Segment 1 Of 7 Next Hearing Segment(2)

SPEAKERS CONTENTS INSERTS

Page 1 TOP OF DOC Segment 1 Of 7

PRESIDENT'S NATIONAL ENERGY POLICY,
PARTS 1 & 2

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

ONE HUNDRED SEVENTH CONGRESS

FIRST SESSION

JUNE 12 AND 14, 2001

Serial No. 107–45

Printed for the use of the Committee on Science

PRESIDENT'S NATIONAL ENERGY POLICY, PARTS 1 & 2

73–323PS
2002

Page 2 PREV PAGE TOP OF DOC Segment 1 Of 7

PRESIDENT'S NATIONAL ENERGY POLICY:
CLEAN COAL TECHNOLOGY AND
OIL AND GAS R&D (PART 1)

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

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Page 3 PREV PAGE TOP OF DOC Segment 1 Of 7

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Page 4 PREV PAGE TOP OF DOC Segment 1 Of 7

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Page 5 PREV PAGE TOP OF DOC Segment 1 Of 7

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TOM HAMMOND *Staff Assistant*

Page 6 PREV PAGE TOP OF DOC Segment 1 Of 7

C O N T E N T S

Part 1

June 12, 2001
Witness List

Hearing Charter

Opening Statements

Statement by Representative Roscoe Bartlett (MD–06), Chairman, Subcommittee on Energy, Committee on Science, U.S. House of Representatives
Written Statement

Statement by Representative Jerry F. Costello (IL–12), Member, Subcommittee on Energy, Committee on Science, U.S. House of Representatives
Written Statement

Statement by Representative Nick Smith (MI–07), Member, Subcommittee on Energy, Committee on Science, U.S. House of Representatives

Panel I—Clean Coal Technology

Mr. Robert S. Kripowicz, Acting Assistant Secretary for Fossil Energy, U.S. Department of Energy

Page 7 PREV PAGE TOP OF DOC Segment 1 Of 7

Oral Statement
Prepared Statement
Biography

Mr. Ben Yamagata, Executive Director, Coal Utilization Research Council (CURC)
Oral Statement
Prepared Statement
Biography
Financial Disclosure

Mr. James E. Wells, Director, Natural Resources and Environment, U.S. General Accounting Office
Oral Statement
Prepared Statement
Biography

Ms. Katherine Abend, Global Warming Associate, U.S. Public Interest Research Group (U.S. PIRG)
Oral Statement
Prepared Statement
Financial Disclosure
Biography

Mr. John S. Mead, Director, Coal Research Center, Southern Illinois University, Carbondale
Oral Statement
Prepared Statement
Biography

Financial Disclosure

Panel I Discussion

Benefits of the Clean Coal Technology Program
Replacing Coal With Other Fuel Sources
New Clean Coal Research Projects
Potential Reductions in Emissions From Coal-fired Plants
Programs to Reduce Dependence on Oil Produced by the OPEC
Alternatives to Fossil Fuels
Cooperation Between State and Federal Clean Coal Programs
Ramifications of Fuel Switching Between Coal and Natural Gas
Clean Coal Technology Aims and Environmental Groups
CO Emissions From Clean Coal and Clean Coal Alternatives
Clean Coal and Distributed Generations
Using Technology to Revitalize Spent Oil Wells
Research & Development Funding and Tax Credits for Energy Efficiency and Renewable Energy
CAFÉ and Hybrid Vehicles
Coal Versus Nuclear Energy
Competitiveness Threshold for Alternative Energy
Request for Breakout of $2 Billion in Proposed Clean Coal Spending
Opinions on S.60

Panel II—Oil and Gas R&D

Ms. Virginia B. Lazenby, Chairman and CEO, Bretagne, GP
Oral Statement
Prepared Statement
Biography
Financial Disclosure

Mr. Paul L. Cuneo, Vice President and Chief Information Officer, Equiva Services, LLC
Oral Statement
Prepared Statement
Biography

Dr. Craig W. Van Kirk, Professor of Petroleum Engineering and Head of the Department of Petroleum Engineering, Colorado School of Mines
Oral Statement
Prepared Statement
Biography
Financial Disclosure

Mr. Alan Huffman, Manager, Seismic Imaging Technology Center, Conoco, Inc.
Oral Statement
Prepared Statement
Biography

Panel II Discussion

Page 10 PREV PAGE TOP OF DOC Segment 1 Of 7

Proposed National Energy Research Center
Fossil Energy Research Priorities
Benefits Derived From Government R&D
Oil Well Life-Extension Technologies and Reserves
The Future of the Petrochemical Industry
The Extent of Worldwide Petroleum Reserves
Use of Petroleum By-products
Proposed U.S. Energy Research Center

Part 2

June 14, 2001
Witness List

Hearing Charter

Opening Statements

Statement by Representative Roscoe G. Bartlett (MD–06), Chairman, Subcommittee on Energy,

Committee on Science, U.S. House of Representatives
Written Statement

Prepared Statement by Representative Jerry F. Costello (IL–12), Member, Subcommittee on Energy, Committee on Science, U.S. House of Representatives

Page 11 PREV PAGE TOP OF DOC Segment 1 Of 7

Prepared Statement by Representative Ken Calvert (CA–43), Member, Subcommittee on Energy, Committee on Science, U.S. House of Representatives

Prepared Statement by Representative Sheila Jackson Lee (TX–18), Member, Subcommittee on Energy, Committee on Science, U.S. House of Representatives

Statement by Representative Lynn Woolsey (CA–06), Member, Subcommittee on Energy, Committee on Science, U.S. House of Representatives

Panel I

The Honorable David K. Garman, Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy
Oral Statement
Prepared Statement
Biography

Dr. H.M. Hubbard, Chair, Committee on Programmatic Review of the U.S. Department of Energy's Office of Power Technologies, National Research Council
Oral Statement
Prepared Statement
Biography
Financial Disclosure

Arthur T. Katsaros, Group Vice President, Engineered Systems and Development, Air Products and Chemicals, Inc., Lehigh Valley, PA, on behalf of the National Hydrogen Association

Page 12 PREV PAGE TOP OF DOC Segment 1 Of 7

Oral Statement
Prepared Statement
Biography
Financial Disclosure

David P. Haberman, Chairman, DCH Technology, Inc., Valencia, CA
Oral Statement
Prepared Statement
Biography

Financial Disclosure

Dr. Peter Lehman, Director, Schatz Energy Research Center, Humboldt State University, Arcata, CA
Oral Statement
Prepared Statement
Biography
Financial Disclosure

Panel I Discussion

DOE Budget Issues
Hydrogen Research Priorities
Hydrogen Safety
Hydrogen Education
Hydrogen Reauthorization
DOE Budget Changes

Page 13 PREV PAGE TOP OF DOC Segment 1 Of 7

The Role of Renewables in Hydrogen Production
Standards and Codes
Foreign Fuel Cell Research and Development
U.S. Hydrogen Funding
DOE's Strategic Review
The National Research Council's Recommendations to the Office of Power Technologies Programs
U.S. R&D Cooperation With International Community
Hindenburg Syndrome

Panel II

The Honorable Lindsey O. Graham, Member of Congress, Representing the Third District of South Carolina
Oral Statement
Prepared Statement

The Honorable Judy Biggert, Member of Congress, Representing the Thirteenth District of Illinois
Oral Statement
Prepared Statement

Joe F. Colvin, President, Nuclear Energy Institute, Washington, DC
Oral Statement
Prepared Statement
Biography
Financial Disclosure

Page 14 PREV PAGE TOP OF DOC Segment 1 Of 7

William D. Magwood, IV, Director, Office of Nuclear Energy, Science and Technology, U.S. Department of Energy
Oral Statement
Prepared Statement
Biography

John F. Kotek, Manager, Special Projects Section, Argonne National Laboratory-West, Idaho, U.S. Department of Energy, on behalf of the American Nuclear Society
Oral Statement
Prepared Statement
Biography
Financial Disclosure

Anna Aurilio, Legislative Director, U.S. Public Interest Research Group, Washington, DC
Oral Statement
Prepared Statement
Biography

Panel II Discussion

Nuclear Site Safety
Nuclear Waste Issues
Generation IV Reactor Technology
Electrometallurgical Treatment Technology

Advanced Reactor Construction Issues
Advanced Reactor Performance in Asia
Nuclear Energy Cost Effectiveness
Long-term Versus Short-term Energy Issues

Appendix 1: Answers to Post-Hearing Questions Submitted by Majority Members of the Subcommittee on Energy

Part 1

Panel I Questions:

Mr. Robert S. Kripowicz, Acting Assistant Secretary for Fossil Energy, U.S. Department of Energy

Mr. James E. Wells, Director, Natural Resources and Environment, U.S. General Accounting Office
Possible Improvements in DOE's Clean Coal Program
Problems in the Clean Coal Technology Program
Successes in the Clean Coal Technology Program

Ben Yamagata, Executive Director, Coal Utilization Research Council (CURC)
Coal Quality, Recoverability and Technology
Producing Electricity From Coal With *de minimus* Emissions
Other Uses for Coal
Carbon Sequestration Technologies

Page 16 PREV PAGE TOP OF DOC Segment 1 Of 7

Potential for Coalbed Methane
Power Plant Improvement Initiative

Ms. Katherine Abend, Global Warming Associate, U.S. Public Interest Research Group (PIRG)
PIRG Concerns About the Use of Coal
U.S. PIRG's Position on Energy Production

John S. Mead, Director, Coal Research Center, Southern Illinois University, Carbondale

Part 1

Panel II Questions:

Mr. Robert S. Kripowicz, Acting Assistant Secretary for Fossil Energy, U.S. DOE Office of Fossil Energy

Virginia B. Lazenby, Chairman and CEO, Bretagne, GP, On behalf of the Independent Petroleum Association of America
Source of the "Energy Crisis"
Unconventional Sources of Natural Gas
The Importance of Stripper Wells to U.S. Energy Production
Implications of Capping a Well
R&D Cycles in the Oil and Gas Industry
Oil and Gas Production Enhancement Technologies

Page 17 PREV PAGE TOP OF DOC Segment 1 Of 7

Paul Cuneo, Vice President & Chief Information Officer, Equiva Services, LLC, On behalf of the American Petroleum Institute
Source of the "Energy Crisis"
Refinery Efficiency, Technology and U.S. Competitiveness
Pipeline Monitoring Technologies
Advantages of Gasoline Infrastructure for Hydrogen Supply

Dr. Craig W. Van Kirk, Professor of Petroleum Engineering; Head, Department of Petroleum Engineering, Colorado School of Mines

Source of the "Energy Crisis"
Unconventional Sources of Natural Gas
Drilling Technology
Increased Recovery of Petroleum
Future Technologies

Alan R. Huffman, Manager, Seismic Imaging Technology Center, Conoco, Inc.
Source of the "Energy Crisis"
Unconventional Sources of Natural Gas
Potential for Ultra-deep Water Technologies
Proposed Operations of the U.S. Energy Center

Part 2

Panel I Questions

Page 18 PREV PAGE TOP OF DOC Segment 1 Of 7

The Honorable David K. Garman, Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy
Hydrogen Funding Levels
Hydrogen Infrastructure Concerns
Hydrogen Program
Hydrogen R&D

Dr. H.M. Hubbard, Chair, Committee on Programmatic Review of the U.S. Department of Energy's Office of Power Technologies, National Research Council

Arthur T. Katsaros, Group Vice President, Engineered Systems and Development, Air Products and Chemicals, Inc., Lehigh Valley, PA, on behalf of the National Hydrogen Association

David P. Haberman, Chairman, DCH Technology, Inc., Valencia, CA

Dr. Peter Lehman, Director, Schatz Energy Research Center, Humboldt State University, Arcata, CA
Hydrogen R&D
Hydrogen Infrastructure Concerns
Renewables in Base Load Generation
Future Hydrogen Infrastructure
Hydrogen Production Today and in the Future

Part 2

Page 19 PREV PAGE TOP OF DOC Segment 1 Of 7

Panel II Questions

William D. Magwood, IV, Director, Office of Nuclear Energy, Science and Technology, U.S. Department of Energy
Administration View of H.R. 1679 and H.R. 2126
Non-Proliferation and Gen-IV Reactor Designs

Joe F. Colvin, President, Nuclear Energy Institute, Washington, DC
LNT and Yucca Mountain
Nuclear Science and Engineering Workforce Needs
NEPO and Other DOE Program Performance
Construction Lead Times for Nuclear Plants

John F. Kotek, Manager, Special Projects Section, Argonne National Laboratory-West, Idaho, U.S. Department of Energy, on behalf of the American Nuclear Society

Anna Aurilio, Legislative Director, U.S. Public Interest Research Group, Washington, DC

Appendix 2: Additional Material for the Record

Part 1

The United States Energy Institute, Executive Summary

Page 20 PREV PAGE TOP OF DOC Segment 1 Of 7

The United States Energy Center, Business Overview
Matthew R. Simmons, President, Simmons & Company International. *Digging Out of Our Energy Mess: The Need For an Energy Marshall Plan*, American Association of Petroleum Geologists, June 5, 2001
Coal Gasification for Power Generation, A New Role for Coal in Meeting America's Clean Energy Challenge, Texaco Power & Gasification, May 14, 2001
Clean Coal Technology: A Story of Success, National Mining Association
Letter dated May 23, 2001 to Rep. Lynn Woolsey (CA–06) from Karl Gawell, Executive Director, Geothermal Energy Association

Part 2

Statement Submitted by the Electric Vehicle Association of the Americas (EVAA)
Realizing A Hydrogen Future, Hydrogen Technical Advisory Panel Recommendations, National Renewable Energy Laboratory, U.S. Department of Energy, August 1999
Strategic Plan for DOE Hydrogen Program, U.S. Department of Energy, January 1998
Renewable Power Pathways, A Review of the U.S. Department of Energy's Renewable Energy Programs, National Research Council, National Academy of Sciences, 2000
International Energy Agreement, Hydrogen Implementing Agreement: Summary of 2001, David Haberman, June 14, 2001

Page 21 PREV PAGE TOP OF DOC Segment 1 Of 7

H.R. 1679, *The Electricity Supply Assurance Act of 2001*
H.R. 1679 Section-by-Section Analysis
H.R. 2126, *The Department of Energy University Nuclear Science and Engineering Act*
H.R. 2126 Section-by-Section Analysis
PL 101–566 and PL 104–271, As Amended by June 11, 2001 Discussion Draft of the Robert S. Walker and George E. Brown, Jr., Hydrogen Energy Act of 2001

THE PRESIDENT'S NATIONAL ENERGY POLICY: CLEAN COAL TECHNOLOGY AND OIL AND GAS R&D, PART 1

TUESDAY, JUNE 12, 2001

House of Representatives,

Subcommittee on Energy,

Committee on Science,

Washington, DC.

The Subcommittee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Roscoe G. Bartlett [Chairman of the Subcommittee] presiding.

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Page 22 PREV PAGE TOP OF DOC Segment 1 Of 7

HEARING CHARTER

SUBCOMMITTEE ON ENERGY

COMMITTEE ON SCIENCE

U.S. HOUSE OF REPRESENTATIVES

President's National Energy Policy:

Clean Coal Technology and Oil and Gas R&D

TUESDAY, JUNE 12, 2001

10:00 A.M.–1:00 P.M.

2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose of the Hearing

On Tuesday, June 12, 2001 at 10:00 a.m., the Subcommittee on Energy will hold a hearing on the "President's National Energy Policy: Clean Coal Technology and Oil and Gas R&D." The President's National Energy Policy developed by the National Energy Policy Development (NEPD) Group chaired by Vice President Cheney recommended that: (1) the Department of Energy (DOE) invest $2 billion to fund research in clean coal technology; (2) DOE and the Department of the Interior promote enhanced oil and gas recovery from existing wells through new technology; and (3) DOE improve oil and gas exploration technology through continued partnership with public and private entities. The purpose of the hearing is to examine the current status of coal and oil and gas technologies and R&D efforts, and the extent to which technologies derived from this R&D will extend the life of these resources.

Page 23 PREV PAGE TOP OF DOC Segment 1 Of 7

The hearing will consist of two panels. The first panel will consider clean coal technology. Witnesses will include: (1) Robert S. Kripowicz, Acting Assistant Secretary for Fossil Energy at the U.S. Department of Energy (Mr. Kripowicz will also appear on Panel 2); (2) Ben Yamagata, Executive Director of the Coal Utilization Research Council (CURC), Washington, DC; (3) James E. Wells, Director of Natural Resources and Environment at the U.S. General Accounting Office; (4) Dr. Robert H. Williams, Senior Research Scientist, Center for Energy and Environmental Studies, Princeton University; and (5) John S. Mead, Director of the Coal Research Center at Southern Illinois University-Carbondale. The second panel will consider how technologies derived from petroleum and gas R&D can be employed to improve exploration, extraction, refining and processing, and transportation of these fossil fuels. Witnesses will include: (1) Virginia B. Lazenby, Chairman and CEO of Bretagne, GP, Nashville, TN, on behalf of the Independent Petroleum Association of America; (2) Paul Cuneo, Vice President & Chief Information Officer of Equiva Services, LLC, Houston, TX; (3) Dr. Craig W. Van Kirk, Professor of Petroleum Engineering and Head of the Department of Petroleum Engineering at the Colorado School of Mines, Golden, CO; and (4) Dr. Alan R. Huffman, Manager of Conoco's Seismic Imaging Technology Center, Houston, TX.

2. Overview

Coal, oil and natural gas are the dominant fuels in the U.S. economy, providing some 85 percent of the Nation's energy in 1999—including over 70 percent of its electricity and almost all of its transportation fuel. By 2020, the DOE Energy Information Administration (EIA) forecasts that the U.S. will use about 22 percent more coal, one-third more oil, and over 60 percent more gas to meet demand.(see footnote 1)

Page 24 PREV PAGE TOP OF DOC Segment 1 Of 7

2.1 Coal

Coal is the Nation's most abundant fossil energy source. According to the EIA, the U.S. demonstrated reserve base of coal contained an estimated 508 billion short tons as of January 1, 1997, with about 54 percent recoverable by mining.(see footnote 2) This compares with a total U.S. 1999 consumption of 1.035

billion tons.(see footnote 3)

Coal is used almost exclusively to generate electricity. Coal power plants account for over 50 percent of all U.S. electricity generation, and over 80 percent of generation in 12 States in the Midwest, Southeast, and West. Currently, coal electricity generation costs are low, and coal prices have proved remarkably stable. Over the past decade, greater efficiencies, lower capital costs, fewer emissions and quicker start-up times have made natural gas power plants a more attractive choice for new electricity generation. However, rising natural gas prices have renewed interest in building coal power plants.

