECA and Summit) offer novel approaches that produce high value

co-products that can significantly reduce the cost of electricity compared with a conventional IGCC plant. In addition, these large scale demonstration projects provide valuable data on a potential CO_2 storage site that will be needed whenever industry is required to reduce CO_2 emissions. DOE believes that leading-edge technology advancement can significantly reduce compliance costs and power losses, and help to ensure continued competitiveness in sales and exports of energy and environmental control equipment.

QUESTION FROM REPRESENTATIVE HARRIS

Q6. During the hearing, you identified water management as the "number two priority with regards to government-funded coal research." Please describe current research needs in this area, and explain why the President's budget proposes to eliminate funding for such a high priority. Please provide a detailed description, including funding levels by fiscal year, of DOE's coal-related water management R&D activities over the last 10-15 years. What water management research issues remain unaddressed?

A6. Research on water management for the Office of Fossil Energy R&D included the following principal focus areas:

Non-traditional sources of cooling water which typically include waters that have previously been considered unsuitable for cooling water purposes due to some form of organic or inorganic contamination, such as the presence of high dissolved solids concentrations.

Innovative water reuse and recovery which involves capturing water that historically has been discharged in either aqueous or vapor form and reusing the water in the power plant.

Advanced cooling technology which involves innovative ways to cool power plant waters while minimizing water consumption.

The Department of Energy/Office of Fossil Energy (DOE/FE) pursued an integrated research and development (R&D) effort directed at technologies and concepts to reduce the amount of freshwater used by power plants and to minimize any potential impacts of plant operations on

water quality. The program sponsored research encompassing laboratory and bench-scale activities through pilot-scale projects.

In FY 2007 fiscal constraints required a reprioritization of program initiatives. It was deemed at that time Industry could and should engage in a more active R&D role in water management. DOE/FE funded through regular appropriation water management R&D through a stand-alone budget line from FY 2002 – 2006. The fiscal budgets for the program are presented in the table below.

	DOE $ (M)
FY 2002	$1.4
FY 2003	$1.9
FY 2004	$2.4
FY 2005	$2.4
FY 2006	$2.4
FY 2007	$0
FY 2008	$0
FY 2009	$12.0*
FY 2010	$3.9*
FY 2011	$0

FY2009 and 2010 in response to Congressional Appropriation language.

QUESTION FROM REPRESENTATIVE HARRIS

Q7. Please provide a summary of non-CCS coal R&D supported by DOE over the last 10-15 years. Include a detailed description of research areas, type and character of R&D supported, and funding levels by fiscal year.

A7. Over the last 10 years, the Department of Energy has funded non-CCS coal research and development (R&D) in the areas of innovations for existing plants which focused on emission control technologies, integrated gasification combined cycle, turbines, fuel cells, combustion systems (such as pressurized fluidized bed), fuels technologies, and advanced crosscutting R&D such as advanced simulation, plant optimization, and water management. However, these efforts are inherently part of making CCS affordable and reliable. While the primary role of these technologies may be considered "non-CCS", they play an important role in reducing carbon dioxide (CO_2) emissions, decreasing the cost associated with CCS, improving the reliability of CCS technologies, and in some cases producing a pure stream of CO_2 as is the case with fuel cells, oxy-combustion and chemical looping. Advancements in these power plant technologies will improve the efficiency of plant operations, reduce CO_2 emissions from the power plant, lessen the energy penalty associated with CCS, and make power plants more amenable to advanced CCS technologies. This research has been conducted at laboratory- through pilot-scale, with collaboration from industry partners, universities, national laboratories, independent research organizations, and non-governmental organizations.

Coal R&D Funding Levels for non-CCS and Dual (CCS and non-CCS as noted) Technology Application (2002-2011)

Fiscal Year ($ millions)	Dual Use?	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Innovations for Existing Plants* (Fine particulate control/air toxics, by-products and water management)	No	23.0	21.6	21.2	18.6	24.5	15.6	0.0	16.2	5.7	0.0
Integrated Gasification Combined Cycle (oxygen separation/production, gasifier, synthesis gas clean-up)	Yes	42.0	43.3	49.1	44.6	54.4	55.5	52.0	63.4	61.3	51.5
Pressurized Fluidized Bed/Combustion Systems	No	10.7	10.1	4.8	5.1	0.0	0.0	0.0	0.0	0.0	0.0
Turbines (Hydrogen turbines)	Yes	18.1	16.5	12.6	15.0	17.4	19.5	23.1	27.2	31.2	30.1
Fuels (hydrogen separation from synthesis gas)	Yes	33.8	30.4	30.4	31.3	27.9	21.5	24.1	24.3	24.3	11.7
Advanced Research (computational science, materials, analysis)	Yes	27.8	32.4	37.5	41.9	51.5	32.2	36.3	27.4	27.4	46.4
Fuel Cells (solid oxide fuel cells – also enables carbon capture)	Yes	56.7	62.0	69.2	75.4	59.8	61.7	54.0	56.4	48.7	48.5
Total		**212.1**	**216.3**	**224.8**	**231.9**	**235.5**	**206.0**	**189.5**	**214.9**	**198.6**	**188.2**

* In FY2008, Innovations for Existing Plants (IEP) Program shifted its focus to post-combustion and oxy-combustion carbon capture. However, in FY2009, the IEP Program funded Fine Particulate Control/Air Toxics ($4.9 million) and By-products and Water Management ($11.7 million) in response to Congressional Appropriations language. In FY2010, the IEP Program funded Fine Particulate Control/Air Toxics R&D ($1.9 million) and By-products and Water Management ($3.8 million) in response to Congressional Appropriation language.

QUESTION FROM REPRESENTATIVE HARRIS

Q8. The most consistent limitation articulated hindering the ability to move beyond current efficiency limits is materials. Why is this so important, and what is the appropriate role for DOE in this area? What is DOE specifically doing to advance basic materials research? Please provide a detailed description, including funding levels by fiscal year, of DOE's coal-related efficiency and materials R&D over the last 10-15 years. What materials-related research issues remain unaddressed?

A8. Over the years many significant increases in efficiency have come about because of a new material. Increased cycle efficiency is the key to the cleaner use of coal for generating electricity. As efficiency increases less coal is burned, and thus, less CO_2 is produced per megawatt of electricity. Improving efficiency requires increasing the maximum steam temperature and thus requires improved materials and components. Novel materials that can withstand high temperatures and extreme environments are dominant themes in materials development for efficient energy systems. These materials will enable increases in plant efficiency resulting in reduced CO_2 emissions, fuel consumption, and all other fuel-related emissions.