Production and environmental issues affect the adequacy of supply, operation of existing coal plants, and decisions on building new plants. Production issues—including the protection of public health, safety, property and the environment—may limit or prevent the production of some coal resources or may result some coal resources becoming uneconomical to produce. Environmental issues impacting the operation of existing coal plants and decisions on building new plants include: (1) regulations under development requiring reductions in emissions of nitrogen oxide, sulfur dioxide, and mercury; (2) rules related to discharges to streams and cooling-water intake structures; (3) possible regulation of large-volume wastes as hazardous wastes; (4) uncertainty over rules requiring air permits for certain modifications to power plants; and (5) uncertainty over global and domestic efforts to reduce carbon dioxide emissions.

2.2 Oil

Remaining U.S. oil reserves, estimated at nearly 21.8 billion barrels, are becoming increasingly costly to produce because much of the lower-cost oil has already been largely recovered.(see footnote 4) The remaining resources have higher exploration and production costs and greater technical challenges, because they are located in geologically-complex reservoirs, (e.g., deep water and harsh environments).

U.S. oil production is expected to decline over the next two decades—from about 5.9 million barrels per day to 5.05 million barrels per day—while demand for natural gas will most likely continue to outpace domestic production.(see footnote 5) As a result, the U.S. is likely to increase its reliance on imports of both natural gas and oil from Canada, and imports of oil and liquefied natural gas from producers across the globe.

2.3 Natural Gas

The U.S. natural gas resource is large—estimated at over 170 trillion cubic feet.(see footnote 6) However, U.S. conventional production is projected to peak as early as 2015. Increasingly, the U.S. will have to rely on natural gas from unconventional resources, such as tight sands, deep formations, deep water, and gas hydrates. Also, many resources are in environmentally-sensitive areas that require use of less intrusive technologies.

Under current policies, EIA projects that nuclear electricity generation and hydropower will decline over the next two decades. Natural gas electricity generation is projected to increase from about 16 to 36 percent of total generation, which would require the tripling of natural gas used for electricity generation. Significantly, this projected increase in natural gas generation assumes that coal electricity generation will continue to account for about 50 percent of U.S. electricity generation. If policies are adopted that sharply lower coal electricity generation, then the likely result is an even greater dependence on natural gas generation.

2.4 Clean Coal Technology (CCT) Demonstration Program

The CCT Program was established in 1984 with $750 million in funds left over from the congressionally-mandated termination of the Synthetic Fuels Corporation, a Government corporation created to help develop new fuels from domestic sources. By 1990, Congress had appropriated approximately $2.6 billion for the program, and DOE selected and made cost-sharing cooperative agreements for a large number of projects of varying size and technologies.(see footnote 7) By the mid-1990s, the potential for adoption of most CCT technologies by industry without Government subsidy began to dim, and DOE in 1994 recommended that no further projects be funded. Since then, approximately $300 million of previously appropriated funding has been rescinded, and other funding has been deferred—including $67 million in FY 2001. President Bush's FY 2002 budget, however, proposes spending $2 billion over 10 years on a restructured CCT program, with the same industrial cost-sharing principle as the existing program.

The 38 active projects in the CCT Program have a total cost of $5,203,707,000, of which DOE has committed $1,755,832,000, or 33.7 percent (industry and State governments have provided the remaining 66.3 percent).

Page 27 PREV PAGE TOP OF DOC Segment 1 Of 7

CCT Program projects fall into four general categories:(see footnote 8)

Environmental Control Devices.—Many of the early CCT projects were retrofits of existing power plants to demonstrate emission control technologies as alternatives to traditional scrubbers or to conversion to low-sulfur coal. The 19 projects in this category were designed to control nitrogen oxide (NO**X**) emissions, sulfur dioxide (SO) emissions, or both. All but two of these projects are completed; one is still operating, and one is on hold at the design stage because the main participant is in bankruptcy.

Advanced Electric Power Generation.—The most expensive CCT projects are advanced power generating facilities, of three main types: atmospheric fluidized bed (AFB) burners, pressurized fluidized bed (PFB) plants, and integrated gasification combined cycle (IGCC) plants. Proponents of these technologies cited the potential of more efficient use of the energy content of coal, as well as their ability to burn coal cleanly without conventional scrubbers, as overcoming their higher cost than conventional coal plants. One AFB project was completed, and another is in the design stage. One PFB plant project was completed, and two are in design. Three IGCC plants were built and are in the operating stage, and one is in design.

Coal Processing.—Five current CCT projects were aimed at converting "run-of-the-mill" coals to high-energy, low-sulfur products. The projects were viewed as having both a domestic and an export market for

the technology and the improved coal. Two projects were completed, two are operating, and one is on hold.

Page 28 PREV PAGE TOP OF DOC Segment 1 Of 7

Industrial Processes.—Using coal to replace coke in steel-making, enabling cement makers to use low-sulfur coal, and converting industry burners to coal from oil or gas, were some of the goals of the industrial CCT program. Three industrial projects were completed, and two are in the design stage.

2.5 Fossil R&D

DOE's Office of Fossil Energy is responsible for Fossil Energy R&D (as well as the Clean Coal Technology Program) and funds a variety of coal, oil, gas, combustion and fuel cell R&D activities.

DOE's FY 2002 request for Fossil Energy R&D is $449.0 million, an increase of $52.341 million—or 13.2 percent—above the FY 2000 appropriation of $396.659 million, and a decrease of $92.463 million—or 17.1 percent—from the FY 2001 appropriation of $541.463 million. Details of the DOE's FY 2002 Fossil Energy R&D request are included in the attachment.

3. Issues

What have been the successes of the CCT Program? What have been the failures?

Have the CCT Program technologies proven to be cost-competitive?

What management weaknesses exist in the CCT Program?

Page 29 PREV PAGE TOP OF DOC Segment 1 Of 7

What cost-sharing lessons have been learned from the CCT Program?

Can pending regulatory requirements for existing coal-fired power plants, such as the NO**X** State Implementation Plan (SIP) call, be met with currently demonstrated technologies, such as selective catalytic reduction (SCR)? If so, what is need for new CCT technologies?

What the status of mercury and carbon dioxide control technologies, and what R&D programs are addressing these?

What is the status of the Gas Hydrate R&D program?

What are the technological challenges facing the oil and gas industry, and what DOE programs are addressing these challenges?

What have been the successes of DOE's oil and gas programs? What have been the failures?

What is the appropriate Federal role in fossil energy R&D?

The President's National Energy Policy recommended that President to direct the Secretary of Energy: (1)

to conduct a review of current funding and historic performance of energy efficiency, renewable energy and alternative energy R&D programs; and (2) based on this review, to propose appropriate funding of those R&D programs that are performance-based and are modeled as public-private partnerships. Why were DOE's Fossil Energy R&D programs exempted?

ATTACHMENT: DOE's FY 2002 Fossil Energy R&D Budget Request

Page 30 PREV PAGE TOP OF DOC Segment 1 Of 7

DOE's Office of Fossil Energy is responsible for the Fossil Energy R&D and Clean Coal Technology Programs. The Science Committee has sole jurisdiction over all Fossil Energy R&D programs with the exception of Fossil Energy Environmental Restoration (jurisdiction shared with the Energy and Commerce Committee), and shares jurisdiction over the Clean Coal Technology Program with the Energy and Commerce Committee.

As shown in the Table, the FY 2002 request for Fossil Energy R&D is $449.0 million, an increase of $52.341 million—or 13.2 percent—above the FY 2000 appropriation of $396.659 million, and a decrease of $92.463 million—or 17.1 percent—from the FY 2001 appropriation of $541.463 million.

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1. Clean Coal Power Initiative *(FY 2001 = $0.0; FY 2002 = $150.0 million)*

The new Clean Coal Power Initiative (CCPI) is intended to increase involvement of the private sector and academia to help conduct and direct research toward the most critical barriers to expansion of coal use for U. S. power generation in the United States. This cooperative effort will require industry to share in the cost of research work, with the industry share increasing as technologies approach commercial stages. The CCPI FY 2002 budget request is $150 million—part of 10-year, $2.0 billion commitment to clean coal R&D. Technologies will be selected with the goal of accelerating development and deployment of coal technologies that will economically meet environmental standards, while increasing the efficiency and reliability of coal power plants.

Page 31 PREV PAGE TOP OF DOC Segment 1 Of 7

2. Fuels and Power Systems *(FY 2001 = $324.025 million; FY 2002 = $159.801 million)*

The Fuels and Power Systems program is developing new technologies that aim to: (1) achieve operating efficiencies of over 60 percent; (2) reduce emissions of air toxics and particulate matter in existing and future plants; (3) lead to economically viable ways to capture and store greenhouse gases; and, (4) produce alternative transportation fuels and chemicals.

The FY 2002 request for Fuels and Power Systems is $159.801 million, a decrease of $47.856 million—

or 23.0 percent—below the FY 2000 appropriation of $207.657 million, and a decrease of $164.224 million —or 50.7 percent—from the FY 2001 appropriation of $324.025 million for five program areas: Central Systems, Distributed Generation Systems-Fuel Cells; Sequestration R&D; Fuels; and Advanced Research.

The Central Systems program *(FY 2001 = $199.135 million; FY 2002 = $61.0 million)* encompasses Innovations for Existing Plants, Advanced Systems, and the Power Plant Improvement Initiative. Innovations for Existing Plants *(FY 2001 = $20.102 million; FY 2002 = $18.0 million)* funding will support development of ultra clean combustors under the Vision 21 program and eliminates a program aimed at optimizing the performance of coal-fired power plants in China and Turkey. Advanced Systems *(FY 2001 = $84.242 million; FY 2002 = $43.0 million)* Low Emission Boiler Systems will continue by using prior year funding; the applicable combustion technology under the Indirect Fired Cycle program is being folded into other areas of Advance Systems; Integrated Gasification Combined Cycle program continues at the FY 2001 level; the Pressurized Fluidized Bed program is transitioning to focus on combustion hybrid technology, gas stream cleanup, and gas conditioning in support of Vision 21 activities; and work on utility-scale Turbines draws to a close. The Power Plant Improvement Initiative *(FY 2001 = $94.791 million; FY 2002 = $0.0)* which focused on demonstrating advanced coal-based power technologies to address electricity reliability issues has been refocused, and these activities will continue, with additional funding, under the Clean Coal Power Initiative.

Page 32 PREV PAGE TOP OF DOC Segment 1 Of 7

Distributed Generation-Fuel Cells *(FY 2001 = $52.584 million; FY 2002 = $45.124 million)* funding will be used to complete efforts to demonstrate a commercial-scale molten carbonate fuel cell power plant system, and a solid-oxide fuel cell/turbine hybrid prototype. The Department plans to narrow its focus in FY 2002, shifting from generic research to the development of a low-cost five-kilowatt solid state fuel cell.

Sequestration R&D *(FY 2001 = $18.746 million; FY 2002 = $20.677 million)* allows the program to continue emphasizing promising research to store and capture carbon gases. In FY 2002 the program will complete proof-of-concept scale research on a number of applied R&D options being investigated as part of prior solicitations.

Fuels *(FY 2001 = $23.423 million; FY 2002 = $7.0 million)* program continues development of ceramic membranes for synthesis gas production. No funding is requested for the steel-making process as the program will be completed in FY 2001.

Advanced Research *(FY 2001 = $30.137 million; FY 2002 = $26.0 million)* continues to pursue research in support of the Vision 21 concept of a power and fuels complex. The decrease in funding reflects the use of prior year funds in FY 2001 to install a high-speed computer data line to expand the computational capability at the National Energy Technology Laboratory (NETL).

3. Petroleum *(FY 2001 = $66.874 million; FY 2002 = $30.499 million)*

In FY 2002, DOE's Petroleum technology research will focus on new tools and technologies that oil producers can use in the next decade to explore for and produce oil from more difficult formations or from resources that are in environmentally sensitive regions. DOE will also fund a strong technology transfer

program to provide smaller, independent oil producers with better tools and knowledge to improve production from marginal U.S. fields.

Page 33 PREV PAGE TOP OF DOC Segment 1 Of 7

The FY 2002 request for Petroleum is $30.499 million. This is a decrease of $25.249 million—or 45.3 percent—below the FY 2000 appropriation of $55.748 million, and a decrease of $36.375 million—or 54.4 percent—from the FY 2001 appropriation of $66.874 million.

Exploration & Production *(FY 2001 = $28.844 million; FY 2002 = $20.35 million)* activities include demonstration of safe, economic slimhole drilling technology in Arctic conditions and methods for locating and producing oil from highly fractured reservoirs or ultra-deep deposits. The program plans to reduce research on oil basin analysis, smart well technology, advanced recovery methods, and fundamental technologies for frontier oil production. In FY 2002, the program plans to reduce research on oil basin analysis, smart well technology, advanced recovery methods, and fundamental technologies for frontier oil production. In addition, the Multi-National Lab/Industry partnership effort and research benefiting the recovery of petroleum through the use of sonication will be eliminated.

Reservoir Life Extension/Management *(FY 2001 = $14.662 million; FY 2002 = $4.849 million)* will focus on near-term technology development and assistance to small, independent operators. No new large-scale Government-industry field demonstrations are planned; however, evaluation of past field trials will be completed and the results shared with private operators. The decrease reflects completion of work to improve oil recovery and resource management capabilities with Native American tribes.

Effective Environmental Protection *(FY 2001 = $10.796 million; FY 2002 = $5.3 million)* continues to develop technologies and practices that reduce the cost of effective environmental protection and compliance, focusing especially on areas that will improve responsible development of gas resources on public lands. The program will reduce work with the states and other federal agencies to streamline regulations.

Page 34 PREV PAGE TOP OF DOC Segment 1 Of 7

Emerging Processing Technology Applications *(FY 2001 = $2.594 million; FY 2002 = $0.0).* The diesel bio-desulfurization project for producing low sulfur diesel fuel will be completed in FY 2001.

Ultra Clean Fuels *(FY 2001 = $9.978 million; FY 2002 = $0.0)* focused R&D related to coal-based transportation fuels will be funded within the Fuels & Power Systems-Fuels program.

4. Gas *(FY 2001 = $45.029 million; FY 2002 = $21.0 million)*

Gas program funding supports new technologies that can tap non-conventional gas resources and help the Nation meet its long-term gas supply needs at reasonable prices. Also included in this portion of the budget are activities that address the growing concern over the Nation's aging gas infrastructure and provide the advanced tools, materials, and mechanical technologies that can improve the maintenance of existing gas

pipelines and storage facilities and position the gas industry to make needed expansions in the future.

The FY 2002 request for Gas is $21.0 million. This is a decrease of $9.809 million—or 31.8 percent—below the FY 2000 appropriation of $30.809 million, and a decrease of $24.029 million—or 53.4 percent—from the FY 2001 appropriation of $45.029 million.

Exploration & Production *(FY 2001 = $14.221 million; FY 2002 = $9.35 million)* activities focus on development and demonstration of new technologies for reservoir imaging systems, drilling, and production that increase production while reducing costs, including the development of the world's first microwave-processed drill bit and composite drill pipe. Efforts will also include locating zones that provide economic rates of flow of gas trapped in low-permeability and naturally fractured reservoirs to reduce the cost of production in these non-conventional reservoirs. Arctic research will be coordinated under the new Arctic Research Program. The budget request does not include funding for field demonstrations of integrated deep drilling systems. In addition, the Multi-National Lab/Industry partnership effort will be eliminated, and no new work in Secondary Gas Recovery will be pursued. Technology transfer work with Petroleum Technology Transfer Council will continue at a reduced level.

Page 35 PREV PAGE TOP OF DOC Segment 1 Of 7

Gas Hydrates *(FY 2001 = $9.938 million; FY 2002 = $4.75 million)* funding allows the program to continue the characterization of Arctic and offshore hydrate resources with the U.S. Geological Survey, Naval Research Laboratory, and academic institutions. Funding to support the FY 2001 solicitation for joint industry projects in seafloor stability, resource characterization and feasibility has been reduced and no new projects will be initiated in FY 2002.

Infrastructure *(FY 2001 = $8.11 million; FY 2002 = $5.05 million)* continues activities to ensure the reliability of the domestic natural gas pipelines and gas storage facilities. FY 2002 activities include the development of advanced storage technologies for high deliverability facilities and smart systems that will enhance pipeline inspections and repairs.

Emerging Processing Technology *(FY 2001 = $10.146 million; FY 2002 = $0.25 million)* provides continued support for the international center for information on natural gas technologies. Ongoing work related to synthetic gas is funded within the Coal and Power Systems-Fuels program. No funding is requested to continue the coal mine methane or low-quality gas upgrading activities in order to direct funding towards higher priority activities within the Fossil Energy.

Effective Environmental Protection *(FY 2001 = $2.614 million; FY 2002 = $1.6 million)* continues development and demonstration of technologies and methods that will improve the economics and environmental performance of all facets of gas supply. In FY 2002, the program will sustain its emphasis on technologies that improve responsible development of gas resources on public lands.

Page 36 PREV PAGE TOP OF DOC Segment 1 Of 7

5. Cooperative Research and Development *(FY 2001 = $8.071 million; FY 2002 = $0.0 million)*

Cooperative Research and Development provides the Federal funding share for Jointly Sponsored Research Programs (JSRP) at the Western Research Institute (Laramie, WY) and the University of North Dakota Energy and Environmental Research Center (Grand Forks, ND). Research projects under JSRP must receive at least 50-percent cost sharing from non-Federal partners. No funding is requested for FY 2002.

6. Environmental Restoration *(FY 2001 = $9.978 million; FY 2002 = $9.5 million)*

Environmental Restoration supports environmental protection activities at FE R&D facilities, as well as off-site locations where R&D projects are sponsored. In addition, FE is responsible for correcting environmental, safety and health problems at the Albany Research Center. In FY 2002, work will continue on ongoing projects.

7. Import/Export Authorization *(FY 2001 = $2.295 million; FY 2002 = $1.0 million)*

Import/Export Authorization supports regulatory functions still required of DOE to review natural gas imports and exports under the Power Plant and Industrial Fuels Use Act of 1978, exports of electricity and the construction and operations of electric transmission lines which cross U.S. international borders, along with other regulatory responsibilities. The FY 2002 request provides for the salaries and benefits of 7 FTEs.