The current DOE R&D effort has already identified suitable materials, gotten the newest technology enabling material, Inconel 740, ASME Boiler Pressure Code approved and continues long-term material testing and evaluation. The next part of this effort is to do the component testing necessary to reduce the technology risk to the utility industry followed by a demonstration plant. In addition to developing technology that will make the U.S. coal power fleet more efficient and give the U.S. boiler and steam turbine manufacturers a competitive advantage, thereby creating U.S. manufacturing jobs.

The requested information on spending for Materials Research appears in following table:

Fiscal Year	Dollars ($M)
1999	$ 4.2
2000	$ 6.2
2001	$ 6.1
2002	$ 6.2
2003	$ 8.0
2004	$10.8
2005	$10.8
2006	$ 7.7
2007	$ 7.5
2008	$ 8.5
2009	$ 7.5
2010	$ 9.1
2011	$ 8.9

Future materials breakthroughs will only come through development of computer models and simulations to study the structure, properties, and processing of materials on the atomic scale. Thus, enabling the advancement of innovative strategies that would replace traditional, trial-and-error experimental methods, which are costly and time-consuming.

QUESTION FROM REPRESENTATIVE HARRIS

Q9. A number of CCS projects currently funded by DOE have the potential to generate alternative revenue streams, such as oil production or industrial use. How much are such revenues expected to offset the higher cost of CCS operations? Even with those additional revenues, will the CCS demonstration projects be economically viable absent continued government support in the form of subsidies or mandates?

A9. Several projects in the Office of Fossil Energy's Carbon Capture, Utilization, and Storage (CCUS) program have the potential to generate revenue streams through Enhanced Oil Recovery (EOR). In addition, some projects might also co-produce high value chemical products (Urea, Urea Ammonium Nitrate, Methanol, Ammonia, etc.) where markets exist that might generate much higher revenues than electricity, thus reducing the cost of electricity required to achieve a given return. The amount of benefit to each project varies based on several variables, including project size, technology type, capture rate, etc. Given that economic viability is also the product of many drivers and market factors that are difficult to predict, it is difficult to make a definitive projection of future viability. Fossil Energy receives frequent input from industrial partners stating that government support in the form of demonstration funding, loan guarantees, tax incentives, etc., is necessary for successful deployment of advanced CCUS technologies.

QUESTION FROM REPRESENTATIVE HARRIS

Q10. Please describe some of the environmental, economic, and operational benefits associated with increasing coal-fired power plant efficiency. What is the potential for greater increases in new plants, and what R&D work needs to be done to accelerate this effort?

A10. Increasing the efficiency of a coal-fired power plant reduces the fuel required to produce the same amount of electric power. The result is lower emissions per megawatt of power generated, reduced cost associated with plant emissions controls, lower fuel cost, as well as reduced costs associated with ash management and maintenance. The research and development work done by the Office of Fossil Energy is focused on reducing the cost of carbon capture and the viability of CO_2 utilization and storage. However, many of these activities also result in efficiency improvements, e.g., development of advanced materials for ultra-supercritical power plants, development of new and efficient gas turbines, gasification technologies with improved performance, and more efficient and lower cost gas separation and cleaning technologies to name a few.

Technologies for new power plants being developed under the Office of Fossil Energy program will allow new Integrated Gasification Combined Cycle (IGCC) power plants with carbon capture and storage (CCS) to be more than 5% more efficient than IGCC plants currently in operation that do not have CCS. Thus, the fuel costs, ash management and maintenance costs will be reduced by similar proportion. Similarly, new combustion technologies, such as systems that burn fuel in pure oxygen, will be as efficient with CCS as current supercritical pulverized coal plants that do not capture the carbon dioxide.

Responses by Ms. Janet Gellici, CAE,
Chief Executive Officer, American Coal Council

Question Submitted by Chairman Andy Harris

Q1. As we examine the future of coal in America, it is important to consider what the President said in November 2008 about the outlook for coal under his Administration. He said that "if somebody wants to build a coal-powered plant, they can. It's just that it will bankrupt them." The American Coal Council's member companies are in the business of building and operating coal plants. What is the status of and outlook for building new plants? And if new power plants do not move forward, what does that mean for electricity supply and reliability?

A1. In response, I would reference a recent Burns & McDonnell which evaluated the existing coal fleet in compliance with various EPA regulations, including a) the proposed Clean Air Transport Rule (CATR)—now known as the Cross State Air Pollution Rule (CSAPR), b) National Emission Standards for Hazardous Air Pollution (NESHAP)—utilizing the proposed Industrial Boiler MACT rule as a proxy since the proposed Utility MACT had not been introduced yet at the time, c) Coal Combustion Residue Regulations and d) Clean Water Act Cooling Water Requirements under sections 316(a) and 316 (b).

B&Ms analysis indicated that these regulations would require approximately $135 billion in retrofit capital costs and $8 billion/year in additional O&M expenses. The additional costs associated with retrofit equipment are expected to increase the U.S. average electricity price by approximately 8%. These costs would force high-cost, smaller units to retire and would force some mid-cost, mid-sized units to retire with most to be retrofitted with compliance pollution control equipment. Most low-cost, large units would be retrofitted.

Announced coal-fired plant retirements as of the summer 2011, total 161 units = 26.5 GW; this represents 7% of the fleet on a capacity basis and 14% of the fleet on a unit basis. B&M believes that 40–50 GW of coal generation will be retired due to low utilization, current coal and gas costs, and upgrade investments. Other industry analysts have projected retirements on the order of 60-80 GW this decade.

Another study prepared by NERA Economic Consulting examined the same EPA regulations and concluded that these policies would lead to 39 GW of prematurely retired capacity by 2015, about 12% of 2010 U.S. coal-fired electricity generating capacity. Compliance costs were projected to be approximately $21 billion (in 2010$) per year over the period from 2012 to 2020. Capital costs for environmental controls and replacement capacity are about $104 billion.

According the NERA study, "Coal-fired generation is projected to decrease by an average of 11.1 percent over the period from 2012 to 2020. The reduction in coal demand is projected to decrease coal prices by 5.7 percent on average. In contrast, the regulations are predicted to increase natural gas-fired generation by 19.7 percent on average over the period and increase Henry Hub natural gas prices by 10.7 percent on average. The increase in natural gas prices would lead to an estimated average increase in costs of about $8 billion per year for residential, commercial and industrial natural gas consumers, which translates into an increase of $52 billion over the 2012–2020 period (present value in 2010 as of 2011 discounted at 7 percent). Average U.S. retail electricity prices are projected to increase by an average of 6.5 percent over the period."

The study further notes that "Over the period from 2012 to 2020, about 183,000 jobs per year are predicted to be lost on net due to the effects of the four regulations. The cumulative effects mean that over the period from 2012 to 202, about 1.65 million job-years of employment would be lost."

With regard to potential job losses, another report released in September 2011 indicates that efforts to curtail development of new coal plants are contributing to potential job losses of 1.24 million jobs in 36 states.

The intent of the Clean Air Act was to ensure that new units met technology limits (New Source Performance Standards – NSPS), while existing units were regulated by air quality standards. Overtime, the fleet would get cleaner. EPA has changed the rules by forcing existing units to meet limits on a schedule which cannot be met without closing those units. Previous CAA programs made it possible to invest in emission controls at the economic units to obtain the greatest reductions. The newest, large units got NSPS technology while allowing the older units to continue to run, enhancing reliability of the electric supply grid. EPA used trading to allow for the most efficient investments to reduce emissions. New EPA programs require technology at all plants with limited trading.

Previous EPA programs provided a 5–10 year compliance schedule, e.g., acid rain regulations were passed in 1990 and required compliance at points in 1995 and 2000; CAIR was promulgated in December 2003, requiring compliance at points in 2010 and 2015. New EPA programs allow less than three years to comply, e.g., HAPS final rule is expected in December 2011 with compliance required by 2014; CSAPR final rule anticipated in August 2011 requires compliance in 2012 and 2014. It is reasonable, therefore, to assume that EPA is interested in closure of coal units, not control of coal-fired emissions.

A combined reduction in coal-fired electricity and a greater reliance on natural gas is likely to result in an increase in the cost of electricity and a loss of jobs. Additionally, prospective coal power plant closures may result in significant challenges for the transmission and power system reliability. As noted by ICF International Inc. "Because system reliability must be ensured during these retirements, many plants slated for closure likely will be put into reliability must run (RMR) status, delaying their decommissioning timelines. Furthermore, significant challenges loom for plants in RMR status. RMR rules are not designed to support multi-year, high-capital retrofit investments but rather temporary status quo operations to address reliability concerns. Plants that fail to retrofit or retire by the deadlines specified in the EPA rules could incur heavy civil and criminal penalties. They could also affect market prices as uneconomic supply is kept on line."

ICF's analysis indicated that the location of the prospective power plant retirements could significantly impact system reliability, not just from a resource adequacy perspective, but with transmission security in mind as well. Among the key study results:

1. Event retiring moderate amounts of capacity can incur the risk of transmission security problems.
2. Demand-side management can help mitigate a low-voltage situation, but cannot solve the problem when load reduction requirements are up to the 30 percent level.
3. Sufficient replacement capacity is only part of the solution. The location of this capacity is also important."

"Removing up to nearly one-sixth of the nation's coal-fueled generation in a geographically concentrated manner, i.e., concentrated in MISO, PJM, and SERC from the power system has billion-dollar implications, and decisions are very difficult to reverse once the train has left the station."

Q2. In the current budget environment, it is imperative that DOE improves prioritization and pursue only the most important and impactful R&D. With that in mind, what would you change about the current DOE R&D portfolio? Specifically, what at the 1–2 areas that you believe deserve highest priority within DOE coal R&D? What are the 1–2 areas or activities currently supported that may warrant cuts in order to pay for the highest priority?

A2. I will stand by my testimony in addressing this question. We need to focus our coal R&D efforts going forward in four areas:

- Advanced Energy Systems
- Carbon Capture and Storage
- Water Use Technologies and
- Demonstration Projects

Given the current uncertainty that Congress will pass climate legislation in the near term, it might be tempting to curtail funding for Carbon Capture and Storage RD&D. The reality is that while GHG legislation may not be imminent, GHG regulation is proceeding and we need technologies to meet our long-term CO2 reduction goals. To be successful, RD&D funding needs to be stable and consistent. Curtailing the CCS technology program today could potentially negate gains we've made to date and impair our ability to meet future requirements.

Q3. The National Coal Council is a Federal Advisory Committee tasked with advising the Secretary of Energy—at his request—on general policy matters relating to coal. The last three NCC reports focused exclusively on CCS and the Committee has not weighed in on non-CCS coal issues in over five years. As a member of the NCC, and in light of the increasing need to prioritize R&D efforts, do you believe there would be value in an NCC report detailing a long-term roadmap to advance entire system-wide advancements of a coal-fired unit to put DOE on a path towards facilitating a new fleet of coal plants? Would it be similarly beneficial if the NCC reviewed how best to meet stringent air toxics rules or handle toxic waste byproducts?

A3. I believe an NCC report detailing a long-term roadmap to advance clean coal technology developments would be duplicative of the efforts historically and presently being advanced by the Coal Utilization Research Council (CURC www.coal.org), in cooperation with EPRI and other industry associates.

Does "toxic waste byproducts" refer to coal ash? Perhaps not since coal ash is not "toxic." If the question does relate to coal ash, I feel again that others, such as the American Coal Ash Association (www.acaa-usa.org) and the Utility Solid Waste Group (www.uswag.org) are already presently addressing these issues and that effort in this area by NCC would be duplicative.

In keeping with its charter, I believe there may be a role for the National Coal Council to advise the Secretary on plans, priorities and strategies to more effectively address technological, regulatory and social impacts of current issues relating to coal production and use. This would include addressing how to facilitate advancement of tomorrow's clean coal fleet.

Responses by Mr. Nick Akins, President and Chief Executive Officer of American Electric Power

Questions Submitted by Chairman Andy Harris

Q1. As we examine the future of coal in America, it is important to consider what the President said in November 2008 about the outlook for coal under his administration. He said that "if somebody wants to build a coal-powered plant, they can. It's just that it will bankrupt them."

American Electric Power is in the business of building and operating coal plants. What is the status of and outlook for building new plants? And if new power plants do not move forward, what does the mean for electricity supply and reliability?

A1. AEP has a long history in building and operating coal plants and is completing our Turk plant, a brand new ultra-supercritical coal plant in Arkansas, which will be among the most efficient and cleanest coal plants in the U.S.

In the near term, there are many uncertainties associated with building new coal fired power plants, including stagnant growth prospects in an already depressed economy, the currently low natural gas prices, and future environmental regulations to name just a few. As a result, AEP will mostly be building new natural gas plants over the next few years to replace retiring existing coal fired units as well as to meet additional demands for power. Furthermore, the addition of new gas-fired capacity will provide for a more diverse portfolio in the AEP generating fleet, which historically has been powered predominantly by coal.

However, over the longer term, we believe that a portfolio of different generating options will be essential in meeting future demands for electricity. This includes coal, natural gas, nuclear and renewable energy. To ensure affordable and reliable electricity, we cannot entrust our future electricity supply to only one fuel or source of power. While generating plants fueled by natural gas look particularly attractive today due to the currently low natural gas prices and the apparent plentiful supply of shale gas in the U.S. due to the advent of natural gas fracking, in the long run, being overly reliant on natural gas for electric power is not a wise strategy. Such a dependence on natural gas has many inherent risks due to real possibility of supply problems, price volatility, and higher prices—all of which have occurred in the recent past. America's coal resources remain plentiful and low cost and need to play an important role in U.S. electricity supply in the future.