Page 37 PREV PAGE TOP OF DOC Segment 1 Of 7

8. Program Direction and Management Support *(FY 2001 = $80.086 million; FY 2002 = $70.0 million)*

Program Direction and Management Support provides funding for salaries, benefits and overhead expenses for management of the Fossil Energy program at DOE Headquarters (110 FTEs in FY 2001; 80 FTEs in FY 2002), the National Energy Technology Laboratory (339 FTEs in FY 2001; 281 FTEs in FY 2002) at Pittsburgh, PA, Morgantown, WV, and Tulsa, OK.

9. Plant and Capital Equipment *(FY 2001 = $3.891 million; FY 2002 = $2.0 million)*

This activity funds general plant projects and capital equipment at the National Energy Technology Laboratory sites and at Albany Research Center in Oregon. The FY 2002 request only includes funding for general plant projects, such as repairs, alterations, etc.

10. Advanced Metallurgical Processes *(FY 2001 = $5.214 million; FY 2002 = $5.2 million)*

In FY 2002, DOE is requesting $5.2 million for Advanced Metallurgical Processes conducted at the Albany Research Center to continue research in advanced materials and on metallurgical techniques to extend the life of materials and/or find substitute materials and processing paths for materials that are environmentally hazardous.

Chairman **BARTLETT.** Let me call our Subcommittee hearing to order. Is Ms. Abend in the room? We are anticipating a fifth witness and hoping that she was in the room. Today we will hear from two panels of witnesses who will discuss how we may potentially use clean coal technologies and petroleum and natural

gas research and development to help meet our increasing demand for energy. Fossil fuel provides over 80 percent of the energy consumed in this country today and is likely to increase in significance as our growing population and economy produce ever greater demands on these ultimately finite energy resources.

Page 38 PREV PAGE TOP OF DOC Segment 1 Of 7

This hearing is part of a House-wide effort and, in fact, a Hill-wide effort to consider the President's National Energy Policy. Vice President Cheney chaired the NEP, National Energy Policy task force, and I believe he did a very creditable job. It is our job in Congress to dissect the report, provide a critical review of his findings, and suggest approaches to implement its provisions where appropriate. The Energy Subcommittee of the House Science Committee has jurisdiction over all nondefense energy research and development and we take this responsibility very seriously.

In previous hearings before this Subcommittee, we heard testimony about the accelerating consumption of our finite fossil energy reserves and the environmental effects stemming from their use. We have also considered testimony about the potential for renewable energy and whether nuclear power can help fill the gap. I am convinced that we must immediately adopt conservation and energy efficiency measures to help extend the lifetime of fossil resources and reduce emissions. We must also rapidly phase in renewable forms of energy.

Yet, even with the transition to alternative energy sources, fossil fuels will continue to be an essential part of our energy mix for the next 20 or 30 years and perhaps beyond. The correlation between economic prosperity and readily available energy is well documented. We use more energy than ever before, but our way of life has become less energy intensive. Technology, innovation, efficiency, and conservation have brought us to the point where we can be more productive with the energy we use. This is certainly an excellent trend.

Unfortunately, we are also reaching a point where the easy and inexpensive fossil fuels are being consumed and we will have to transition toward more difficult-to-extract and costly fossil fuels. We Americans are also demanding cleaner air, so some sources of fossil fuels, such as coal, that are abundant and cheap, are shunned in favor of cleaner burning natural gas, which, though currently abundant, is also finite and increasingly costly.

Page 39 PREV PAGE TOP OF DOC Segment 1 Of 7

The question before us today is, can technology derived from R&D efforts in the government, private sector, and in our universities assist us in producing more energy more efficiently and in a way that comports with the needs of public and worker health and safety and the health of our environment?

Our first panel will consider all aspects of clean coal power technology, including how the President's proposed $2 billion in spending on clean coal technologies may both increase efficiency and reduce emissions from utilities and find innovative new uses for coal and coalbed methane.

Our witnesses will be Robert S. Kripowicz, Acting Assistant Secretary for Fossil Energy at the U.S. Department of Energy. Mr. Kripowicz will also appear on Panel II. Ben Yamagata, Executive Director of the Coal Utilization Research Council; James E. Wells, Director of Natural Resources and Environment at the U.S. General Accounting Office; Katherine Abend, Global Warming Associate at the U.S. Public Interest Research Group, U.S. PIRG; and John S. Mead, Director of the Coal Research Center at Southern Illinois University, Carbondale. I understand that my colleague, Mr. Costello, will be introducing his constituent, Mr. Mead, formally at the conclusion of my remarks.

The second panel will consider how technologies derived from petroleum and gas R&D can be employed to improve exploration, extraction, refining, and processing, and transportation of these fossil fuels. Our witnesses will include Virginia Lazenby, Chairman and CEO of Bretagne, GP, Nashville, Tennessee, on behalf of the Independent Petroleum Association of America; Paul Cuneo, Vice President and Chief Information Officer of Equiva Services, LLC, Houston, Texas, on behalf of the American Petroleum Institute; Dr. Craig W. Van Kirk, Professor of Petroleum Engineering and Head of the Department of Petroleum Engineering at the Colorado School of Mines, Golden, Colorado; and Dr. Alan Huffman, Manager of Conoco's Seismic Imaging Technology Center, Houston, Texas.

Page 40 PREV PAGE TOP OF DOC Segment 1 Of 7

I look forward to hearing today's testimony and pursuing these subjects in greater detail. Before we get started, however, I would like to remind the members of the Subcommittee and our witnesses that this hearing is being broadcast live on the Internet, so please keep that in mind during today's proceedings. I would also like to ask for unanimous consent that all members who wish may have their opening statements entered into the record. Without objection, so ordered. I now turn to my distinguished colleague, Mr. Costello, for an introduction and his opening remarks.

[The prepared statement of Mr. Bartlett follows:]

PREPARED STATEMENT OF CHAIRMAN ROSCOE BARTLETT

We will now convene the hearing. The hearing will come to order.

Today we will hear from two panels of witnesses who will discuss how we may potentially use clean coal technologies and petroleum and natural gas research and development to help meet our increasing demand for energy. Fossil fuel provides over 80 percent of the energy consumed in this country today, and is likely to increase in significance as our growing population and economy place ever-greater demands on these, ultimately finite, energy resources.

This hearing is part of a House-wide effort, and in fact, a Hill-wide effort, to consider the President's National Energy Policy (NEP). Vice President Cheney chaired the NEP Task Force, and I believe he did a very credible job. It is our job in Congress to dissect the report, provide a critical review of its findings and suggest approaches to implement its provisions, where appropriate. The Energy Subcommittee of the House Science Committee has jurisdiction over all non-defense Energy research and development (R&D), and we take this responsibility very seriously.

In previous hearings before this Subcommittee, we heard testimony about the accelerating consumption of our finite fossil energy reserves and the environmental effects stemming from their use. We have also considered testimony about the potential for renewable energy and whether nuclear power can help fill the gap. I am convinced that we must immediately adopt conservation and energy efficiency measures to help extend the lifetime of fossil resources and reduce emissions. We must also rapidly phase in renewable forms of energy. Yet, even with the transition to alternative energy sources, fossil fuels will continue to be an essential part of our energy mix for the next twenty or thirty years, and perhaps beyond.

The correlation between economic prosperity and readily available energy is well documented. We use more energy than ever before, but our way of life has become less energy intensive. Technology, innovation, efficiency and conservation have brought us to the point where we can be more productive with the energy we use. That is certainly an excellent trend.

Unfortunately, we are also reaching a point where the "easy" and inexpensive fossil fuels are being consumed and we will have to transition towards more difficult to extract and costly fossil fuels. We Americans are also demanding cleaner air, so some sources of fossil fuels, such as coal, that are abundant and cheap are shunned in favor of cleaner burning natural gas, which, though currently abundant, is also finite and increasingly costly.

The question before us today is: Can technology derived from R&D efforts in the government, private sector and in our universities assist us in producing more energy, more efficiently and in a way that comports with the needs of public and worker health and safety, and the health of our environment?

Our first panel will consider all aspects of clean coal power technology, including how the President's proposed $2 billion in spending on clean coal technologies may both increase efficiency and reduce emission from utilities, and find innovative new uses for coal and coalbed methane. Our witnesses will be:

(1) Robert S. Kripowicz, Acting Assistant Secretary for Fossil Energy at the U.S. Department of Energy (Mr. Kripowicz will also appear on Panel 2);

(2) Ben Yamagata, Executive Director of the Coal Utilization Research Council (CURC);

(3) James E. Wells, Director of Natural Resources and Environment at the U.S. General Accounting Office;

(4) Katherine Abend, Global Warming Associate at the U.S. Public Interest Research Group (U.S. PIRG); and

(5) John S. Mead, Director of the Coal Research Center at Southern Illinois University-Carbondale. I understand that my colleague, Mr. Costello, will be introducing his constituent, Mr. Mead, formally at the conclusion of my remarks.

The second panel will consider how technologies derived from petroleum and gas R&D can be employed to improve exploration, extraction, refining and processing, and transportation of these fossil fuels. Our witnesses will include:

Page 43 PREV PAGE TOP OF DOC Segment 1 Of 7

(1) Virginia B. Lazenby, Chairman and CEO of Bretagne, GP, Nashville, TN, on behalf of the Independent Petroleum Association of America;

(2) Paul Cuneo, Vice President & Chief Information Officer of Equiva Services, LLC, Houston, TX on behalf of the American Petroleum Institute;

(3) Dr. Craig W. Van Kirk, Professor of Petroleum Engineering and Head of the Department of Petroleum Engineering at the Colorado School of Mines, Golden, CO; and

(4) Dr. Alan R. Huffman, Manager of Conoco's Seismic Imaging Technology Center, Houston, TX.

I look forward to hearing today's testimony and pursuing these subjects in greater detail.

Before we get started, however, I would like to remind the Members of the Subcommittee and our witnesses that this hearing is being broadcast live on the Internet so please keep that in mind during today's proceedings.

I would also like to ask for unanimous consent that all Members who wish might have their opening statements entered into the record. Without objection, so ordered.

I now turn to my distinguished colleague, Mr. Costello, for an introduction and his opening remarks.

Mr. **COSTELLO.** Well, Mr. Chairman, thank you very much, and I thank you for calling this hearing today. I will submit my statement, my formal statement, for the record. I welcome all of our witnesses here today and I look forward to hearing their testimony.

Page 44 PREV PAGE TOP OF DOC Segment 1 Of 7

In particular, I welcome a constituent and friend, John Mead, who is a part of the first panel. Mr. Mead is the Director of the Coal Research Center at Southern Illinois University in Carbondale. In fact, I recently attended just a few weeks ago a forum on clean coal technology and the future of coal at Southern Illinois University in my Congressional district. Mr. Mead was the moderator. It was a forum called by the Governor of Illinois and Senator Dick Durbin, as well as Members of the Congressional delegation, my colleagues, David Phelps and John Shimkus, also attended. John is very familiar with coal issues. He has been at the research center at Southern Illinois University for many years and is very familiar with clean coal technology.

Mr. Chairman, there is no question that clean coal technology exists today that, in fact, significantly

reduces emissions of air pollutants. And there is new technology that I believe will reduce emissions to a greater extent than we ever imagined or anticipated. Over 50 percent of all electricity generation comes from coal-powered plants in the United States today. We have an abundance of coal in Southwestern Illinois and other parts of this country and I believe that we, in fact—any policy—energy policy coming out of the White House or the Congress should, in fact, include, to a large part, coal.

I applaud the Administration and Vice President Cheney, as well as President Bush, for asking the Congress to put additional money in fossil fuel research and development and in clean coal technology. We, in fact, need to continue to do research and development so that we can burn coal in the most efficient and environmentally friendly manner. And with that, Mr. Chairman, I will insert my statement in the record and look forward to hearing from our witnesses. Thank you.

Page 45 PREV PAGE TOP OF DOC Segment 1 Of 7

[The prepared statement of Representative Jerry F. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

I'd like to thank the Chairman for calling today's hearing and welcome our witnesses. First, I would like to introduce Mr. John Mead from my Congressional District in Southern Illinois. I am pleased the Chairman extended an invitation to him to testify today at my request. Mr. Mead is the Director of the Coal Research Center at Southern Illinois University-Carbondale and is well acquainted with issues related to clean coal technologies. I am pleased that he is able to participate as a member of today's panel.

As Mr. Mead and our other panelists will testify, current clean coal initiatives have already proven to significantly reduce emissions of air pollutants and new advanced initiatives will be able to further reduce emissions to a greater extent than initially anticipated.

Clean air initiatives and coal usage can go hand in hand. That is why I believe it is so important to ensure that we include the President's Clean Power Initiative in any energy plan that comes out of this Committee, and that we do not permit cuts to the Fossil Energy R&D budget. As I have testified on several occasions my district was devastated by the loss of thousands of coal miners when the Clean Air Act went into effect. *We can burn cleaner coal.* We need to look at new advanced technologies to ensure the best possible methods are utilized. There are many opponents of coal, however, it is important to realize that over 50 percent of all U.S. electricity generation comes from coal power plants. And, there is going to come a time in the not too distant future when we will need to rely even more on this abundant resource. That is why we need to ensure *now* that we will have the technologies to burn cleaner coal.

Page 46 PREV PAGE TOP OF DOC Segment 1 Of 7

I look forward to hearing from our witnesses.

Chairman **BARTLETT.** Thank you very much. I note that we have been joined by two additional members of our panel, Mr. Smith and Ms. Biggert. You may make an opening statement if you wish. Any

formal statement will be included in the record. Do you have comments before we welcome our witnesses? Mr. Smith.

Mr. **SMITH.** Mr. Chairman, if I may, I was on the Presidential Oil Policy Committee during the Arab Oil Embargo back in the early '70's and it seems like again a revisiting of some of the concerns of our increased dependency on especially imported petroleum products. At that time, we were importing about 35 percent of our petroleum energy needs. Now, it is approaching 58 percent, I believe. And so, again, it should be a heads up and a reminder that that kind of dependency makes us more vulnerable and has a tremendous impact on both the economy and the environment. So thank you and the Ranking Member for holding this hearing. Thank you.

Chairman **BARTLETT.** Well, thank you very much. And I might add that there is a national security implication too and we are getting nearly 60 percent of oil from overseas. That is too little recognized, I think. Without objection, the full written testimony of all the witnesses will be entered into the record. I would ask that you summarize your testimony in five minutes so we will have plenty of time for questions. And let me assure you that any detail that you wish to expand on, you will have ample opportunity to do that during the question and answer period. So without any further delay, Mr. Kripowicz, you may begin.

Panel I

Page 47 PREV PAGE TOP OF DOC Segment 1 Of 7

STATEMENT OF ROBERT S. KRIPOWICZ, ACTING ASSISTANT SECRETARY FOR FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. **KRIPOWICZ.** Thank you, Mr. Chairman. Mr. Chairman, and members of the Subcommittee, I appreciate the opportunity to appear today with both panels and I want to commend the Subcommittee for holding this hearing. I believe it is important that periodically we step back from the day-to-day conduct of our programs and ask the questions, are we making progress, is that progress benefiting the American people, and are we moving in the right direction?

I believe that for the Federal Fossil Energy Program, the answer to each of those questions is an unequivocal yes. And I appreciate the initiative, Mr. Chairman, you have taken in holding this hearing to review the progress and benefits to date and to discuss the course we should be setting for the future.

In my formal statement I have used specific examples to illustrate some of the technology advances that have resulted from our partnerships with industry and academia. For each item I have cited, there are many more that could be referenced. In the interest of time, however, and to provide adequate opportunity for my fellow panelists, I will highlight only a few examples.

Let me begin with the Clean Coal Program. As you are aware, the President has made clean coal technology one of the core elements of his National Energy Policy. Why clean coal?

Page 48 PREV PAGE TOP OF DOC Segment 1 Of 7

As the chart on page 2 of my statement illustrates, coal supplies more than half the electricity consumed in this country and America has more than two-and-a-half centuries of recoverable coal. So at a time when a major issue confronting this Nation is the future reliability of electricity, it makes little sense to turn our back on this abundant resource, especially if we can develop technology that reduces, or perhaps 1 day soon eliminates, environmental concerns over its use.

The Clean Coal Technology Program that began in the mid-1980's and extended through five rounds of industry competition laid the groundwork for such technology. Thirty-eight projects ultimately were part of this program. Several are still underway. Of the 30 or so that have been completed, 22 have achieved some form of commercial success.

But more importantly, the Nation has benefited. When the Clean Coal Program began, power generations had only a limited number of choices for reducing most types of air emissions, and what was available was generally expensive and, in some cases, unreliable.

Today, largely because of the Clean Coal Program and related R&D, the menu of options has been greatly expanded. Low-NO**X** burners, for example, were unproven when the Clean Coal Program began. Now, because of the experience gained in several Clean Coal projects, three out of every four coal-fired power plants in the U.S. are, or will soon be, equipped with low-NO**X** burners.

Within the next two years, 30 percent will be outfitted with selective catalytic reduction for even greater NO**X** control. Again, the Clean Coal Technology Program helped demonstrate the technology and lower costs.

Page 49 PREV PAGE TOP OF DOC Segment 1 Of 7

In fact, before the Clean Coal Program, options for controlling nitrogen oxides could cost as much as $3,000 per ton of NO**X** removed. Today, these costs have been cut in half for selective catalytic reduction. And low-NO**X** burners can reduce nitrogen oxide pollutants at costs of less than $200 per ton.

Flue-gas scrubbers for sulfur dioxide, once expensive and unreliable, now cost g of their 1970's costs. Not only are they reliable, but the technology is now available to convert the sulfur they take out as a pollutant into a product that can be used to make wallboard, for example.

Again, Mr. Chairman, for a country that is increasingly concerned about the costs of electricity, having technology available that can reduce environmental compliance costs from what is already our lowest cost fuel for power generation, creates an enormous economic benefit.

Perhaps, equally important, the Clean Coal Program has provided the basis for future benefits, benefits that the President's new clean coal initiative is intended to achieve.

Coal gasification-based power generation is one of those new technologies. Because of the Clean Coal Program, we now have the first pioneering gasification combined cycle power plants operating commercially in the U.S. Their environmental performance approaches that of natural gas.