Regarding reliability, our greatest concern in the near term is that the new EPA regulations that I discussed in my testimony will force a significant number of coal fired plants to retire prematurely in just the next 2–3 years. This could pose significant local and regional reliability problems because new replacement capacity, transmissions improvements and other measures to address reliability problems cannot be completed in that short a period of time. As I have noted, these reliability problems (along with adverse impacts on jobs and the economy) can be largely resolved simply by extending the compliance time frames through federal legislation.

Q2. In the current budget environment, it is imperative that DOE improves prioritization and pursue only the most important and impactful R&D. With that in mind, what would you change about the current DOE R&D portfolio? Specifically, what are the 1–2 areas that you believe deserve highest priority with DOE coal R&D? What are the 1–2 areas or activities currently supported that may warrant cuts in order to pay for the highest priority?

A2. AEP believes that the Department of Energy (DOE) should focus its coal R&D efforts on developing advances in "next generation" technologies to address the high cost and energy penalty concerns associated with the reduction of CO2 emissions from coal fueled power plants. Such technologies could include the following:

- Advanced oxygen production systems;
- oxy-combustion systems;
- coal gasification systems with CO2 capture and sequestration, including polygen systems that produce high value products in addition to electricity; and
- post-combustion CO2 capture systems that employ catalysts, advanced enzymes or emerging membrane separation technologies as a means to reduce dramatically energy penalties associated with the operation of CO2 capture technology.

These next generation technologies hold out the promise of generating electricity with very low emissions of both CO2 and other conventional air pollutants at much lower energy consumption and operating costs than currently available technologies. AEP believes that the development and deployment of these technologies is critical

to ensure that coal, with its relatively low cost and abundant domestic supply, remains a viable and important component of a portfolio of domestic generation sources.

AEP generally does not favor in the near term federal expenditures for additional large scale demonstration projects beyond those that are already underway for deploying existing CO2 capture technologies. However, federal investments that encourage early commercial deployment of these CO2 capture technologies could be warranted for those projects that use the captured CO2 for enhanced oil recovery (EOR) due to their very large economic, energy independence, and energy security benefits. DOE studies have identified 45–67 billion barrels of domestic oil resources, most of which can only be produced if additional volumes of CO2 from fossil fueled power plants and industrial sources become available. At current prices for oil, these resources have an estimated direct economic value of $5–7 trillion, and would provide important energy independence, energy security, and employment benefits to the nation. In the near-term, development of this domestic energy resource may best be fostered by favorable federal policies to encourage the deployment of these CO2 capture technologies for EOR purposes. In the longer term, the federal coal R&D efforts recommended above for developing next generation technologies would support development of this domestic energy resource by lowering energy consumption and overall operating costs of generating electricity while capturing CO2.

Questions Submitted by Ranking Member Brad Miller

Q1. Please provide your name and employing organization(s).

A1. Nick Akins, President and Chief Executive Officer of American Electric Power.

Q2(a). Are you an officer or employee of, or otherwise compensated by, any other organization(s) that may have an interest in the topic of this hearing?

A2(a). No

Q2(b). If the answer to question 2a is "yes," please specify the organization(s) and the nature of your relationship with the organization(s).

Q3(a). In the last three calendar years, including this one, have you been a registered lobbyist?

A3. No

Q3(b). If the answer to question 3a is "yes," please list all of your client(s) that may have an interest in the subject matter of this hearing, and the dates between which you represented that client or those clients.

Q4. If you have worked as an attorney, contractor, consultant, paid analyst, or in any other professional services capacity, please provide a list of all of your firm's clients who you know to have an interest in the subject matter of this hearing. These should be clients that you have personally worked with in the last three calendar years (including the present year). Provide the name of the client, the matter on which you worked and the date range of that work. If there was a deliverable, please describe that product.

A4. I have only been an employee of American Electric Power during the specified 3-year period. I have not worked as an attorney, contractor, consultant, paid analyst, or in any other professional services capacity for any other company or firm during the last 3 years.

Q5. Please provide a list of all publications on which you have received an author or coauthor credit relevant to the subject of this hearing. If the list is extensive, the 10 most recent publications would be sufficient.

A5. Not applicable. I am not an author of publications relevant to the subject of the hearing. This does not include any other publications of American Electric Power related to our business, such as annual reports, etc. Those are publications of the corporation, and not written by me personally.

After several attempts by the Committee staff to obtain responses to post-hearing questions, Mr. Foerter refused to furnish answers for the record.

Questions submitted to Mr. David Foerter,
Executive Director,
Institute of Clean Air Companies

RALPH M. HALL, TEXAS
CHAIRMAN

EDDIE BERNICE JOHNSON, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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November 1, 2011

Mr. David Foerter
Executive Director
Institute of Clean Air Companies
1220 N. Fillmore St., Suite 410
Arlington, VA 22201

Dear Mr. Foerter:

On behalf of the Committee on Science, Space, and Technology, I want to express my appreciation for your participation in the October 13, 2011 hearing entitled *Advancing Coal Research and Development for a Secure Energy Future.* I have attached a verbatim transcript of the hearing for your review. The Committee's rule pertaining to the printing of transcripts is as follows:

> *The transcripts of those hearings conducted by the Committee and Subcommittees shall be published as a substantially verbatim account of remarks actually made during the proceedings, subject only to technical, grammatical, and typographical corrections authorized by the person making the remarks involved.*

Transcript edits, if any, should be submitted **no later than November 15, 2011.** If no edits are received by this date, I will presume that you have no suggested edits to the transcript.

I am also enclosing questions submitted for the record by Members of the Committee. These are questions that the Members were unable to pursue during the time allotted at the hearing, but felt were important to address as part of the official record. **All of the enclosed questions must be responded to no later than November 15, 2011.**

All transcript edits and responses should be submitted to me and directed to the attention of Taylor Jordan at Taylor.Jordan@mail.house.gov. If you have any further questions or concerns, please contact Mr. Jordan at (202) 225-5967.

Thank you again for your testimony.

Sincerely,

Andy Harris M.D.
Chairman
Subcommittee on Energy & Environment

cc: Rep. Brad Miller
Ranking Member
Subcommittee on Energy & Environment

Enclosures: Transcript and Member Questions

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy & Environment

Hearing Questions for the Record
The Honorable Andy Harris

Advancing Coal Research and Development for a Secure Energy Future
Thursday, October 13, 2011

Questions for Mr. Foerter

1. Are there any coal-fired units in EPA's Information Collection Request (ICR) database that can meet all three standards in the proposed utility MACT?

2. Your testimony mentions the availability of dry sorbent injection as a technology option for pollutant control. As you know, EPA's proposed utility rule relies heavily on this technological fix. Which coal-fired units in the United States utilize dry sorbent injection to capture more than 90 percent of acid gases?

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy & Environment

Hearing Questions for the Record
The Honorable Brad Miller

Advancing Coal Research and Development for a Secure Energy Future
Thursday, October 13, 2011

1. The utility industry's estimates for the cost of complying with EPA regulations are often based on assumptions that the most expensive pollution control equipment and the most time-consuming retrofits will be required, thus providing policy makers with a worst case cost scenario. Yet, others say that there are a number of technology options that might be much less costly and faster to implement. If so, these technologies might even allow some older plants to stay online a while longer.

   a. Can you characterize some of the options power companies might have, and what the biggest factors are in how these companies choose to proceed with either upgrading or shuttering facilities?

   b. How do cost estimates tend to change as stakeholders learn more about their technological, regulatory and financial options?

   c. Please comment on the technological and commercial readiness of these options. To what extent does the pollution control equipment industry require more government-funded research and development to bring these technologies to a point where industry can deploy them to meet current and upcoming EPA regulations?

2. Please provide your name and employing organization(s).

3. a. Are you an officer or employee of, or otherwise compensated by, any other organization (s) that may have an interest in the topic of this hearing?

( ) Yes
( ) No

b. If the answer to question 2a is "yes," please specify the organization(s) and the nature of your relationship with the organization(s).

4. a. In the last three calendar years, including this one, have you been a registered lobbyist?

( ) Yes
( ) No

b. If the answer to question 3a is "yes," please list all of your client(s) that may have an interest in the subject matter of this hearing, and the dates between which you represented that client or those clients.

5. If you have worked as an attorney, contractor, consultant, paid analyst, or in any other professional services capacity, please provide a list of all of your firm's clients who you know to have an interest in the subject matter of this hearing. These should be clients that you have personally worked with in the last three calendar years (including the present year). Provide the name of the client, the matter on which you worked and the date range of that work. If there was a deliverable, please describe that product.

6. Please provide a list of all publications on which you have received an author or coauthor credit relevant to the subject of this hearing. If the list is extensive, the 10 most recent publications would be sufficient.

Responses by Mr. Stu Dalton,
Senior Government Representative-Generation,
Electric Power Research Institute

Questions Submitted by Chairman Andy Harris

1. *Please provide a summary of the ongoing roadmapping process between the Electric Power Research Institute and the Coal Utilization Research Council. Provide any additional documents that may inform the Committee's effort to improve identification and prioritization of coal R&D needs.*

The Coal Utilizations Research Council (CURC) states on their website the following:

> "The Coal Utilization Research Council supports the use of coal in the United States and worldwide and advocates the formation of credible and effective partnerships between industry and government to pursue the development of technologies that will enable coal to be used economically, efficiently and in an environmentally compatible manner.
>
> The CURC has developed, in coordination with the Electric Power Research Institute (EPRI), an agreed upon statement (or "Roadmap") that specifically addresses the importance of the economic, efficient and environmentally-friendly use of coal. Underscoring the importance of coal as a vital component of the energy mix for the U.S. and the world, the roadmap identifies the research, development and demonstration (RD&D) objectives necessary for coal to maintain its place in the nation's energy mix."

For the past decade CURC and EPRI have periodically prepared and updated a roadmap for coal utilization, issuing versions of this in 2003, 2006, and 2008 and undertaken again this year (with the next update expected early in 2012). The process this year has been moved forward by dozens of organizations involved in a variety of areas including: coal production, academic organizations, equipment suppliers of coal-based and pollution control equipment, service suppliers supporting the industry, as well as firms using coal for power generation and other purposes and EPRI. Volunteers work unpaid by CURC or EPRI to provide advice on the research and development needs to enhance the utilization of coal, identify gaps where these needs are unmet, develop timing and cost of the research to fill those gaps and discuss priority for the R&D which fills the needs. CURC has developed an interim report to help inform the Subcommittee on Energy and the Environment's discussions and this is available on CURC's website www.coal.org under the CURC-EPRI link http://www.coal.org/roadmap which leads to the Interim Report with the url http://www.coal.org/userfiles/file/Interim%20Roadmap%20Summary%20Posted%2011-14-11.pdf

2. *In the current budget environment, it is imperative that DOE improves prioritization and pursue only the most important and impactful R&D. With that in mind, what would you change about the current DOE R&D portfolio? Specifically, what are the 1-2 areas that you believe deserve highest priority within DOE coal R&D? What are the 1-2 areas or activities currently supported that may warrant cuts in order to pay for the highest priority?*

The first two items listed in my written testimony of October 13, 2011 are ultra-high efficiency steam power cycles and improved water management. Specifically advanced ultrasupercritical steam cycle materials development carried to large scale demonstration and water consumption, use and discharge RD&D are discussed in the testimony. The work on materials is discussed in a later question. The work on water is needed due to dwindling or unreliable sources of water, growing population leading to growing competition for water, increasing concern over the quality of water discharged to water bodies, etc. Water use for cooling is common to almost all sources of electricity (coal, gas, biomass, nuclear, geothermal, central station solar) except photovoltaic, wind and hydro. In written testimony we stated these areas were not sufficiently covered. These are high priority and will pay off for the US and successful R&D will enhance the environmental impact and efficiency of coal use no matter what climate legislation may be enacted. As noted in prior written testimony, these need additional support.

However, we also stated as concluding remarks in the testimony that …"EPRI's analysis of options needed for the future validates DOE's high prioritization of RD&D to establish effective, economical and publicly acceptable technologies to reduce atmospheric greenhouse gas buildup. This supports DOE's work on coal-based technology including CO_2 capture at power plants, cost-effective cleanup and compression for on-site geologic injection or transportation off-site, CO_2 utilization where economical, and secures long-term storage away from the atmosphere. In particular, EPRI identifies the following current work as warranting continued RD&D to achieve the cost and efficiency improvements necessary to allow viable commercial deployment:

1. R&D, scale-up, and integrated operation of coal power systems based on gasification and oxy-combustion technologies (presently through Clean Coal Power Initiative and American Reinvestment and Recovery Act funding, loan guarantees, and other mechanisms plus base program DOE funding)
2. CO_2 capture, compression, and storage RD&D to seek breakthrough innovations for low-cost capture, lower-energy compression, and larger scale integrated projects, to understand operational flexibility, cost reduction options, and techniques to verify long-term storage
3. CO_2 utilization: because CO_2 used for enhanced oil recovery (or other means of generating revenue) will be essential to jump-starting CCS deployment, and may also help in reducing dependence on foreign oil, additional geologic characterization of areas near concentrations of power plants may be a logical follow-on under the DOE regional carbon sequestration partnerships programs"…

EPRI has not identified specific projects or areas for cuts.