Page 50 PREV PAGE TOP OF DOC Segment 1 Of 7

Moreover, further improvements lie in the future. The use of fuel cells and advanced turbines, in combination with a coal gasifier, the ability to convert a portion of the coal gas into premium liquid fuels and chemicals, the potential to develop a coal-based energy system that lends itself to the future capture and sequestration of carbon dioxide—all of these are future pathways opened up by the clean coal gasification projects underway at Tampa, Florida and West Terre Haute, Indiana.

In fact, Mr. Chairman, as I mention briefly in my prepared statement, we see the very real possibility of future coal-fired plants that are virtually pollution-free. That for all intents and purposes, remove environmental objections from the use of our most abundant fossil energy resource.

Now, let me turn briefly to the subject of your second panel, which is petroleum and natural gas technology. Again, the long-term ability of our energy industry to find and produce the liquid and gaseous fuels on which our economy depends, will largely be dictated by continuing advancements in technology.

The Vice President's National Energy Policy Development Group recognized this and recommended efforts to continue fostering improvements in oil and gas technology. Again, in this area, I believe our track record is good.

One of the major advancements in oil and gas technology in the last 20 years has been the polycrystalline diamond drill bit, and we are proud of the fact that one of our national labs solved the bonding problem that made such bits possible. Today, we are working with national laboratories, universities, and the industry to make the next leap forward in drill bit technology. For example, using special microwave techniques to develop a bit that will last longer and drill deeper and faster.

Page 51 PREV PAGE TOP OF DOC Segment 1 Of 7

I have described new seismic technologies that were supported in our program, like four-dimensional seismic technology that adds time to the imaging equation, and new imaging systems that work at the bottom of an oil or gas well and whose resolution is ten times more precise than other technology.

These are technologies that offer benefits across the board for all types of companies drilling in more complex environments. But in recent years, the nature of our domestic oil industry has changed and so has the focus of much of our research.

Today, smaller independent companies are rapidly becoming the dominant oil and gas producers in the United States. Independent producers account for 40 percent of the crude oil produced in the United States and 50 percent of the oil produced in the lower 48. They produce h of our Nation's natural gas and they account for 85 percent of all the new wells drilled in the United States.

Now, very few of these companies conduct significant research by themselves. Traditionally, most have relied on technology to trickle down from the majors, but with more and more of the larger companies moving to more lucrative prospects overseas, the flow of new technology has slowed.

Our program attempts to fill the gap, working with independent producers to determine whether promising, but high-risk approaches work, and, if they do, requiring the producer and others in the industry to undertake an aggressive technology transfer effort.

Page 52 PREV PAGE TOP OF DOC Segment 1 Of 7

I have cited two examples in my testimony of partnership projects that have worked. One of the projects involved a complete oil field workover using new technology to locate and produce oil that had been previously abandoned. In the last five years, that project, near Bakersfield, California, has produced more than one million barrels of oil that, otherwise, would have remained in the ground. More importantly, it stimulated 100 new privately funded wells in the surrounding area.

That was a full cost-shared field test. Often, however, we find that small grants, targeted at very specific production problems, can return major benefits. A small producer working in a field in Los Angeles wanted to try a new type of acid treatment to remove downhole deposits that were on the verge of putting many of his wells out of operation. He applied for a DOE grant to help cover the risks of this unproven technique and was selected for a cost-sharing project in a DOE competition. The treatment has exceeded expectations. Oil flow not only has been restored, but is now four times the previous rate. And the producer is now holding workshops and technical meetings to describe the new acid treatment process to other producers.

These, I believe, Mr. Chairman, are the keys to successful Federal research programs. First, partner with industry to support the new ideas that otherwise would be too risk to pursue. Secondly, wherever possible, support new ideas through cost-sharing and where industry must compete with their peers for Federal support. And third, ensure that there is a built-in technology transfer, where the involvement of industry and the financial commitment that industry makes provide natural conduits for successful technologies to be used commercially once the Federal project is over.

Our goal is to foster this type of research program in the Fossil Energy Program at the Energy Department. With fossil fuels supplying 85 percent of the Nation's energy, we believe that such a program is a necessary component of a more energy secure, economically strong, and environmentally healthy future. Thank you for the opportunity to testify.

Page 53 PREV PAGE TOP OF DOC Segment 1 Of 7

[The prepared statement of Mr. Kripowicz follows:]

PREPARED STATEMENT OF ROBERT S. KRIPOWICZ

Mr. Chairman and Members of the Subcommittee:

I am pleased to have this opportunity to describe some of the most prominent efforts in the Department of Energy's fossil energy research, development and demonstration program. Rather than outlining all of the activities we have underway in our program, I have organized this statement around some of our most notable accomplishments and the benefits that have accrued to the Nation's energy industry and to the public.

Given the role that clean coal technologies play in President Bush's recently released National Energy Policy and the President's commitment to invest in a new generation of clean coal power technologies, my formal statement begins with a description of clean coal technology progress to date and the President's plan for new clean coal investments in the future.

The Clean Coal Technology Program

The Clean Coal Technology Program was a major government-industry initiative undertaken in combination with an ongoing coal research program to develop environmental solutions for the Nation's abundant coal resources.

Page 54 PREV PAGE TOP OF DOC Segment 1 Of 7

Begun in 1986, the program was a response to concerns over acid rain, which is formed from sulfur and nitrogen pollutants emitted by coal-burning power plants and industrial operations, as well as by vehicles and other sources. As the program progressed, its goals broadened to include reductions in greenhouse gas emissions through enhanced fuel efficiencies—i.e., generating more electricity using less fuel with fewer carbon dioxide emissions.

Industry-proposed projects were selected through a series of five national competitions aimed at attracting promising technologies that had not yet been proven commercially.

Ultimately, 38 pioneering projects in 18 states became part of the Clean Coal Technology Program. The public-private partnerships formed in this program involved:

More than 55 individual electric generators serving customers in 33 states;

Utilities that operate more than 170,000 megawatts, about 23 percent of U.S. capacity and consume 36 percent of U.S. coal production; and

More than 50 technology developers and 30 engineering, constructing or technical service providers.

The Federal Government's funding share totaled $1.8 billion—actually below the original government estimate of $2.5 billion. The private sector, on the other hand, exceeded expectations, contributing $3.5 billion or nearly two-thirds of total project costs, well above the legally-mandated requirement of 50 percent non-federal financing.

Page 55 PREV PAGE TOP OF DOC Segment 1 Of 7

Why Clean Coal?

Coal is the United States' most abundant domestic energy resource. One quarter of all the world's known coal supplies are found within the United States. In terms of energy value (Btus), coal constitutes approximately nearly three-fourths of U.S. fossil energy reserves.

Our Nation's recoverable coal has the energy equivalent of about one trillion barrels of crude oil—comparable to all the world's known oil reserves. At today's consumption rates, U.S. coal reserves could last at least 250 years.

Coal is also an energy bargain. Historically it has been the least expensive fossil fuel available in the United States, and in contrast to other primary fuels, its costs are likely to remain stable or decline as mine productivity continues to increase. During the past decade, in fact, coal prices at U.S. steam electric power plants actually declined about 18 percent, in nominal terms, while petroleum and natural gas prices increased by 31 percent and 11 percent, respectively.

Because of its abundance and low cost, coal now accounts for more than half of the electricity generated in the United States.

The Nation is likely to use more coal in the future, especially as strong economic growth, including the expanding digital economy, creates new demands for electricity.

Page 56 PREV PAGE TOP OF DOC Segment 1 Of 7

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Even with the large projected growth in other power generation fuels—especially natural gas—coal will continue to supply about half our electric power for at least another 20 years. Because of the overall increase in power demand, the Energy Information Administration forecasts that the Nation will likely require nearly 20 percent more coal be used by 2020.

Given that the United States needs all the electricity it can generate from its most reliable and stable resources, coal can remain one of America's greatest energy strengths—especially if new technology can reduce environmental impacts and help keep the Nation's energy affordable.

The Clean Coal Power Initiative

The Bush Administration is proposing a new vision for research into clean coal technology, pledging to invest $2 billion in clean coal power technology over the next 10 years. In setting the direction for new, competitively awarded clean coal research, development and demonstration efforts, greater emphasis will be placed on seeking the advice of industry in shaping the program. We intend to investigate the use of consortia of companies, an industry board, or other mechanisms that can enhance the private sector's participation in planning this initiative.

The program will also solicit participation by universities as well as government laboratories in a broad-based effort to apply the best minds and institutions to eliminate the barriers to enhanced coal use. Successfully implemented elsewhere in DOE, industry-guided research will choose the most important projects based on industry-defined merit.

Page 57 PREV PAGE TOP OF DOC Segment 1 Of 7

This is an investment well worth making. The President's initiative builds on a solid track record of accomplishments that have resulted from the Federal Government's significant investment in clean coal technologies in the late 1980s and 1990s. From that investment has come:

Cleaner Air Made More Affordable. Tight new environmental standards enacted in 1990 as part of the Clean Air Act Amendments put America's utilities and factories on a new path toward sharp reductions in air emissions. For many companies, the combination of coal research and development and the Clean Coal Technology Program provided better options to meet the more stringent regulations while at the same time, continuing to fuel America's astounding economic growth during the 1990s.

The following chart of the 38 Clean Coal Technology projects shows that 22 of the original projects have achieved commercial success—either by continuing to operate with private sector financing or by being sold and replicated in other commercial applications.

[NOTE: Several of the 38 are still in the design, construction or testing phase, therefore it is likely that the number of commercial "success stories" will increase in the future.]

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Page 58 PREV PAGE TOP OF DOC Segment 1 Of 7

U.S. utilities, to meet America's growing power demands, increased coal use 60 percent between 1980 and 1998. Yet, because of new technology and market-based emission compliance policies, the Nation's power plants reduced emissions of sulfur dioxide by 22 percent and emissions of nitrogen oxides by 13 percent. Moreover, under today's regulatory strategies, further reductions are occurring. Preliminary indications show nitrogen oxides, for example, dropping another 10 percent in 2000.

Consumer Benefits. Clean coal technology has helped the U.S. power industry meet new emission standards and, at the same time, keep electric bills relatively low.

Americans pay over $200 billion a year for electricity. Yet, U.S. citizens still enjoy some of the lowest electric rates of any free market economy in the world. Low cost coal is a major reason. The lower cost clean coal technologies that became available in the 1990s are one reason why the Nation's utilities could meet new environmental standards without imposing harsh price hikes on ratepayers.

Some of the specific benefits from the federal investment to date in clean coal technologies include:

*Reducing Smog—NO**X** Controls:* Before the Clean Coal Technology Program, most options for significantly reducing smog-forming nitrogen oxide (NO**X**) pollutants were untried and expensive, in some cases, costing $3,000 per ton of pollutant removed. The Clean Coal Technology Program demonstrated new ways to reduce nitrogen oxides at lower costs.

Page 59 PREV PAGE TOP OF DOC Segment 1 Of 7

The result is that 75 percent of the existing coal-fired generating units have been or are currently being retrofitted with low-NO**X** burners that can reduce nitrogen oxide emissions at costs of less than $200 per ton.

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For utilities operating in areas where even more stringent air emission standards are in place, the Clean Coal Technology Program showed how "selective catalytic reduction" could be applied more reliably using U.S. coals. This technology now costs half what it cost in the 1980s, and systems are on order or under construction on 30 percent of U.S. coal-fired generating capacity.

Because of these improvements, U.S. utilities are projected to reduce nitrogen oxide emissions by 25 million tons *more* than would have been the case without the clean coal research and demonstration program —and do so cost-effectively.

Reducing Acid Rain—Flue Gas Cleanup: When the Clean Coal Technology Program began, flue gas desulfurization units—or "scrubbers"—were already being installed on many of the Nation's power plants. But scrubbers were expensive and difficult to operate, and early technologies were unreliable. The Clean Coal Technology Program sponsored tests of new types of scrubbers with higher reliability and lower costs. The technological advances stimulated manufacturers to make improvements in virtually all scrubbers.

Flue gas desulfurization systems now cost one-third what they did in the 1970s, and more than 400 commercial units have been deployed.

Page 60 PREV PAGE TOP OF DOC Segment 1 Of 7

Powering the 21st Century—The Next Generation of Power Plants: Prior to the Clean Coal Technology Program, the technology for coal-fired power plants was generally limited to the pulverized coal boiler—a large furnace-like unit that burns finely-ground coal. The Clean Coal Technology Program demonstrated alternatives with higher fuel efficiencies and superior environmental performance.

For example, a "fluidized bed" combustor—a technology that can trace much of its roots to early federal research—has the inherent advantage of burning virtually any type of coal (and other fuels) while removing pollutants inside the boiler. No scrubber or nitrogen oxide control system is needed.

Although used in small-size industrial applications, e.g., factories, chemical plants, steam heating plants, etc., they had not been tested at utility power plant scales. The Clean Coal Technology Program showed that utility-size fluidized bed combustors could be operated reliably. As a result, nearly $8 billion in commercial sales have been made.

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The Clean Coal Technology Program also introduced a new way to use coal generate electricity. Rather than burning, coal could be gasified—i.e., turned into a combustible gas. In gaseous form, virtually all pollutant-forming impurities can be removed. The coal gas can be made as clean as natural gas. Like natural

gas, it could be burned in a gas turbine-generator, and the turbine exhaust used to power a steam turbine-generator. This "combined cycle" approach raised the prospects of unprecedented increases in fuel efficiency.

Page 61 PREV PAGE TOP OF DOC Segment 1 Of 7

Gasification combined cycle plants built as part of the Clean Coal Technology Program near Tampa, Florida, and West Terre Haute, Indiana, are the cleanest, most efficient coal plants in the world. Today, gasification combined cycle is rapidly gaining favor around the world. Over 1500 megawatts are operating using coal today, and another 1900 megawatts are gasifying refinery wastes. Another 2200 megawatts are in the design stage.

Why a New Clean Coal Commitment?

Many of the innovations likely to emerge from the President's new effort will be directed at new challenges largely unanticipated at the time of the original Clean Coal Technology Program:

Tighter Air Quality Standards: The original Clean Coal Technology Program began in the mid-1980s as a response to increasing concerns over acid rain, and especially the impact of acid rain pollutants drifting into the Northeast and across the U.S. border into Canada. Midway through the program, Congress passed the 1990 Clean Air Act Amendments which set new pollution standards for sulfur dioxide and nitrogen oxide emissions.

Since the Clean Air Act Amendments were enacted, even more stringent environmental standards have been put into place—most of which directly affect coal-burning power plants. For example:

— The Environmental Protection Agency has promulgated new regulations to reduce the regional transport of ozone (a pollutant that can cause smog and visibility problems), which will require eastern utilities to sharply reduce nitrogen oxide emissions below levels in the 1990 Clean Air Act Amendments.

Page 62 PREV PAGE TOP OF DOC Segment 1 Of 7

— The National Ambient Air Quality Standards, revised in 1997, are intended to reduce the levels of airborne particulate matter—including ultra-tiny particles. Since gaseous emissions of nitrogen oxides and sulfur dioxide can condense in the atmosphere and form these small particles, the new rules will require further reductions in these pollutants.

— Mercury: Trace amounts of mercury are released when coal is burned. The Environmental Protection Agency intends to propose new mercury control regulations by December 2003. At this point, however, there is no consistent, reliable technology for removing mercury that works for all boiler types used in coal-fired power plants.

With new, lower cost technology, power plants that might otherwise be retired, or whose generating output might be reduced, can be kept in operation and in compliance with new air quality requirements. New power plants can be built with even better environmental performance. Both will be especially

necessary at a time when consumers are demanding more electricity, not less.

The Nation's Appetite for Electricity Continues to Grow. Today's best forecasts indicate that from 1999 to 2020, electricity demand in the United States will increase by 45 percent. The projected rise in demand would require the construction of 1,300 to 1,900 new power plants—about 65 each year. The Nation has not experienced that type of capacity growth in the last 15 years.

Moreover, this could be a conservative estimate. Throughout the 1990s, actual electricity consumption far outstripped the best projections—driven largely by an expanding economy.

Page 63 PREV PAGE TOP OF DOC Segment 1 Of 7

New Technologies Have Emerged. The computer revolution since the mid-1990s has also played an important role in the development of new power plant technologies. New computer-aided control systems, running off neural networks and artificial intelligence, could make it possible to fine-tune combustion processes to their peak efficiency—not only boosting the amount of electricity an existing plant can generate but also helping it to reduce air emissions.

Improved burner designs, better gas cleaning systems, higher performance turbines and fuel cells are just a few examples of new technologies that can generate electricity from coal with unprecedented emission reductions and higher fuel efficiencies. Increasing fuel efficiency not only makes pollution control more cost-effective, it also reduces the release of greenhouse gases—making it one of the most affordable ways to deal with concerns over climate change.

Ultimately, the early prototypes of a virtually "zero-emission" coal-based energy plant could emerge from the Department's coal research and development program. The Department has termed the effort the "Vision 21" program—a concentrated research and development program designed to produce a pollution-free, coal-based power plant by 2015. The Clean Coal Technology Program has shown how several new technologies —from coal gasification to advanced coal-to-liquids production—could make this multi-fuel, multi-product energy plant possible.

The Gas Turbine of Tomorrow

Page 64 PREV PAGE TOP OF DOC Segment 1 Of 7

While the Clean Coal Technology Program was one of the largest and most diverse public-private initiatives to improve the way electricity is generated, other government-industry partnerships have also produced significant successes. One of the most significant has been the successful partnership of government and industry to accelerate development of a "breakthrough" gas turbine. This program is now drawing to a conclusion, having successfully produced its desired goals.

Natural gas turbines are likely to dominate the power generating market in the foreseeable future. For many years, however, gas turbine manufacturers faced a barrier that, for all practical purposes, capped power generating efficiencies for turbine-based power generating systems. The barrier was heat. Above

2300 degrees F, the scorching heat of combustion gases caused metals in the turbine blades and in other internal components to begin degrading. Since higher temperatures are the key to higher efficiencies, this effectively limited the generating efficiency at which a turbine power plant could convert fuel into electricity.

In February 2000, GE Power Systems unveiled the first gas turbine slated for the U.S. market that would break through the temperature barrier and push efficiencies to unprecedented levels. Using advanced materials and revolutionary new steam-cooling technology, the new turbine is capable of operating at 2600 degrees F.