3. *Coal generates approximately 40% of global electricity and developing nations continue to build coal-fired power plants at a rapid rate. Even if the United States does not construct any new coal-fired power plants, there will be an extensive worldwide market for the materials and system components for new units. Can you speak to the global market implications for fostering domestic expertise in associated coal technology systems?*

The U.S. can take the lead in showcasing application of high temperature materials developed in a DOE program over the past decade, and use of these materials in China and India can improve the efficiency of coal-based electricity generation, thereby reducing pollutant emissions locally and reducing the contributions of these large and growing sources of global CO_2 emissions. New coal generation capacity is continuing to be built internationally with a large portion of the growth in India and China. On their web site http://www.pewclimate.org/global-warming-basics/coalfacts.cfm the Pew Center states:

"To meet their rising needs, China and India are certain to burn more coal."

- It is estimated that 86 percent of incremental world coal demand between now and 2030 will come from China and India.

China's coal output increased from 1.3 billion tons in 2000 to 2.23 billion tons in 2005 making China by far the world's largest coal producer (next largest is the U.S. with 1.13 billion tons produced in 2005).

- About half of China's coal use is for electricity; and 80% of electricity generation is fueled by coal.
- China reportedly added over 90 gigawatts of new coal-fired power plant capacity in 2006 alone – the equivalent of almost 2 large coal power plants a week, and more than the entire fleet of generating plants in the United Kingdom"...

More recent International Energy Agency data http://www.iea.org/stats/coaldata.asp?COUNTRY_CODE=CN shows that 2008 coal consumption was approximately 2.9billion tons indicating the rapid rise in coal use – now triple that of the U.S.

Based on repeated visits to China, EPRI and others have observed the Chinese are building large new units, mostly with current state-of-the-art materials and most with modern pollution control facilities for SO_2 and NOx though much remains to be done. China has stated they are interested in increasing the efficiency of their new generation and reducing its CO_2 per MWh of generation. Chinese and Indian firms have already made contact with U.S. firms interested in the DOE-supported novel American-developed alloys and components fabricated from these materials. It has taken a decade for the U.S. firms to develop materials, test and verify performance and to develop the technology to fabricate, forge the metals and create the components that use the materials. It will be necessary for any firms worldwide to source the early components and highest alloy materials (e.g., in the highest temperature range materials capable of operating at

up to 760°C [1400°F]) from the U.S. and potentially license the technology later to assure the benefits from this development.

Dr. Jeff Phillips of EPRI made a presentation at the Tenth Annual Conference on Carbon Capture and Sequestration titled "*Reducing Coal Power Plant CO_2 Emissions via Higher Thermal Efficiencies: The Impact of Recent Advances in Boiler & Steam Turbine Materials*". His was the only conference presentation in a unique session which did not discuss CO_2 capture or storage per se but addressed the impact of efficiency on CO_2 avoidance. He illustrated the impact of China applying the technology for new projected capacity, namely a startling saving in CO_2 as well as reduced resource use (coal, water) and reduced emissions concluding that, if China were to use the technology on all new coal-fired power plants, avoided CO_2 would average 127 Million tons a year. It would be equivalent to 90% CO_2 capture retrofits of over 40 power plants rated at 500MW (~20,000 MW total of retrofits or new units) , or about a 5% reduction in CO_2 emissions from the US electricity generation sector. U.S. suppliers in multiple states cited in my written submission can benefit, and the U.S. can export the technology to developing countries as they continue to use coal even if it is not implemented heavily in the US in the short term due to natural gas availability. If the U.S. retains fuel diversity and renews some of the coal fleet with CCS at a later date, the capability of having demonstrated the technology will reduce the duty on the CO_2 captured and stored to meet a specific limit, will reduce the amount of coal used and byproducts produced and will make it easier to meet the DOE cost goals. It will also enhance the U.S. the capacity to produce these high-alloy tubes and components, as well as leading to cost reductions If China decides to install CCS at a later date, China will have less CO_2 to capture, transport and store.

Overall this area would be a prime example of taking prior DOE lead work in an area and prior DOE investment and fostering expertise and capabilities by U.S. suppliers in the advanced coal materials, design and construction areas.

4. *The National Coal Council is a Federal Advisory Committee tasked with advising the Secretary of Energy-at his request-on general policy matters relating to coal. The last three NCC reports focused exclusively on CCS, and the Committee has not weighed in on non-CCS coal issues in over five years.*

   As a member of the NCC, and in light of the increasing need to prioritize R&D efforts, do you believe there would be value in an NCC report detailing a long-term roadmap to advance entire system-wide advancements of a coal-fired unit to put DOE on a path towards facilitating a new fleet of coal plants? Would it be similarly beneficial if the NCC reviewed how best to meet stringent air toxics rules or handle toxic waste byproducts?

Other National Coal Council (NCC) Members and I received a copy of a new request to NCC Chairman Hopf from Secretary Chu dated October 28, 2011 which has requested that the NCC …" conduct a new study that focuses on the capture of carbon dioxide (CO_2) emissions from the combustion of fossil fuels for power generation, the production of alternative fuels and products and the production of synthetic natural gas. CO_2 use for enhanced oil production (EOR) or production of other products and storage of CO_2 should also be addressed"…

The letter further goes on to discuss the potential for the National Coal Council and National Petroleum Council to work together to discuss EOR and the potential to enhance U.S. oil production.

EPRI will of course work with NCC to respond to the Secretary's request as we have done on prior studies. EPRI has been part of many of these studies and will contribute our own planning document which shows R&D needs and which was referenced in our original testimony to the Energy and Environment Subcommittee as well as the information in EPRI's report titled "*Advanced Coal Power Systems with CO_2 Capture: EPRI's CoalFleet for Tomorrow® Vision – 2011 Update*". In that document EPRI also talked about the needs for increased generation efficiency, reduced water use and other matters not strictly related to CCS.

Separate public EPRI analyses include projections of relative wholesale generation costs for 2025 (*Program on Technology Innovation: Integrated Generation Technology Options* report #1022782 http://my.epri.com/portal/server.pt?Abstract_id=000000000001022782) This study has shown that coal can be a competitive fuel in the future absent carbon requirements and even with carbon requirements assuming successful outcome of advanced coal and carbon capture and storage R&D.

A NCC study to look at roadmaps for R&D requirements for alternate future end-points and to find paths of work that that would pay off with or without CCS may be very valuable. This could outline the R&D needs and augment the kind of planning done by EPRI for alternate future scenarios. The work on efficiency and water cited in testimony are two simple examples of areas which warrant more attention.

As was stated in my written testimony, DOE has funded a large national R&D program on advanced materials to improve coal plant efficiency using American-developed materials and American fabrication of components. Finding ways to take this high-efficiency program forward to commercial application would be a win for the USA under many future scenarios. This general area has been highlighted in past NCC reports but could be updated. One of the strongest proponents of this in public has been Professor Emeritus of MIT Dr Janos Beer, an NCC member, who has many publications citing the advantages of increasing efficiency of generation.