The H System*TM* gas turbine was one of the culminating achievements of the Department of Energy's Advanced Turbine System research program. Designed to work in a combined cycle mode (i.e., in combination with a steam turbine generator), the H System will be the first to surpass the 60 percent efficiency threshold—the *"four minute mile"* of turbine technology. Moreover, the H System*TM* will operate cleaner than any of today's utility gas turbines. Its nitrogen oxide emissions levels of 9 parts-per-million without additional external controls will be half the average of the turbines now in use, making the technology suitable for siting in some of the Nation's most environmentally constrained areas.

Page 65 PREV PAGE TOP OF DOC Segment 1 Of 7

The unit announced in February 2000 will be one of two advanced turbines that will power the 800-megawatt Heritage Station in Scriba, New York. The power plant, being built by Sithe Energies, one of the Nation's leading independent power generators, is scheduled to go online during 2002.

Innovations from DOE's turbine R&D program have already found their way into commercial plants. In April 2001, the Millennium power plant in Charlton, MA, came online using advanced gas turbine technology developed in DOE's program. At the core of the 360-megawatt natural gas combined cycle plant, owned by PG&E National Energy Group, is a Siemens Westinghouse Power Corp. gas turbine that incorporates advanced compressor technology, improved materials and seals, and new combustor enhancements developed as part of DOE's program. Siemens Westinghouse plans to have an even more advanced machine on the market in 2004/5 that will be the major product of its joint development effort with the department.

Fuel Cells—A New Power Source

Fuel cells are a technology with the potential to fundamentally change the nature of electric power generation. What makes fuel cells attractive is that they can produce high-quality power from hydrocarbon fuels without combustion.

The basic concept of fuel cells has been known for more than a century. They began to receive serious attention in the 1950s and 60s when NASA chose them as the best technology for producing power on-board the Gemini and Apollo spacecraft. These early cells required pure hydrogen and oxygen fuels and used high-cost materials such as platinum electrodes. Over the past three decades, significant effort has been expended to develop practical and affordable designs for stationary power production.

Today, fuel cell costs continue to be reduced, although they are still well above those of more conventional power sources. Nonetheless, the first fuel cells have moved into commercial applications. Nearly 200 "first generation" phosphoric acid fuel cells—the product of DOE's R&D program in the 1970s and early 1980s—are now installed worldwide.

Since the mid-1980s, the Department's fuel cell research funding has been focused primarily on technologies that work at higher temperatures, generating power more efficiently and improving the economic outlook for this new power generating approach. In recent months, significant milestones have been achieved that have raised optimism that advanced generations of fuel cells will soon cross over the commercial threshold. For example:

Fuel Cell Energy Corp. has "cut the ribbon" for its new fuel cell manufacturing facility in Torrington, CT. Incorporating several new manufacturing methods developed in DOE's program, the new facility will increase the company's fuel cell production capacity 10-fold, a production rate of 50-megawatts per year. This facility will be the largest in the world for the manufacturing of molten carbonate fuel cell systems.

The company, which has been a partner in DOE's fuel cell program since the 1970s, is also receiving its first orders for commercial-scale "market entry" fuel cells. Its 250 kW Direct Fue1Ce11® power plant unit will be installed by the Los Angeles Department of Water and Power this year (the utility has also ordered two more units); another unit will help power the Mercedes-Benz U.S. International, Inc., plant in Tuscaloosa, AL, with funding from Southern Company, the Alabama Municipal Electric Authority, and FuelCell Energy; a third unit recently began generating power for the Rhon-Klinikum Hospital in Bad Neustadt, Germany; and the company recently announced an agreement with King County, WA, to supply a fuel cell that will be fueled by wastewater digester gas from the South Wastewater Treatment Facility in Renton, WA.

Siemens Westinghouse Power Corporation, also a long-time partner in DOE's fuel cell program, is moving its all-ceramic solid oxide fuel cell into commercial-scale development. An early prototype 100-kilowatt unit recently achieved a world-record 16,598 hours of operation at a power plant in the Netherlands, and the company is preparing to demonstrate a 250-kilowatt fuel cell-turbine hybrid unit at the National Fuel Cell Research Center in Irvine, CA. A 1-megawatt unit is planned for the Environmental Protection Agency's laboratory at Ft. Meade, MD. Siemens Westinghouse has also received two major European contracts to install solid oxide fuel cell power systems in Essen, Germany, and Milan, Italy, in 2002, and recently, the company signed an agreement with four European utilities to install a fuel cell-turbine hybrid system in Marbach, Germany in 2003.

At current costs of $2,500 to $4,000 per kilowatt, fuel cell technology is still considerably more expensive than comparable gas turbine based power systems. Even if costs are reduced to the $1,000 to $1,200 per kilowatt range; the technology will largely be demand only for applications where premium-quality, on-site

power is critical to commercial operations or where environmental restrictions limit other types of power sources.

It may be possible, however, to reduce future fuel cell costs to as low as $400 per kilowatt—a cost that will make the technology highly competitive with virtually any power source. DOE is investing in a new Solid State Energy Conversion Alliance (SECA) that focuses the efforts of government, commercial developers, universities, and national laboratories on bringing to fuel cell technology the same advancements that have revolutionized the solid state electronics industry. The basic building block of the SECA effort will be a 5-kilowatt solid state fuel cell module that can be "mass customized" for use in residential or auxiliary power units, or linked together like batteries for larger power applications.

Page 68 PREV PAGE TOP OF DOC Segment 1 Of 7

Deeper, Faster, Smarter, Cleaner—DOE's Oil and Gas Successes

Oil and natural gas remain the dominant fuels in the U.S. economy, providing 62 percent of the Nation's energy and almost 100 percent of its transportation fuels. By 2020, the Energy Information Administration expects the United States to need about 50 percent more natural gas and one-third more oil to meet demand.

When the National Energy Policy Development Group presented its report a few weeks ago, it included two recommendations that emphasized the importance of new technology for the U.S. oil and gas industry:

The NEPD Group recommends that the President direct the Secretaries of Energy and the Interior to promote enhanced oil and gas recovery from existing wells through new technology;

The NEPD Group recommends that the President direct the Secretary of Energy to improve oil and gas exploration technology through continued partnership with public and private entities.

The emphasis in the President's National Energy Policy on advanced technology for oil and gas exploration and production is well-founded. Finding, developing, and producing oil and gas today is an extremely high-tech venture, with private industry relying on cutting edge innovations that rival the most sophisticated technologies of any of our most advanced modern-day industries.

Page 69 PREV PAGE TOP OF DOC Segment 1 Of 7

New oil and gas technologies have proven their worth—both in terms of providing vital oil and gas supplies from domestic fields to improving environmental protection in and around oil and gas operations. For example, technological advances have enabled oil and gas producers to:

Access new frontiers—It is now possible to drill in deeper waters, deeper in the earth, in the cold frontiers of the arctic, and in new resource settings such as coal seams, all thought uneconomic not too many years ago.

Find oil and gas more efficiently—Drilling success rates have doubled in the last two decades, resulting in fewer dry holes.

Find more oil and gas per well drilled—Today, fewer than half as many wells must be drilled to locate the same amount of oil and gas reserves as two decades ago.

Reduce costs—In inflation-adjusted dollars, wells can be drilled today to the same depth 20 percent cheaper than in the 1980s.

Extract more oil and gas from discovered fields—Enhanced recovery now allows industry to produce a higher proportion of the hydrocarbons in discovered reservoirs, leaving less behind.

DOE's technology development program has contributed to this progress. Some of the most notable accomplishments have been:

Page 70 PREV PAGE TOP OF DOC Segment 1 Of 7

Polycrystalline diamond drill bits—Nearly 20 years of attempts to increase the durability of drill bits by bonding industrial diamonds to the bit had not been successful until DOE's R&D program found a way to use "diffusion bonding"—an outgrowth of defense research—to permanently adhere the diamond cutters to the bit. The resulting polycrystalline diamond drill bit has shown its ruggedness by drilling 20,000 feet without a bit change. In time-critical drilling, the bit can save as much as $1 million per well. Now, the bits make up at least one-third of the worldwide drill bit market, and DOE is working with universities and industrial groups to continue improving the technology. Microwave-hardened drill bits may be the next major advance coming from DOE's R&D program.

4-dimensional seismic imaging—One of the most significant advances in petroleum technology has been the development of 3–D seismic imaging which gives producers the ability to "see" potential oil- and gas-bearing formations in three spatial dimensions. In recent years, a DOE cost-shared project showed that imaging technology did not have to limited to only three dimensions. A fourth—time—could be added to reveal entirely new arid valuable data about the productive potential of an oil reservoir. 4-dimensional seismic imaging gives petroleum engineers a way of visualizing how fluids move through reservoirs, revealing zones where oil is being drained from the formation and other zones where oil remains untapped. Because of DOE's, 4–D seismic technology now accounts for more than $500 million in commercial oil and gas services in the Gulf of Mexico alone.

Cross-Well Imaging—"Cross-well" seismic imaging technology was first developed in DOE's oil and gas research at a national laboratory. This work expanded the use of seismic waves to image the reservoir by applying the technology downhole between wells rather than from the surface. This new seismic system generates images with much greater clarity, for example, surface seismic can detect features as small as 50 feet, crosswell imaging can detect features as small as five feet.

Page 71 PREV PAGE TOP OF DOC Segment 1 Of 7

In recent years, DOE's petroleum and natural gas program has increasingly recognized the technology needs of the smaller, independent oil producer. Today this segment of the industry accounts for 40 percent of the crude oil produced in the United States (and 50 percent of the oil produced in the lower 48 States)

along with 66 percent of the Nation's natural gas production. Nearly 85 percent of all the wells now drilled in the United States are drilled for and by independent producers.

DOE's partnership efforts with smaller, independent producers have led to notable successes and active technology transfer efforts to neighboring producers and fields. For example:

New Life for an Abandoned Field—An abandoned Bakersfield, CA, oil lease was brought back into production in 1995 in a DOE program that provided cost-sharing for trials of promising, but largely unproven technology. Earlier this year, the Department announced that the field has now produced more than a million barrels of oil—nearly half as much as the field produced in its first 80 years of production. More importantly, because of the success, oil is flowing from 100 new privately funded wells in the immediate vicinity.

An Acid Test of a New Technique—In an oil field in downtown Los Angeles, a small producer applied for and received a DOE grant to test a new type of acid treatment to remove scale and other deposits that had gradually clogged production from his marginal wells. The treatment, which avoids the long-term damage to the formation common to other acid methods, proved to be a major success. Oil from the treated wells is now flowing at 4 times the pre-treatment rate, and the technique is being made available to other producers facing similar production obstacles.

New innovations can also take the form of better ways to improve environmental compliance. DOE's oil and gas program continues to work with a variety of government and private sector partners to lower the costs and improve the effectiveness of environmental compliance methods. For example:

The Risk Based Data Management System—Developed in a cooperative effort between DOE and the Ground Water Protection Council, this PC-based computer system is now being used by 17 states to make better regulatory and resource management decisions. These states have already recorded more than $20 million in regulatory cost savings while, at the same time, improving their confidence that decisions are economically and environmentally sound.

Cleaning Contaminated Soils—A DOE national laboratory project has shown that software and data collection techniques originally developed to clean up Cold War defense sites could help save the Nation's oil and gas producers millions of dollars in cleaning up soils contaminated with naturally occurring radioactive material. Using portable detection equipment and a unique DOE-developed statistical software program, researchers showed how a the costs of locating and cleaning up a contaminated petroleum pipe yard could be reduced by as much as 90 percent.

Conclusion

When Vice President Cheney presented the report of the National Energy Policy Development Group to the President last month, he prefaced it with the statement:

"[The report] envisions a comprehensive long-term strategy that uses leading edge technology to produce an integrated energy, environmental and economic policy."

Technology is a core element of the President's National Energy Policy because technology R&D has played a major role in bringing about the energy successes of the past 20 years. Advances in clean coal technologies have enabled coal to maintain its position as a reliable, low cost provider of electricity. Advances in turbine technology have encouraged the reentry of natural gas into electric power generation. Advances in drilling and production technologies, such as new seismic imaging and high-strength drill bits, have opened up opportunities for increased oil and gas production with higher success rates and lower costs.

Our goal at the Energy Department in the future is to continue to foster these types of technological advances through partnerships with the private sector. Our challenge is to determine where the government's role can be most productive and beneficial to the national need for affordable, reliable and environmentally clean energy.

With fossil fuels now providing 85 percent of the Nation's primary energy—an amount that could increase to nearly 88 percent by 2020—we take this challenge very seriously.

Thank you for the opportunity to describe many of our accomplishments to date.

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Page 74 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** Thank you very much. Mr. Yamagata.

STATEMENT OF BEN YAMAGATA, EXECUTIVE DIRECTOR, COAL UTILIZATION RESEARCH COUNCIL (CURC), WASHINGTON, D.C.

Mr. **YAMAGATA** . Public and private partnerships. I pretend to be a technologist, but that is clear evidence that that is not the case. In any case, we have submitted a written statement. In that written submittal, may I commend to you, Mr. Chairman, and to members of the Subcommittee, for your review, there is a detailed description and discussion of our organization's coal technology road map which has been an attempt by our membership to outline the technology needs for coal that at least we believe will best ensure the long-term economic and environmentally acceptable use of this very plentiful domestic and secure energy resource.

May I also commend to your viewing an electronic version of a document prepared by the National Mining Association that describes the overall benefits of coal and the value of the government and industry's Clean Coal Technology Program. Within the time allotted to me, Mr. Chairman, I would like to use this handout that I have prepared for the Committee's perusal, and to discuss with you very generally the elements of the CURC technology road map and then to suggest to you that successful pursuit of this road map or any other like technology road map will require a commitment, a commitment on the part of industry and government, a commitment that must form—be formed by adequate amounts of time and adequate amounts of cost-shared funding.

Over the course of the last couple of years, the membership of CURC has drafted and agreed upon the key elements of a coal technology road map. This is not unlike the roadmaps that have been produced by the Department of Energy in their Vision 21 program.

Page 75 PREV PAGE TOP OF DOC Segment 1 Of 7

May I turn your attention to page 3 of this handout? That page is entitled, "Performance Targets for Coal Generation." Herein lies the essence of our coal technology road map that sets forth the goals and the timetables for technologies to ensure the continued long-term use of coal.

Very, very briefly, this is a chart that attempts to explain the time frames for technology development. That is, the technologies that we have today, both their costs and their performance criteria, along with the technologies in the 2010 and the 2020 time frame, which we believe industry and government are capable of achieving.

Let me just point out that one of the metrics in the 2020 time frame is that we try to, and we believe we can, develop technologies that are twice as efficient as the type of power plants we see today. Technologies that will be cost effective and embedded in the technologies themselves are the ability to sequester CO to the extent that that is necessary.

May I turn your attention to page 4 of the handout entitled, "CURC Highest Priority, Coal-Fired Generation Technology Development?" Here we have attempted to identify the critical technology needs for coal by describing a set of five technology platforms. That is along the left-hand hash marks of the chart. These technology platforms focus upon coal technology needs that are required in the near term to address existing power plant emission regulations. In the mid term, that is to 2010. For—so that we can contemplate the expanded use of what we know we have today—that is, pulverized coal units in the form of supercritical and ultra-supercritical coal units. And in the farther out period, that is the 2020 time period, primarily to use gasification or combustion gasification systems to achieve very high, cost-effective high efficiency and high emission control technologies.

Page 76 PREV PAGE TOP OF DOC Segment 1 Of 7

I would hasten to add that gasification currently exists with Texaco and others, as it is now applied commercially around the world. It is, however, also the building block upon which future technology ought to be developed. Importantly—importantly, we have also estimated the total funding requirements that these technology platforms will be acquired. That is, to meet the goals and the time tables laid out in the chart on page 3.

In our view, an investment of at least $10 billion will be required over the next 20 years, up to b from the private sector and the remaining from the public sector, over the next 20 years. This public/private commitment includes time and funding for research and development and also for demonstration and deployment of new first-of-a-kind systems.

Two quick points, Mr. Chairman, if I may. First, the existing Clean Coal Program has been a great success. As Assistant Secretary Kripowicz has pointed out, 38 projects undertaken, a total of more than $5 billion committed and spent. I commend to you an attachment in my written testimony, drafted by the Southern Company, that seeks to identify the benefits of joint industry government clean coal efforts, for those so critical of past clean coal efforts, please look at the facts.

Second, and most importantly, we are delighted with President Bush's commitment to a multi-year clean coal development program. He has sought to initiate that commitment with $150 million request this year, to begin a long-term demonstration program. I would point out, however, that you cannot take funds away from the basic coal R&D program to cover the costs of the demonstration program. We need both of them. We need R&D, particularly, because it is the seed corn that will grow improvements later on.

Page 77 PREV PAGE TOP OF DOC Segment 1 Of 7

In this same vein, the Vision 21 program, which, frankly, is more aggressive in its technology goals than even the CURC roadmap, needs to contemplate demonstration programs on a scale that will provide industry with confidence that the technology actually works.

In conclusion, there are plenty of technology road maps. We have one of them. We know what needs to be done, Mr. Chairman, and, Members of the Subcommittee. It is time and money that must be committed by both the private sector and the public sector. We need to set a course for coal-based R&D and then we need to stick to it. Thank you.

[The prepared statement of Mr. Yamagata follows:]

PREPARED STATEMENT OF BEN YAMAGATA

This statement is submitted on behalf of the members of the Coal Utilization Research Council (CURC). The CURC is an ad hoc group of electric utilities, coal producers, equipment suppliers, state government agencies, and universities. Members of CURC share a common vision of the strategic importance for this country's continued utilization of coal in a cost-effective and environmentally acceptable manner. The CURC membership also believes that coal-based generation should be preserved to ensure a diversity of fuel supply, produce affordable and reliable electricity, and maintain a strong U.S. economy.