EPRI is independently planning and conducting work in some areas such as water use and treatment in conjunction with industry. Water has been identified by senior power industry advisors to EPRI as one of the future limiting factors in coal use and power plant siting. One need only look to the droughts in the Southeastern U.S. a few years ago or in Texas this past year to see that it is not only the arid Southwestern U.S. with water issues. Power companies have issues to deal with on both sources and discharge of water and new intake limitations and discharge regulations are proposed which require novel approaches and R&D to meet these requirements, cost-effectively and without impacting reliability.

Because of the short-term nature for industry compliance with HAPs MACT, a NCC report on HAPs may be more difficult to implement by industry. By the time a NCC report could be completed and work started, the window for new industry or DOE work to contribute to the compliance deadlines may be past. EPRI has ongoing work in this area with industry to look at novel sorbents, water and solid waste treatment and other issues raised by control technology which is potentially useful to comply with proposed HAPS MACT (*aka* MATS) and CSAPR requirements. In the past, DOE has supported industry efforts on HAPs, testing numerous plants for mercury control, and it may be possible to get short term help on this area from their

background expertise. However, a new NCC report may not be ready in time to shift emphasis to provide this support when needed.

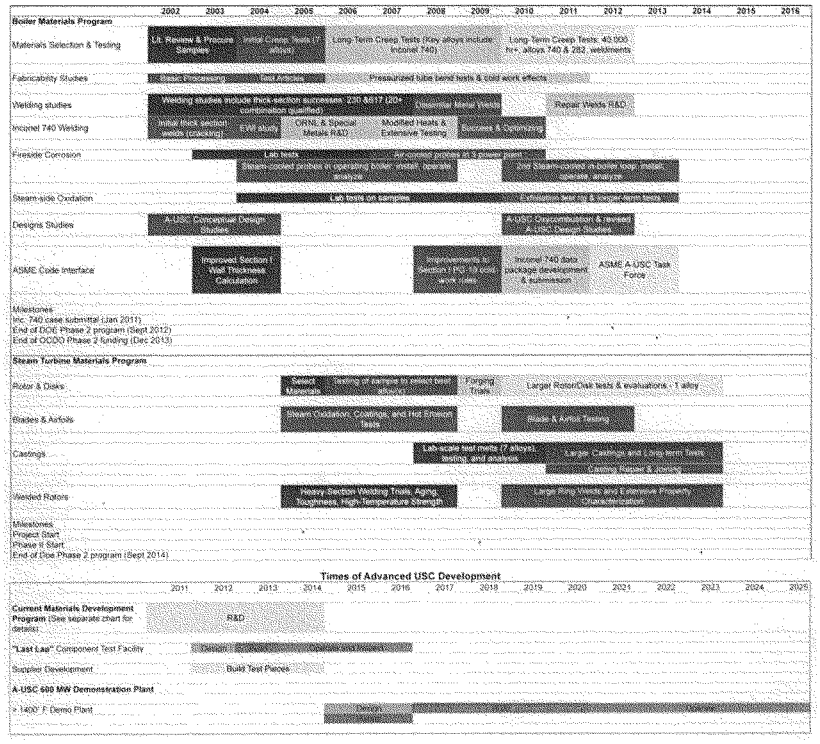
5. *Please describe some of the environmental, economic, and operational benefits associated with increasing coal-fired power plant efficiency. What is the potential for greater increases in new plants, and what R&D work needs to be done to accelerate this effort?*

Higher efficiency coal fired plants use fewer resources to generate the same electric output including coal, cooling water and consumable supplies, while simultaneously producing less ash, fewer sulfur emissions, and fewer other pollutants. They produce less CO_2 per amount of power generated. As an example, comparing an advanced very high efficiency plant such as is described in the EPRI report I cited in written testimony #1022770 *" U.S. Department of Energy and Ohio Coal Development Office Advanced Ultra-Supercritical Materials Project for Boilers and Steam Turbines"* and comparing this to a "subcritical" steam coal power plant (typical of many of the current fleet), the relative emissions of CO_2 are 19 percent lower (729 kg/MWh vs. 900 kg/MWh). Emissions of gaseous pollutants and ash, as well as discharges of sulfur products like gypsum, would also be reduced by approximately the same proportion as would cooling load and withdrawn water used to support that load.

Economic benefits come partly from the reduced cost for fuel and make-up chemicals and operating cost for equipment, and are counterbalanced by the additional cost of high alloy materials and special fabrication costs. NETL evaluations (cited on page 12 in the previously mentioned EPRI report) showed that for plants without post-combustion CO_2 capture, the levelized cost of electricity generation is almost the same, for subcritical and advanced supercritical units, but costs improved with the advantage toward high temperature materials use if post-combustion CO_2 capture or oxy–combustion technology was used. This is because less CO_2 is created so less needs to be captured and stored. The power will actually be cheaper to dispatch because operating cost of fuel is much lower for high efficiency plants (cost of capital equipment does not factor in the dispatch decisions).

Operational benefits include having to manage smaller coal, ash and byproduct streams, having a smaller plant layout area and lower avoided cost of CO_2. One advantage not usually recognized is high temperature materials will not require novel system training because other than temperature and efficiency these processes will be similar to the ones in operation at state of the art plants today.

The R&D required to take this forward is laid out in greater detail in the report mentioned in this section and in testimony. The bottom of the final page (page 22 of the document) summarizes accomplishments to date from the US DOE and Ohio Coal Development Office Advanced Ultra-Supercritical Materials Project for Boilers and Steam Turbines and shows next steps in chart form (inserted below).



Part of the remaining R&D effort is aimed at qualifying an alloy from a second US supplier for use in A-USC plants and that by doing so fostering competition which should lead to lower prices for these alloys. As you can see from the diagram above, the component test facility R&D work is the last step before full scale application of the technology in a 1400°F demonstration plant. This may be accelerated to skip the component test facility and go straight to a demonstration if the risk sharing is sufficient to make the project financially feasible.

The ultra high efficiency coal plant can also be combined with a post combustion CO_2 capture plant in a configuration dubbed "UltraGen" and described in our Report *"Advanced Coal Power Systems with CO_2 Capture : EPRI's CoalFleet for Tomorrow® Vision – 2011 Update"* pages 8-9 to 8-12. This combined approach may be feasible if the project can be risk-shared by DOE to make it competitive with other generation options, possibly including installation near an enhanced oil recovery location to provide a revenue stream for CO_2.