U.S. economic growth and worldwide sustainable economic development depends upon plentiful and relatively low cost supplies of energy and industrial feedstocks made readily available to consumers, with appropriate assurance provided to protect the environment. Supplies of affordable energy, as well as industrial feedstocks, can be best achieved and maintained if the marketplace has a variety of reasonable options available from which to choose. Coal is a critical component of our domestic energy portfolio, and coal-based R&D has great value to the American economy (Attachment A). This abundant and secure domestic energy resource comprises 90 percent of combined U.S. energy reserves and currently fuels 51 percent of the electricity generated in the United States. Coal will remain an indispensable fuel in the U.S.; we have 250 years of supply at current rates of consumption. On the international front, coal use is expected to double from the current 25 percent, to 50 percent of worldwide energy consumption by the year 2015, as

developing countries seek an increasing supply of readily available, least-cost energy. Further, in light of the enormous use of petroleum products in the transportation and industrial sectors, and the attendant impacts of changes in oil prices on the global economy, it is probable that coal will play an increasingly important role in the transportation and industrial sectors as petroleum stocks diminish and prices rise.

Page 78 PREV PAGE TOP OF DOC Segment 1 Of 7

Notwithstanding the importance of coal to the global economy, this fuel faces significant challenges that could impede its continued contribution to the Nation's energy mix. The development and widespread use of technologies will improve the cost competitiveness of coal, enhance the efficiency by which it is converted to useful energy, and ensure the minimization of its environmental impacts. In fact, investment in clean coal technologies has already produced a number of benefits (Attachment B), but more must be done.

In 1998, the membership of the CURC developed a Technology Roadmap designed to guide the application of resources in the development of technologies intended to insure the long-term utilization of coal. Since that time, a series of events led the CURC to re-examine the elements of the Roadmap and to make modifications. The updated roadmap, which I am submitting for the record (Attachment C), is intended to focus attention on the need for government and industry to work together to insure the timely commercialization and utilization of advanced coal-based technologies. The Roadmap is just that—a tool that outlines the necessary R&D priorities that will enable the long-term, continued use of coal. The CURC membership spent an extensive amount of time determining feasible, yet challenging, technology targets for timeframes of 2010 and 2020. Establishing goals and timelines is a means to continuously measure success or the lack thereof. The performance targets chart below illustrates, for example, the CURC's goal of a 45%–60% coal conversion efficiency rate by 2020; up from today's 35%–40% conversion efficiency levels. The Roadmap also defines realistic performance targets for emissions released by coal-fired generation and targets the costs at which we believe these ambitious goals can be achieved. The following summarizes the CURC goals and timetables.

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Page 79 PREV PAGE TOP OF DOC Segment 1 Of 7

The CURC recognizes that these performance targets and timetables are ambitious, but they are important in order to keep coal a cost-competitive and environmentally compliant option well into the future. To achieve these goals, government and industry must work together to support an appropriate balance of short-term and long-term activities. In order to reach these targets, the following elements must be included in any strategy that seeks to develop technologies that will cost-effectively achieve the goals of the Roadmap.

1) A coal-based technology R&D program that addresses technology needs to improve efficiency and reduce emissions from coal-based generation.

2) A financial incentives program designed to encourage application of advanced technologies to existing coal units to increase efficiency and improve emissions control.

3) A demonstration program that provides tax incentives and/or financial assistance to demonstrate advanced clean coal technologies at home and abroad.

To insure that a healthy and continuing R&D program is identified and undertaken, the CURC has established a compilation of its highest R&D priorities for coal-fired power generation technology development. These priorities are highlighted below. Members of the CURC determined that power plant emissions reductions, supercritical and ultra-supercritical plants, gasification-based power plants and CO sequestration are the technology platforms upon which the future of cost competitive and environmentally compliant coal use rests. The chart provides a short explanation of outstanding technical issues, and the reasons why the market requires R&D in these areas.

Page 80 PREV PAGE TOP OF DOC Segment 1 Of 7

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To address the technical and economic risks of new technology application, financial incentives are necessary to encourage businesses to make the expensive decision to utilize advanced clean coal technologies and to apply these technologies to the fleet of existing coal-fired power plants. Legislation has been introduced in the Senate to provide tax incentives in addition to authorizing new funding for advanced coal technology research and development. The National Electricity and Environmental Technology Act, outlined below, would comprise an important part of a comprehensive clean coal technology initiative. A part of that proposal directly addresses the type of incentives required to encourage the use of technologies on the Nation's fleet of existing coal-fired power plans. The CURC Technology Roadmap in part depends on the existence of financial incentives like these to reach the performance targets outlined in the CURC Roadmap.

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Slightly differing versions of Title III are incorporated into comprehensive energy legislation introduced by Senator Bingaman (S. 596) and Senator Murkowski (S. 389) as well.

The final component of a successful clean coal initiative is an effective demonstration program that will provide industry with assurances that the technologies developed in the laboratory have been demonstrated successfully in actual commercial-scale applications. The ultimate success of joint technology development efforts must be judged in the context of whether the technology is used commercially. R&D and pilot plants are not enough. If the technology is to be utilized commercially, it is oftentimes necessary to assist in helping to defray the risks of early commercial scale applications of the technology. Only when the technology has been commercially demonstrated and judged to be competitive with other options can there be any assurance that the technology might be adopted commercially. The CURC is very pleased to see that the President has recommended a significant increase in funding for cost-shared clean coal demonstrations. The new Clean Coal Power Initiative (a follow-on program to the Power Plant Improvement Initiative that Congress began in FY 2001), is a welcome signal. There is a recognition of the need to conduct demonstration scale projects to provide assurances to industry that a technology will operate successfully at commercial (or near commercial) scale. In addition, the Clean Coal Power Initiative demonstrates the

President's commitment to a promise he made during his campaign to initiate a 10-year and $2.0 billion clean coal program. The proposed Clean Coal Power Initiative is a welcome downpayment on that promise. The CURC supports the $150 million requested by the President for the FY 2002 budget and urges the Congress to grant the appropriations.

Page 81 PREV PAGE TOP OF DOC Segment 1 Of 7

It is exceedingly important, however, that these funds be utilized judiciously.

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As the Committee knows, the Department has yet to select proposals from the on-going Power Plant Improvement Initiative. The CURC has steadfastly advised that funding should be granted to proposals that will demonstrate near commercial-scale applications of technologies. Moreover, because these projects are likely to be large and costly, it is anticipated that very few projects will be selected—providing support for a great number of proposals may defeat the purpose of a program designed to encourage commercial demonstrations. Appropriations to initiate the Clean Coal Power Initiative should be similarly directed; that is large scale, cost-shared projects should be anticipated and the technology criteria should be ever more demanding so that demonstrations in each subsequent year result in significantly improved means to use coal.

Federal Funding

While we enthusiastically welcome the new Clean Coal Power Initiative, funding for this demonstration program should not be accomplished at the expense of the Department's on-going coal research and development program. These R&D programs are the means through which the President's decade-long demonstration program will be successful. R&D provides the seeds from which continuous improvements are made.

Page 82 PREV PAGE TOP OF DOC Segment 1 Of 7

The CURC has examined the proposed FY 2002 funding levels for several coal-based R&D programs against the timelines and objectives outlined in the Roadmap. In several important areas, DOE's FY 2002 budget request falls short of the targets set forth in the CURC Roadmap and must be increased or environmental and efficiency targets will not be achieved.

By reducing, or in certain cases eliminating funding, it is our contention that the technologies will not be developed in the timeframes required to insure that coal remains a dominant contributor to meeting the Nation's energy needs. As an attachment to this testimony, detailed information is provided on each DOE coal-related R&D program that is supporting technologies necessary to further the goals set forth in the CURC Roadmap. Attachment D explains the nature of the research and the technology targets that would be jeopardized without sufficient federal funding provided.

To develop the Roadmap, the members of the CURC interacted with the Department of Energy in an

effort to compare, contrast and, where appropriate, coordinate industry's priorities with the ongoing efforts of the Department, including those programs that support the Vision 21 program. The Department's Vision 21 program goals and key technologies are generally consistent with the CURC Roadmap. It should be noted, however, that the Vision 21 program goals are even more ambitious than the CURC's; specifically, the 60 percent efficiency target by 2015. The CURC aims for 45 percent efficiency by 2010 and between 45 percent and 60 percent efficiency by 2020. In order to achieve the Vision 21 efficiency goals or the more modest goals of the CURC Roadmap, substantially more funds need to be invested by the Federal Government and industry for coal R&D.

Summary

Page 83 PREV PAGE TOP OF DOC Segment 1 Of 7

Where should we go from here? The CURC Technology Roadmap has been completed and approved by its membership (Attachment E) and a financial incentives package has been introduced in the Senate (S. 60). Other legislative proposals have also been introduced or proposed that focus on the utilization of coal resources. As this Administration and this Congress deliberate on energy legislation, we hope that Congress will recognize the necessity of a comprehensive R&D program that addresses the need to encourage timely research, development and demonstration.

Advances in technology are costly, but they are an increasingly good investment for industry, the Federal Government, and the American public. Fortunately for the U.S. electric consumer, technologies can be developed and commercially deployed to vastly enhance coal's environmental performance while reducing costs. Considering the tremendous U.S. reliance on coal and the high prices associated with other energy alternatives, faulting coal out of the future generation mix is just not an option.

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Page 84 PREV PAGE TOP OF DOC Segment 1 Of 7

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Page 85 PREV PAGE TOP OF DOC Segment 1 Of 7

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Chairman **BARTLETT.** Thank you very much. Mr. Wells.

Page 86 PREV PAGE TOP OF DOC Segment 1 Of 7

STATEMENT OF JAMES E. WELLS, DIRECTOR, NATURAL RESOURCES AND ENVIRONMENT, U.S. GENERAL ACCOUNTING OFFICE

Mr. **WELLS.** Thank you, Mr. Chairman, and, members of the Subcommittee. We, too, are pleased to be here today to discuss our past work on the Clean Coal Technology Program. In almost 20 years since it started, a lot has been said, both for and against this program. Our report last year that looked at the status of the program at the end of 1999, talked to 60-some projects that had been awarded and funded out of roughly 210 proposals that had been submitted.

In reporting on the status of the program, we noted that 24 projects had been completed at that time, 16 were currently active, and 10 had been terminated or withdrawn, along with another 10 or so that had fallen out earlier in the program. No new projects have been started in the last five or six years. About $800 million of the 1.8 billion Federal funds, of the share, had not been spent at that time.

The just-completed White House National Energy Policy Group is recommending that the Administration invest $2 billion in a new restructured Clean Coal Program over the next 10 years. In this context, my testimony today will focus on the findings of our last decades of audits of the Clean Coal Program and the lessons that may have been learned from those past efforts. My full statement was prepared and talks to the successes and the weaknesses that we saw in the program.

This morning, I will let the other distinguished panel members here speak to the successes of the program and I will highlight some of the problems that we observed over the last decade. As you know, as auditors, we are best at identifying problems.

Page 87 PREV PAGE TOP OF DOC Segment 1 Of 7

1989—as the first awards were made, there were many company financial problems and delays in getting the business arrangements made. The awardees raised issues to DOE relating to their reluctance to repay the Federal cost share. Again, concerns over viability in a competitive marketplace.

Proprietary data issues arose over the possible public release of competitive information that may have disadvantaged companies. Again, frustrating delays in achieving and obtaining various permits, either at the national or state or local levels, and not surprisingly, with any new Federal program, there were cumbersome headquarters review and approval processes.

1990—as we looked at DOE, as how they were evaluating, ranking, and selecting the projects, we found that some of the awards that appeared weak in meeting all of the evaluation criteria, especially as it related to solving some of the acid rain issues. Some technical readiness issues were observed that surfaced, that showed up in major project delays and completion date slippages. This caused us to think, in the early '90's, that perhaps too much money may be chasing less than the best projects. We suggested that the program be slowed down a little bit in awarding new money to new projects again in 1990.

We also did some work looking at the potential for the utilities to use the clean coal technology and found, at that time, a cloudy vision for the future. Their interest was relatively low at the time. Most utilities were not sure what the future demand for coal was going to be, given the expanding natural gas availability

and pricing structure. We are uncertain, at this time, and suspect that the future and the vision still may be cloudy today.

Page 88 PREV PAGE TOP OF DOC Segment 1 Of 7

1991—we raised concerns about how we were using Federal funds to support projects that were close to commercialization. We also raised concerns related to being unable to find buyers for the developed products and the technologies.

1994—we commended DOE for doing good cost-sharing features of the cooperative agreements that they put in place to be used in the Clean Coal Program. The process of using multiple solicitations in stages allowed DOE, as the program progressed, to make major improvements and adjustments to how the program was being run. Some earlier problems with financing, with proprietary data handling and sharing of costs were improved. However, the instances of continuing project delays, cost increases, and compliance issues, and projects still changing locations throughout the country, remained.

1996—we looked in general at recovering Federal investments in technology, especially if the products were being used overseas. Having flexible repayment provisions, such as was used in the Clean Coal Program, was found to be a positive thing. Adjustments were made and an increased Federal cost recovery was achieved. However, again, some of the companies continued to be concerned about lowering their rate of returns which may have, at that time, discouraged some participation. Even the agency themselves worried about the administrative burden of negotiating, auditing, and enforcing repayment provisions.

Year 2000—our most recent work for the House Budget Committee were, we were asked to go in and focus on the money that was left in the program and what was happening with 13 of the projects that were remaining that had millions of dollars unspent. Five of those projects were nearing completion and the remaining eight showed signs of the same problems that we had seen over the years—serious delays in being completed—two to seven years; continuing financial problems with company financing, including ongoing bankruptcy procedures—proceedings. And once again, we observed that projects continued to be moving around the country, cities to cities, owners to owners, in some sense, continuing to look for success.

Page 89 PREV PAGE TOP OF DOC Segment 1 Of 7

In summary, I think I will stop here, Mr. Chairman. My time is running out. The Clean Coal Program clearly has had its ups and downs. Today, as you and fellow Members of the Congress are addressing today's energy challenges, we would hope that you would take some of the lessons learned from the Clean Coal Technology Program to allow you help decide how you would like to spend your future research dollars. Mr. Chairman, this concludes my short summary and I would be glad to answer questions at the end of the Panel presentation. Thank you.

[The prepared statement of Mr. Wells follows:]

PREPARED STATEMENT OF JAMES E. WELLS

Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss our past work on the Department of Energy's (DOE) Clean Coal Technology program. As you know, the program was established in 1984 to provide cost-sharing assistance or partnerships with industry in demonstrating the commercial applications of emerging technologies, referred to as "clean coal." The success of the demonstration program was tied to creating technological innovations to help clean the environment, fuel an expanding economy with more coal energy and new jobs, make the U.S. more competitive, achieve commercial sales, and create new government-industry partnerships.

DOE funded a variety of projects under the program. DOE was authorized to fund up to 50 percent of an individual project's cost, with nonfederal participants funding the balance. DOE reported to us that the actual cost-sharing was about 34 percent from DOE and 66 percent from industrial participants. Overall, DOE has contributed about $1.8 billion, while the private sector and other nonfederal participants have contributed about $3.4 billion, for a combined commitment of about $5.2 billion.

Page 90 PREV PAGE TOP OF DOC Segment 1 Of 7

In reporting on the status of the program last year, we noted that 24 projects had been completed, 16 were currently active, and 10 had terminated or withdrawn.(see footnote 9) No new projects have been started in the last 5 years. As of October 1999, about $784 million of the available appropriations had not been spent. Of that amount, DOE expected to use $589 million to complete the projects and $66 million for program administration through fiscal year 2004. The Congress rescinded $441 million (from April 1995 through October 1998) in unobligated funds associated with terminated or restructured projects. About $129 million remained unobligated.

The just-completed report of the White House National Energy Policy Development Group is recommending that the Administration invest $2 billion in a new restructured clean coal program over the next 10 years. In this context, our testimony today focuses on the findings of our reviews of the Clean Coal Technology program conducted over the last decade and the lessons that can be learned from past efforts on this front. In particular, we want to discuss (1) the successes DOE has reported, (2) some weaknesses we identified, and (3) lessons learned in cost-sharing.

In summary, the Clean Coal Technology program has had its ups and downs. DOE has numerous examples of successes in the program, including commercialization of some technologies—the primary way DOE measures success. From a management perspective, we found that many projects had experienced delays, cost overruns, bankruptcies, and performance problems. We also expressed concerns about some of the projects DOE had selected. Nevertheless, this program serves as an example to other cost-share programs in demonstrating how the government and the private sector can work effectively together to develop and demonstrate new technologies.

Page 91 PREV PAGE TOP OF DOC Segment 1 Of 7

Background

Although the Nation is heavily reliant on coal as a fuel source for electricity generation, burning coal has well recognized environmental consequences. Coal accounts for over 90 percent of the proven U.S. energy reserves and supplies about half of the Nation's electricity. According to the Environmental Protection Agency, coal-fired power plants produced about 63 percent of U.S. emissions of sulfur dioxide and about 19 percent of the nitrogen oxides. When emitted into the air, these two gasses may be transformed into tiny sulfate and nitrate particles, both of which may be transported hundreds of miles away. These gases and substances can harm human health and the environment in various ways. For example, "acid rain"—formed when sulfate and nitrate particles are deposited by precipitation—harms human health and damages forests, lakes, and streams. In addition, global climate change has been linked, in part, to carbon dioxide emissions from burning coal. To help address this problem, DOE began exploring technologies to get the benefits of the Nation's huge coal resources without the adverse environmental consequences. In fact, the Clean Coal Technology program has been one of the largest environmental technology development efforts the Federal Government has ever conducted.

The program has been implemented in a series of five solicitations for project proposals (rounds of nationwide competitions) spread over 9 years. Industry sponsors proposed demonstration projects in response to each competitive solicitation, and DOE evaluated and selected projects on the basis of evaluation criteria. The criteria include (1) the project's adequacy and technology's readiness for the proposed demonstration, (2) the sponsor's commercialization plan and the technology's potential contribution to emission reductions, and (3) the sponsor's plan for financing the project. Each project was carried out and funded under a cooperative agreement between DOE and the project's sponsor. The sponsors directed the design, construction, and operation of their projects, and DOE oversaw project activities and assessed progress.

Page 92 PREV PAGE TOP OF DOC Segment 1 Of 7

DOE-Reported Successes in the Clean Coal Technology Program

DOE has reported numerous successes in the program.(see footnote 10) DOE noted that the program has been highly successful in bringing a broad suite of clean, efficient power technologies and control systems into the marketplace, which is the program's primary goal and which will provide the primary benefits to the Nation. DOE has completed 24 projects at a cost of about $400 million. Of these, 15 had sales of a demonstrated clean coal technology—3 in the domestic market, 3 in the international market, and 9 in both.

These 15 projects cost DOE $282 million and DOE reported that they are returning billions in commercial sales in addition to numerous U.S. and international patents for technology. A specific example of the program's success is a total of 162 commercial units of two clean-coal technologies (the atmospheric circulating fluidized bed and the pressurized fluidized bed combustion) either in operation or soon to be commissioned. These units are distributed in Europe, Asia, and North America. Valued at $9 billion, they represent a commercial return of over $9 for every $1 of DOE's investment, according to DOE. In addition, the technologies present an opportunity to use low-quality coal. DOE also counts as a success the over 700 U.S. and international patents awarded to domestic technology suppliers of advanced electric power

generation, environmental control, coal processing, and industrial application technologies. These patents position U.S. industry to compete for an estimated $480 billion export market over the next 30 years that will support more than 600,000 jobs in the U.S. power equipment industry.

GAO-Reported Weaknesses in the Clean Coal Technology Program

Page 93 PREV PAGE TOP OF DOC Segment 1 Of 7

Over the years we identified numerous management weaknesses in the program. In particular, we reported that multiple clean coal technology demonstration projects experienced problems and difficulties in meeting cost, schedule, and performance goals. As we reported last year, of 13 projects we examined, 8 had serious delays or financial problems—6 were behind their original schedules by 2 to 7 years, and 2 projects were bankrupt and will not be completed.(see footnote 11) The delays and cost overruns occurred, in part, because of changes in a project's site as well as a project's participants. DOE extended deadlines several times on some projects to allow their sponsors to restructure the projects, find suitable alternative project sites, and obtain financing commitments to make the projects economically viable.

On another front, in 1991, we questioned whether DOE had adequately protected federal investments in the projects it funded.(see footnote 12) For example, DOE did not always comprehensively consider whether projects were likely to be successfully completed when it provided additional funding to cover cost increases. Some projects were withdrawn from the program after receiving additional funds. Furthermore, DOE requires that project sponsors eventually repay the federal investment from revenues resulting from the subsequent use of the technologies. However, DOE reduced the likelihood of recouping its investment by reducing the percent of sales revenues subject to repayment.

In addition, we reported on problems with DOE's project selection process. For example, we identified some projects demonstrating technologies that might have been commercialized without federal assistance. We also identified projects that might have limited potential for widespread use as well as projects that have proven not to be economically viable. DOE selected such projects to achieve a diversity of technologies. Although these projects met DOE's selection criteria, they may not be the most effective use of federal funds.

Page 94 PREV PAGE TOP OF DOC Segment 1 Of 7

In 1990, we also questioned the pace and focus of the program.(see footnote 13) We noted that many of the technologies selected for demonstration may have limited potential for achieving nationwide emission reductions when used at existing coal-burning facilities. Also, some of the selected projects may have difficulty in successfully demonstrating, and ultimately commercializing, their technologies. Given the selections that DOE made in its second round, we were concerned that it may have problems in identifying and funding additional promising projects in future rounds. Delaying subsequent rounds until DOE obtained additional demonstration results from projects already in the program would allow DOE to make more informed decisions regarding the identification, selection, and funding of the more promising technologies. It would also help ensure that the funds allocated to this program were effectively and efficiently spent.

Cost-Sharing Lessons Learned

In a 1994 report, we noted that the Clean Coal Technology program offered an example of the government and the private sector working together effectively to develop and demonstrate new technologies.(see footnote 14) We identified lessons learned from the program that could be applied to other cost-share programs. They included:

Full funding (through advanced appropriations) to cover the total federal share of project costs increases participant confidence that federal funds will be available for multi-year projects.

Cooperative agreements between the Federal Government and participants allow participants more flexibility in managing their projects, providing clear instructions on the roles and responsibilities of the government and the non-federal participants.

Page 95 PREV PAGE TOP OF DOC Segment 1 Of 7

Federal cost-sharing limits help to ensure the industry's commitment.

Early industry participation in developing solicitation documents helps the industry to structure responsive proposals.

A comprehensive process for evaluating and selecting projects and keeping it free of political influence helps ensure the program's integrity.

Multiple, sequential solicitations for project proposals enable an agency to modify the program's objectives to meet changing needs and to benefit from lessons learned.

In conclusion, to address today's energy challenges, the lessons learned from the Clean Coal Technology program should be considered as the Congress decides how to use future research dollars.

Mr. Chairman, this completes my prepared statement. I would be happy to answer any questions you or Members of the Subcommittee may have.

BIOGRAPHY FOR JAMES E. WELLS

Currently, Mr. Wells is a Director in the Natural Resources and Environment Team at GAO. Mr. Wells joined GAO's Norfolk Regional Office in 1969 and worked in the GAO European Office in Frankfort, Germany covering military and international issues. Returning to GAO's Washington, D.C. headquarters, he worked extensively in environmental issues including radiation standards, natural resources forest service, land management issues, and agricultural issues involving farmers home loan programs. He spent a year with the Kellogg Company in Battle Creek, Michigan as a participant in the White House President's Commission for Executive Exchange program. Mr. Wells in 1990 served as acting assistant regional manager in Chicago followed by an assignment with a subcommittee of the House Government Operations Committee on Capital Hill. He performed in a staff role being assigned to the Assistant Comptroller General for Operations creating performance measurements and handling regional field operations issues. Mr. Wells served as an Associate Director in both Energy and Science and Housing and Community Development

Issue Areas testifying many times on energy and housing issues. He was a Division Operations Director where he handled human capital issues for a large division and field office core group structure. Mr. Wells served as an Issue Area Director of the Energy, Science and Natural Resources Area before his current assignment.

Page 96 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. Wells received a B.S. degree in business administration from Elon College and has completed executive development courses at Harvard University's John F. Kennedy School of Government, and Penn State University. He has received numerous GAO awards, including outstanding Achievement Awards, Meritorious Service Award and the Distinguished Service Award in 1998.

Chairman **BARTLETT.** Thank you very much. Ms. Abend, welcome, and you may proceed. Could you turn on your microphone, please?

STATEMENT OF KATHERINE ABEND, GLOBAL WARMING ASSOCIATE, U.S. PUBLIC INTEREST RESEARCH GROUP, WASHINGTON, D.C.

Ms. **ABEND.** Good morning. My name is Katherine Abend, and I am the Global Warming Associate for U.S. PIRG. Thank you, Mr. Chairman, and the Subcommittee for the opportunity to testimony on our views on the Department of Energy's Clean Coal Technology Program.

U.S. PIRG is the national lobbying office for the state Public Interest Research Groups. The PIRGs are nonprofit, nonpartisan and work on environmental, consumer, and good government issues across the country.

We believe that the so-called Clean Coal Program is mismanaged and threatens public health and the environment by subsidizing the burning of dirty coal. Since 1985, the DOE's so-called Clean Coal Technology Program has received more than $2.3 billion in Federal funds, as well as hundreds of dollars through a separate DOE coal research and development program. Unfortunately, there is no such thing as clean coal. Proposed clean coal plants will still emit carbon dioxide, which causes global warming, smog-forming nitrogen oxide, lung-damaging particulates, toxic mercury, which contaminates water and land.

Page 97 PREV PAGE TOP OF DOC Segment 1 Of 7

Now President Bush wants to waste an additional $2 billion subsidizing the coal industry. It is time to protect our pocketbooks and stop wasting money on so-called clean coal programs, and it is time to protect our health with stronger clean air standards. It is time for the wealthy coal industry to finance its own research.

No Clean Coal Technology Program can eliminate carbon dioxide pollution, nor would they need to. Reducing carbon dioxide emissions is not a criterion for the program. In fact, some attempts to reduce emissions of NO**X**, SO**X**, and mercury from coal-fired power plants results in greater emissions of carbon dioxide, the main component of global warming pollution. In all, coal-fired power plants are responsible for

27 percent of total U.S. global warming pollution. Last week, the National Academy of Science released a report confirming that there is a consensus in the scientific community that global warming that has occurred in the last 50 years is likely the result of increases in greenhouse gases.

Extreme weather events, which are associated with global warming, are on the rise. According to U.S. PIRG's recent report, worldwide, the number of great weather disasters in the 1990's was more than five times the number for the 1950's and the damages were more than ten times as high, adjusted for inflation. In the United States, extreme weather caused $204 billion in economic losses during the 1990's. Clearly, global warming is too expensive to ignore.

Coal-fired power plants emit 90 percent of all pollution from the electric industry. The four main pollutants, NO**X**, SO**X**, CO, and mercury, cause serious environmental health threats, including smog, particulates, acid deposition, and toxic impacts to health and ecosystems.

Page 98 PREV PAGE TOP OF DOC Segment 1 Of 7

Fine particulate pollution from U.S. power plants is responsible for the deaths of more than 30,000 people each year. Eighteen thousand of these could be avoided with a 75 percent reduction in emissions. A typical coal-powered plant releases about 170 pounds of mercury, a neurotoxin, into the air annually. Less than a teaspoon deposited in a 25-acre lake can make the fish unsafe to eat. Most so-called clean coal systems in use remove less than 30 percent of mercury.

Clearly, burning coal has a huge impact on our health and environment. Unfortunately, the Department of Energy's optimistically named clean coal programs subsidize burning more dirty coal. Billions of dollars have been spent, yet our health and that of the planet is threatened by dirty coal plant emissions. So called clean coal still leads to more dirty air. According to a General Accounting Office report, emerging coal technologies will probably not contribute significantly to the reduction of acid rain causing emissions in the next 15 years.

The DOE's own evaluations of some of its projects show that new coal technologies were 40 percent less effective in removing SO emissions than conventional smokestack scrubbers.

Clearly, more subsidies will not help protect public health. Unfortunately, some coal supporters are proposing to squander even more money and explicitly roll back health protections. Twenty-four senators have co-sponsored S.60 an industry-backed bill to spend $1 billion over 10 years for research on clean coal, and up to $6 billion in tax breaks for utilities to upgrade plants or building new ones using the technology. This bill would exempt even new coal technology from its promises. Congress should oppose this and other harmful bills that would waste our money and weaken clean air protections.

Page 99 PREV PAGE TOP OF DOC Segment 1 Of 7

Environmental problems are not the only shortcomings of the clean coal programs. Since its conception, clean coal technology has been marked by mismanagement. The GAO has released at least seven reports

documenting waste and mismanagement in the Clean Coal Technology Program. Last year, in a sampling of 13 government-supported clean coal projects, GAO watchdogs found $588 million in unspent Federal funds. As of March 2000, n of the total projects had either been withdrawn or eliminated.

The Clean Coal Technology Program is redundant with the Clean Air Act Amendments of 1990, which already create financial incentives to develop cleaner burning coal technologies by allowing utilities to buy, sell, and trade emissions allowances to reach required emission levels.

For the past 8 years, U.S. PIRG has been working to cut polluter pork programs, Federal spending or subsidies that harm the environment at taxpayer expense. Our coalition of environmental, taxpayer, and safe energy groups has helped to save taxpayers nearly $24 billion by cutting funding for harmful programs. In February, the PIRGs released with other groups, the Green Scissors Report, which recommends cutting 74 wasteful, environmental-damaging programs to save taxpayers $55 billion. One of these programs is the so-called Clean Coal Technology Program.

The coal power industry is mature and lucrative. At a time of scarce Federal dollars, these industries should be weaned from the Federal dole. Some of the Nation's largest and wealthiest corporations are also—are beneficiaries of the program, including General Electric, United Technologies, and Westinghouse. General Electric reported record earnings of over $3 billion for the first quarter of 2001.

Page 100 PREV PAGE TOP OF DOC Segment 1 Of 7

The GAO seems to agree that these mature, profitable companies do not need subsidies. In an audit, the GAO noted that clean coal technology spending may not be the most effective use of Federal funds. For example, some projects are demonstrating technologies that might have been commercialized without Federal assistance.

Any legislation from the House Science Committee authorizing funding for the DOE should phase out wasteful spending on clean coal programs and increase funding for energy efficiency and renewable energy programs. Continued subsidies for the polluting coal industry creates an unfair playing field for clean energy sources. Congress should reauthorize the $588 million in unused clean coal funds to pay for part of the following proposals.

There are clean, affordable energy alternatives. Energy efficiency offers the fastest, cleanest, cheapest solution. Americans today consume 40 percent less energy and thus have 40 percent lower energy bills as a result of smart energy efficiency policies created over the past 25 years.

President Bush's proposed energy budget would cut funding for some energy efficiency and renewable—would cut funding for energy efficiency and renewable energy programs in half. Instead, this Committee should direct the Department of Energy to double funding for energy efficiency between 1998 and 2003.

According to the DOE, 100 square miles of solar panels could meet the annual electricity needs of the United States. Meanwhile, wind energy is now cost competitive with fossil fuel energy in some areas. The Bush Administration cut funding for renewables by nearly 50 percent. Instead, this Committee should direct the DOE to increase funding for renewable research and development to over $750 million per year.

Page 101 PREV PAGE TOP OF DOC Segment 1 Of 7

In conclusion, we believe that the so-called Clean Coal Program is mismanaged and threatens public health and the environment by subsidizing the burning of dirty coal. This Subcommittee should seize the opportunity to end the oxymoronic Clean Coal Program. Thank you.

[The prepared statement of Ms. Abend follows:]

PREPARED STATEMENT OF KATHERINE ABEND

Good morning. My name is Katherine Abend and I am the Global Warming Associate for the U.S. Public Interest Research Group (U.S. PIRG). Thank you for the opportunity to testify on our views on the Department of Energy's (DOE's) Clean Coal Technology Program.

U.S. PIRG is the national lobbying office of the state Public Interest Research Groups. PIRGs are non-profit, non-partisan and work on environmental, consumer and good government issues across the country.

Introduction

We believe that the so-called "clean coal" Program is mismanaged and threatens public health and the environment by subsidizing the burning of dirty coal. Since 1985, the DOE's so-called Clean Coal Technology Program has received more than $2.3 billion in federal funds as well as hundreds of millions of dollars through a separate DOE coal research and development program. Unfortunately, there is no such thing as "clean coal". Proposed "clean coal" plants will still emit CO, that causes global warming, smog-forming nitrogen oxide, lung-damaging particulates and toxic mercury, which contaminates water and land. Now President Bush wants to waste an additional $2 billion subsidizing the coal industry. It is time to protect our pocketbooks and stop wasting money on so-called "clean coal" programs and it is time to protect our health with stronger clean air standards. It's time for the wealthy coal industry to finance its own research.

Page 102 PREV PAGE TOP OF DOC Segment 1 Of 7

Environmental Impacts of Coal-Fired Power

Coal power results in devastating environmental impacts including global warming, other air pollution and toxic mining pollution. Taxpayers should not pay to subsidize an industry that threatens public health and the environment.

Global Warming

No Clean Coal Technology programs can eliminate CO pollution. Nor would they need to. Reducing CO emissions is not a criterion for the program. In fact, some attempts to reduce emissions of NO**X**, SO**X**, and mercury from coal-fired power plants result in greater emissions of CO, the main component of global

warming pollution: In all, coal-fired power plants are responsible for 27 percent of total U.S. global warming pollution.(see footnote 15) Last week the National Academy of Science released a report requested by the Bush administration, on the state of global warming science. The report confirms that there is a consensus in the scientific community that "global warming that has occurred in the last 50 years is likely the result of increases in greenhouse gases".(see footnote 16)

Given this conclusion, we are disappointed by the Bush Administration's recent rejection of mandatory carbon pollution reductions and delay of a decision to improve auto fuel efficiency standards. These choices threaten the planet and deny American consumers the savings that real energy efficiency measures would offer. The President cites concerns about the costs of addressing global warming while ignoring the economic costs of extreme weather events associated with global warming. According to U.S. PIRG's recent report, worldwide, the number of great weather disasters in the 1990s was more than five times the number for the 1950s, and the damages were more than ten times as high, adjusted for inflation.(see footnote 17) In the United States, extreme weather caused $204.3 billion in economic losses during the 1990s.(see footnote 18)

While the costs of ignoring global warming are high, measures that address the problem will actually save consumers money. For example, improving auto fuel efficiency standards would save consumers $60 billion per year at the gas pump and avert 100 million tons of global warming pollution per year.(see footnote 19) The standards would also save 15 times the amount of oil in the Arctic National Wildlife Refuge and result in a net increase of 244,000 jobs nationwide, with 47,000 of these in the auto industry.(see footnote 20),(see footnote 21)

Health Impacts

Coal-fired power plants emit 90 percent of all pollution from the electric industry. The four main pollutants—NO**X**, SO**X**, CO, and mercury—cause serious environmental health threats including smog, particulates, acid deposition, and toxic impacts to health and ecosystems.(see footnote 22) The following are some impacts of coal-fired power plants:

Fine particle pollution from U.S. power plants is responsible for the deaths of more than 30,000 people each year. 18,000 of these could be avoided with a 75 percent reduction in emissions.(see footnote 23)

Hundreds of thousands of Americans suffer from asthma attacks, cardiac problems and other respiratory problems associated with fine particle matter from power plants.(see footnote 24)

Infants in high pollution areas are 40% more likely to die from a respiratory disease.(see footnote 25)

A typical coal powered plant releases about 170 lbs. of mercury, a neurotoxin, into the air annually, when less than of a teaspoon deposited in a 25-acre lake can make the fish unsafe to eat.

There are 2,073 current fish consumption advisories in forty states, and eleven states have issued statewide advisories for mercury contamination in their lakes and rivers. 68 percent of all advisories are due to mercury contamination.(see footnote 26)

Most so called "clean coal" systems in use remove less than 30 percent of mercury.(see footnote 27)

Clearly, burning coal has a huge impact on our health and environment. Unfortunately, the Department of Energy's optimistically named "clean coal" programs subsidize burning more dirty coal. Billions of dollars have been spent, yet our health and that of the planet is still threatened by dirty coal plant emissions. So called "clean coal" still leads to more dirty air. According to a General Accounting Office (GAO) report, "Emerging clean coal technologies will probably not contribute significantly to the reduction of acid rain causing emissions in the next 15 years."(see footnote 28)

GAO has found that coal subsidies squandered taxpayer dollars on technologies that were less effective at cutting pollution that technologies already on the market. This report reveals that "DOE's evaluation of two project proposals indicated that the technologies to be demonstrated were expected to reduce SO emissions by 50 percent at the projects' sites. In comparison, conventional scrubber technology can reduce SO emissions by 90 percent."(see footnote 29) The DOE's own evaluations of some of its projects showed that new "clean coal" technologies were 40 percent less effective in removing SO emissions than conventional smokestack "scrubbers".(see footnote 30)

Clearly, more subsidies will not help protect public health. Unfortunately, some coal supporters are proposing to squander even more money and explicitly roll back health protections. Twenty-four senators have co-sponsored S. 60, an industry-backed bill to spend $1 billion over 10 years for research on "clean coal" and up to $6 billion in tax breaks for utilities to upgrade plants or build new ones using the technology. This bill would exempt even new coal technology from clean air act requirements, making plain that even the proponents of the technology doubt its promises. Senator Murkowski has called for similar amounts of spending and weakening of the Clean Air Act in his recently released comprehensive energy bill, S. 389. Congress should oppose these and any other harmful bills that would waste our money and weaken clean air protections.