6. *Mr. Foerter states in his testimony that R&D "is clearly not needed to effectively address the air pollutant emissions of conventional pollutants." But in EPRI's recent*

comments on the Utility MACT, you stated that no coal-fired electric generating unit in EPA's database would meet the new 'MACT limits for all three standards- particulate matter, mercury, and hydrogen chloride. Could you help to reconcile this apparent discrepancy, and describe the complexity of complying with this combination of standards, including the availability and cost-effectiveness of currently-deployed technology?

EPRI's statement relates to the data that EPA gathered, which shows that only a small subset of the ICR units tested had average emission values below the proposed limits for all three HAPs or HAPs surrogates with primary limits (TPM, Hg, and HCl). Note that this does not necessarily mean that these units would comply with a 30-day rolling average. EPRI's analysis indicates little similarities in the power plant design for this small subset of units; i.e., there's no clear and certain path to meeting all three limits simultaneously and, hence the need for further R&D. The existing plants were not designed for mercury and HCl removal though some of the systems installed can help capture mercury and HCl. Since they were not designed or operated to meet the newly proposed emission limits on pollutants not heretofore regulated, it will take changes to make them comply with new requirements. EPRI is currently conducting R&D, some sponsored solely by industry and other together with DOE and industry to understand the issues in meeting the requirements; technologies like improved dry sorbents and "semi-dry" processes, which as Mr Forter indicated may provide less capital-intensive ways to meet the proposed existing unit limits, are among the processes being tested. These sorbents are still being evaluated in many cases. EPRI has even been developing in-situ methods of creating sorbent, potentially reducing these material costs significantly, to find ways to comply with the requirements cost-effectively and flexibly. Our members see this work as necessary, and we see DOE as a knowledgeable partner based on joint similar work in the past.

Another concern requiring R&D is cross-media issues. For instance methods for mercury control such as activated carbon injection, sometimes augmented with bromine, may remove mercury and capture it, but may also make fly ash from the plant unusable for construction purposes and difficult to dispose. Another example is when a wet scrubber used primarily for SO_2 control captures metals such as mercury and selenium; it makes water treatment more complex. This has become of greater concern recently with new Effluent Guidelines liquid discharge limits pending, and may require novel flowsheets to properly treat the water, again requiring research and development. While EPRI is addressing some of these issues in industry-funded R&D, we and the industry do not have the resources to address simultaneously all the known and to be uncovered issues in time to meet compliance deadlines, while obtaining feedback and lessons learned after the first units. Absent a substantial acceleration of the R&D, the industry will be deprived of the opportunity to modify processes based on lessons learned with early installations as it has been with prior more manageable research, development, demonstration and deployment timelines in the past.

While power plants may be able to meet all proposed air emission limitations (HAPS MACT and CSAPR) simultaneously by implementing combustion and post combustion NOx controls, new sorbent injection, fabric filters (aka baghouses), scrubbers, and post scrubber particulate removal like wet electrostatic precipitators, the cost will rise with each added control and the impacts on wastewater discharge and fly ash or gypsum use more difficult to mitigate. RD&D is needed to overcome these challenges.

Another issue regarding the ability of new plants to meet the proposed MACT limits is the fact that many of the values that EPA has proposed are below the detection limits of currently available sampling and analytical procedures. It should be noted that our evaluation of the ICR data indicate that even the unit that was selected to set the new unit standard would not likely meet the new unit based on all of that unit's measurements. This is due to EPA using the lowest average test series, and not all that unit's measurements. In order to be in compliance, utilities will have to rely on accurate monitoring data from technologies that are not available today. Thus, another need for R&D is new and improved methods to accurately sample and analyze for the HAPs that will be controlled or their surrogates.

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy & Environment

Hearing Questions for the Record
The Honorable Brad Miller

Advancing Coal Research and Development for a Secure Energy Future
Thursday, October 13, 2011

1. Please provide your name and employing organization:
   Stuart M. Dalton; Electric Power Research Institute (EPRI)

2. a. Are you an officer or employee of, or otherwise compensated by, any other organization (s) that may have an interest in the topic of this hearing?

   ( ) Yes
   (x) No

   b. If the answer to question 2a is "yes," please specify the organization(s) and the nature of your relationship with the organization(s).

3. a. In the last three calendar years, including this one, have you been a registered lobbyist?

   ( ) Yes
   (x) No

   b. If the answer to question 3a is "yes," please list all of your client(s) that may have an interest in the subject matter of this hearing, and the dates between which you represented that client or those clients.

4. If you have worked as an attorney, contractor, consultant, paid analyst, or in any other professional services capacity, please provide a list of all of your firm's clients who you know to have an interest in the subject matter of this hearing. These should be clients that you have personally worked with in the last three calendar years (including the present year). Provide the name of the client, the matter on which you worked and the date range of that work. If there was a deliverable, please describe that product.

   I am employed by EPRI and receive no compensation from any other entity. EPRI conducts research and development relating to fossil, nuclear and renewable generation, as well as delivery and use of electricity for the benefit of the public. EPRI receives research funding from entities engaged in the generation, distribution and transmission of electricity in the United States, including Federal power agencies, municipal and public power agencies and rural electric cooperatives, investor owned

utilities, independent power producers, as well as from the Department of Energy and international companies.

5. Please provide a list of all publications on which you have received an author or coauthor credit relevant to the subject of this hearing. If the list is extensive, the 10 most recent publications would be sufficient

- May 2-5, 2011 – Pittsburgh PA Plenary presentation "**A Perspective on a Decade of CCS RD&D - With a View to the Future.** Presented at the Tenth Annual Carbon Capture and Sequestration Conference (proceedings available)
- January 9-12, 2011 International Congress on Sustainability Science & Engineering presentation Tucson AZ **Advances in Low Carbon Generation- Efficiency and Emissions** (proceedings available)
- November 19, 2010 Paris, France – International Energy Agency Coal Industry Advisory Board Presentation -**Role of CCS Technology, Costs and Implications of Timing** (proceedings available)
- July 21, 2010 Bismarck ND, CoalFleet for Tomorrow® meeting **CoalFleet International Update**
- May 11, 2010 Pittsburgh PA, 9th Annual Carbon Capture and Sequestration Conference
  CO_2 Capture and Storage Issues and Solutions (proceedings available)
- April 27-30, **2011**Melbourne Australia International Symposium on the Sustainable Use of Low Rank Coals **Advances in Combustion Technology and Performance Improvement** (proceedings available)
- April 27-30, 2011 Melbourne Australia International Symposium on the Sustainable Use of Low Rank Coals **International Collaboration for Low-Rank Coal - Successes and Lessons Learned** (proceedings available)
- April 23, 2010 Brisbane, Australia Stanwell Corporation Briefing **Generation Options and Future Trends**
- April 23, 2010 Brisbane, Australia , Tarong Energy Briefing **Coal, Renewables and CO_2**
- April 5, 2010 Sacramento California, briefing for California Energy Commissioners **CO_2 Capture and Storage-Drivers, Options, Issues and Opportunities**