Coal Mining Pollution

Destruction and pollution from coal mining destroys communities, fills streams with waste, and devastates landscapes. Coal mining in the U.S. leaves millions of tons of waste creating significant groundwater contamination. Acid mine drainage leaves toxic yellow residue in rivers. Meanwhile, mines of all sorts are prone to destabilize the soil and cause water run-off and siltation of streams. Longwall coal mining, in particular, can lead to loss of well water where mining is underneath the wells. Mining has also scarred hundreds of thousands of acres of American wilderness.(see footnote 31) By subsidizing and promoting increased coal use, these so-called "clean coal" programs will mean more coal mining devastation.

Page 106 PREV PAGE TOP OF DOC Segment 1 Of 7

Mismanagement of Taxpayer Dollars

The so-called Clean Coal Technology Program has received over $2.3 billion in federal funds. The coal industry also receives hundreds of millions of dollars through a separate DOE coal research program. Since its conception, the Clean Coal Technology Program has been marked by mismanagement.

The GAO has released at least seven reports documenting waste and mismanagement in the Clean Coal Technology Program. A March 2000 report found that eight ongoing projects "had serious delays or financial problems." Two of the eight were in bankruptcy and the other six were behind schedule by two to seven years. Of these six alone, DOE funding is at least $519 million.(see footnote 32)

Last year in a sampling of 13 government supported "clean coal" projects, GAO watchdogs found $588 million in unspent federal funds.(see footnote 33)

As of March 2000, one-fifth of the total projects had either been withdrawn or eliminated.(see footnote 34)

Today, of the fifty projects originally scheduled to be funded through the Clean Coal Technology Program, only 22 are completed, 10 are in operation or under construction, seven are being designed, and several have been canceled.

Page 107 PREV PAGE TOP OF DOC Segment 1 Of 7

Redundancy With Other Financial Incentives

The Clean Coal Technology Program is redundant with the Clean Air Act Amendments of 1990, which already create financial incentives to develop cleaner burning coal technologies by allowing utilities to buy, sell and trade emissions allowances to reach required emissions levels.

Polluter Pork—Handouts to a Mature Industry

For the past 8 years, U.S. PIRG has been working to cut polluter pork programs—federal spending or subsidies that harm the environment at taxpayer expense. Our coalition of environmental, taxpayer and safe energy groups has helped save taxpayers nearly $24 billion by cutting funding for harmful programs. In February, PIRGs around the country joined taxpayer, free-market and other environmental groups, such as Friends of the Earth, the Concord Coalition, and Taxpayers for Common Sense in releasing the Green Scissors Report which recommends cutting 74 wasteful, environmentally-damaging programs to save taxpayers $55 billion. One of these programs is the so-called Clean Coal Technology Program.

In addition to the Green Scissors report, this wasteful program was targeted in 1997 by the "Stop Corporate Welfare!" coalition. Congressmen Klug (R–WI), Foley (R–FL) and Miller (R–FL) offered an amendment to rescind $292 million which was supported by 173 members of Congress and a coalition which included: Citizens Against Government Waste, Taxpayers for Common Sense, U.S. PIRG, Friends of

'the Earth, Citizens for a Sound Economy, National Taxpayer's Union, Public Citizen, CapitalWatch, the Competitive Enterprise Institute, and Americans for Tax Reform.

Page 108 PREV PAGE TOP OF DOC Segment 1 Of 7

The coal power industry is mature and lucrative. At a time of scarce federal dollars, these industries should be weaned from the federal dole. For example, American Electric Power, which receives funds from the Clean Coal Technology Program, has doubled its revenues this year to $13.54 billion.(see footnote 35) Southern Company, another recipient of "clean coal" funding, reported record earnings of $1.4 billion for 2000, and their stock price reached a 52-week high in April 2001.(see footnote 36) Some of the nations largest and wealthiest corporations are also beneficiaries of the program, including General Electric, United Technologies, and Westinghouse. General Electric reported record earnings of over $3 billion for the first quarter of 2001.(see footnote 37)

The GAO seems to agree that these mature, profitable companies do not need subsidies. In an audit, the GAO noted that Clean Coal Technology spending "may not be the most effective use of federal funds, for example, some projects are demonstrating technologies that might have been commercialized without federal assistance."(see footnote 38) The DOE has recouped only a small portion of taxpayers' money devoted to the program. A 1996 audit of the DOE found that there was a potential loss of $133.7 million out of a $151 million investment in six clean coal technology projects.

Solution: Energy Efficiency and Renewable Energy

Any legislation from the House Science Committee authorizing funding for the DOE should phase out wasteful spending on "clean coal" programs and increase funding for energy efficiency and renewable energy programs. Continued subsidies for the polluting coal industry creates an unfair playing field for clean energy sources. Congress should reauthorize the $588 million in unused "clean coal" funds to pay for the part of the following proposals.

Page 109 PREV PAGE TOP OF DOC Segment 1 Of 7

Increase Funding for Energy Efficiency

There are clean, affordable energy alternatives. Energy efficiency offers the fastest, cleanest, cheapest solution. Americans today consume 40 percent less energy and thus have 40 percent lower energy bills as a result of smart efficiency policies initiated over the past 25 years. Had government leaders not implemented those programs, Americans would have spent $260 billion more on energy bills in 2000. Efficiency is more than simply a "personal virtue." It is a smart way to save money, energy, and the environment. President Bush's proposed federal budget would cut funding for some energy efficiency and renewable energy programs in half. *Instead, this committee should direct the DOE to double funding for energy efficiency between FY 1998 and FY 2003, resulting in a budget of $1.22 billion in FY 2003. This means an increase in funding for energy efficiency research, development and deployment by approximately $170 million in FY 2002.* We strongly support DOE's energy efficiency programs except the Partnership for a New Generation

of Vehicles program or other programs that subsidize the development of diesel engine technology.

Increase Funding for Clean, Renewable Energy

According to the DOE, 100 square miles of solar panels could meet the annual electricity demands of the United States. Meanwhile, wind energy is now cost competitive with fossil fuel energy in some areas, and the Union of Concerned Scientists has shown that 6 percent of the contiguous U.S. land area could produce 1g the amount of electricity used in the U.S. in 1999. Denmark expects to get 50 percent of its power from wind by 2030. The Bush Administration cut funding for renewables by nearly 50 percent, from $376 million to $186 million in its budget proposal. *Instead, this committee should direct the DOE to increase funding for renewable research and development to over $750 million per year.* We strongly support DOE's renewable energy programs except we do not support any funding for hydropower, municipal solid waste incineration, and burning trees that are not dedicated crops.

Page 110 PREV PAGE TOP OF DOC Segment 1 Of 7

Conclusion

In conclusion, we believe that the so-called "clean coal" Program is mismanaged and threatens public health and the environment by subsidizing the burning of dirty coal. This subcommittee should seize the opportunity to end the oxymoronic Clean Coal Program. Thank you.

Financial Disclosure

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BIOGRAPHY FOR KATHERINE ABEND

Katherine Abend is the Global Warming Associate for the U.S. Public Interest Research Group (U.S. PIRG). She is responsible for research and advocacy on a wide range of energy issues. Ms. Abend received her Bachelor of Science with a dual concentration in Resource Ecology and Environmental Policy from the University of Michigan School of Natural Resources and the Environment. She is the author of the U.S. PIRG Education Fund's report *Flirting With Disaster: Global Warming and the Rising Costs of Extreme Weather.*

Reports

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Page 111 PREV PAGE TOP OF DOC Segment 1 Of 7

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Pumping Up the Price: The Rising Costs of Outdated Fuel Efficiency Standards, U.S. PIRG Education

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http://www.pirg.org/reports/enviro/dirty–*power/index.html*

The Green Scissors Report, The Green Scissors Coalition, February 2001.
http://www.greenscissors.org

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Chairman **BARTLETT.** Thank you very much. Mr. Mead.

STATEMENT OF JOHN S. MEAD, DIRECTOR, COAL RESEARCH CENTER, SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE

Mr. **MEAD.** Thank you, Mr. Chairman. Mr. Chairman, and, members of the Subcommittee, while the future of coal's use is really a national concern, some states have taken a leading role in supporting clean coal research, development, and deployment. Midwestern states, with their high-sulfur coal reserves, have been significant stakeholders since the 1970 Clean Air Act Amendments. These states, particularly Ohio and Illinois, have been frequent participants in U.S. DOE clean coal projects.

Page 112 PREV PAGE TOP OF DOC Segment 1 Of 7

In the past year, the State of Illinois has taken dramatic steps to increase the development of new power generation with a strong emphasis on development and deployment of clean coal technologies. Mr. Chairman, I think I can say that Illinois is very enthusiastic about clean coal technology.

Illinois has been a pioneer in the development of these technologies, dating back to the early 1970's, with the development of the first generation of fluidized bed combustion, the earliest gasification tests, and other technologies designed to help the high-sulfur coal reserves of the state.

That has continued with a partnership with the U.S. Clean Coal Technology Program and with significant state programs that are—that have been developed with industry and without Federal Government support.

This year, the Illinois General Assembly, with the support of Governor Ryan, developed a dramatic new set of coal-enhancement programs, including a total of $3.2 billion of state resources dedicated to the development of new power generation capacity, particularly coal-fired capacity. These incentives include $500 million in potential grants from state funding for new development of projects; $1.7 billion in revenue bond authority to provide loans for the development of new power plants; and $300 million in the development of advanced systems, including alternative technologies, the improvement of the infrastructure of power transmission.

And included in this will be an examination of where it may be appropriate to increase and further strengthen the state's Clean Air Act laws as they are applied to older, existing power plants. And these are

power plants that will have higher emission levels than new generation because of the nature of the requirements for new power plants under the Clean Air Act.

Page 113 PREV PAGE TOP OF DOC Segment 1 Of 7

Exploratory clean coal research and development with an emphasis on eventual commercial adoption of clean coal technologies, is another hallmark of Illinois' program. Southern Illinois University has been involved in the development of an exciting new program, based on $25 million of funding from a major state utility, to develop and commercialize more advanced coal technologies. We issued our first request for proposals 1 year ago and we are very excited to receive 16 proposals from projects that would total over $400 million in investment in new power generation capability. This was a single program developed by a single state at one of its universities. A very dramatic development—and I think one that in the recent months has been amplified in Illinois and throughout the country with a tremendous increase in the interest in new power generation.

While Illinois is really emphasizing the development of commercial projects, there is a very significant need for the continued development, aggressive development, of very advanced ultra clean coal-fired capacity for this country. This is still at the level of exploratory research and pilot scale development. This is an area where a single state or groups of states interested in coal production and power generation cannot, on their own, solve these technical scientific problems. We need the help of the Federal Government. We need the continued support of the Department of Energy.

Mr. Kripowicz and Mr. Yamagata talked about the need for the development of these high-performance, high-efficiency systems. I agree. I believe that we need increased Federal support for these very advanced technologies that can promise both reduced emissions of global climate-changing gases and of the current criteria pollutants, as well as increased efficiency and better mining methods. Together and integrated, these technologies can provide a truly advanced clean source of energy for our country for the next hundred years. Mr. Chairman, thank you very much.

Page 114 PREV PAGE TOP OF DOC Segment 1 Of 7

[The prepared statement of Mr. Mead follows:]

PREPARED STATEMENT OF JOHN S. MEAD

Coal has fueled America's growth, from 19th century industrial expansion to today's electric power generation, transmission and distribution system. By providing over half of the Nation's electric energy, coal's contribution to our economy and quality of life is undeniable.

As significant as coal's role in building America's energy infrastructure may be, scientific and public concerns about the environmental and human health effects of coal extraction and combustion have overshadowed other aspects of coal use in the past thirty-five years. Legislative and regulatory responses to environmental concerns have influenced the direction of both the electric utility and coal industries. The

extended use of older generating stations coupled with the tremendous expansion of low sulfur coal mining is a legacy of state and federal clean air legislation. Such strategies have achieved regulatory compliance and positive environmental results; however, additional strategies will be needed in order to ensure that coal can remain a full partner in our nation's energy solutions for the next century.

A key strategy for coal is the expanded development and deployment of clean coal technologies. The Federal Government, together with selected states, has helped industry demonstrate and commercialize an array of new technologies designed to meet current environmental and commercial requirements. A renewed federal effort in clean coal technology, one that will be positioned to help both deploy near commercial technology and explore highly innovative uses of coal, will be enormous value to our energy security.

Page 115 PREV PAGE TOP OF DOC Segment 1 Of 7

While the future of coal's use is truly a national concern, some states have taken a lead in supporting clean coal research, development and deployment. Midwestern states, with their higher sulfur coal reserves, have been significant stakeholders since the 1970 Clean Air Act amendments. These states, particularly Ohio and Illinois, have been frequent participants in clean coal projects. In the past year, the State of Illinois has taken dramatic steps to increase the development of new power generation.

The Illinois experience in clean coal technology goes back to pioneering projects of the 1970s. First generation atmospheric fluidized bed combustion and early gasification for electric power production were constructed or conceptualized for Illinois facilities. In the 1980s, a series of successful circulating fluidized bed combustion projects were supported. Active Illinois partnerships with the U.S. DOE have continued to the current day with projects such as the Low Emission Boiler System demonstration at Elkhart, Illinois (see Appendix I for a list of Illinois clean coal demonstration projects).

An ambitious legislative energy package was developed in the Spring 2001 session of the Illinois General Assembly. This legislation, which has the support of Illinois Governor George Ryan, is designed to encourage the construction of new base load electric generating stations as well as support added air pollution control systems at existing stations. The following is a summary of this important legislation from a release by Governor Ryan:

Designation of new electric plants and the coal mines that fuel them as High-Impact Businesses, providing those businesses with a number of tax incentives, including sales tax exemptions on building materials and equipment, utility tax exemptions and investment tax credits.

Page 116 PREV PAGE TOP OF DOC Segment 1 Of 7

Creation of a $500 million financial assistance program for coal-fired generating plants equal to the amount of general obligation bond-funding that can be repaid by coal tax revenues gained on new Illinois coal purchases.

Up to $1.7 billion in revenue bond authorization to provide financing for electric plants generating Illinois

coal mining jobs, including mine-mouth plants and plants that use clean coal technology, repayable by the developers.

Up to $300 million in revenue bond authorization designed to spur upgrades to the electric transmission grid within Illinois, repayable by the owner of the transmission lines.

Up to $500 million in revenue bond authorization to finance projects using renewable energy sources such as wind and solar power, and $500 million for existing coal-fired plants to add scrubbers to reduce air emission, both repayable by the developer.

A review by the Illinois Environmental Protection Agency of the need for new state regulations governing emission by older coal-fired power stations not subject to stricter air quality restrictions imposed on new generating units.

Creation of additional local options for property tax abatement.

Related to the coal package is an amendment to Ryan's earlier Executive Order creating a top-level Governor's Energy Cabinet. Under the revised order, the Cabinet will have the responsibilities in siting new electric generating facilities, overseeing the implementation of environmental regulations on new plant developers and streamlining the state permitting process for new generating plants.

Page 117 PREV PAGE TOP OF DOC Segment 1 Of 7

Exploratory clean coal research and development, with an emphasis on supporting eventual commercial adoption of clean coal technologies, has been another hallmark of Illinois' clean coal activities. In the past three years, research on advanced mining methods,-combustion, residues management, coal preparation, flue gas cleanup and gasification has been commissioned. This research has been carried out at Southern Illinois University along with other institutions, including organizations outside of Illinois (see Appendix II for recent research/development projects).

Southern Illinois University, in cooperation with the Illinois General Assembly and industry, has initiated a unique program to identify and support the application of clean coal technologies. This program has been funded with a $25 million gift from the Commonwealth Edison Company. Technologies developed or tested in research over the past decade, along with new applications of proven clean coal technologies, are selected by the Clean Coal Review Board (a panel of state government, industry, labor and university leaders). The first program solicitation, held in 2000, generated 16 projects and a remarkable $417 million in potential projects. Seven innovative projects were selected in the first round of funding (see Appendix III).

The future of clean coal technology projects in Illinois and the Midwest may be very positive. The new Illinois support initiatives should match well with the Power Plant Improvement initiative and its successor programs. Projects being discussed today will, if constructed, raise the commercial acceptance of critical technologies such as Integrated Gasification-Combined Cycle systems. But federal clean coal technology funds can provide value far beyond the support of near commercial or demonstration projects. The federal clean coal program can provide crucial support for a new generation of power systems that are only in the conceptual stages today: ultralow emission technologies that address all emissions, including carbon

dioxide. Such low or zero emission systems may be years away from commercialization, but the knowledge gained from such studies will likely have good transfer to improving today's state of the art systems. The eventual application of ultraclean systems will hold tremendous value to a nation whose greatest fossil energy resource is coal.

Page 118 PREV PAGE TOP OF DOC Segment 1 Of 7

Appendix I

State of Illinois Clean Coal Development/Demonstration Projects

Combustion Engineering Inc., Great Lakes Naval Base* *AFBC*
Allis-Chalmers/Khagas, Alton* *Gasification*
Midwest Grain Products Company, Pekin *ACFBC*
B.F. Goodrich, Henry *ACFBC*
Abbott Power Plant, Champaign *FGD*
Anderson Clayton Foods, Jacksonville *AFBC*
Archer Daniels Midland Company, Decatur *CAFBC*
EERC–CRSI, Hennepin and Springfield* *NOX—Gas Reburn*
Tecogen, Carterville* *Coal Water Combustion*
TCS Micronized Coal Systems, Rochelle *Combustion*
SIUC Cogeneration, Carbondale *ACFBC*
S&L LEBS Copper Oxide System, Carterville* *FGD*
S&L SOAPP, Chicago *Power Systems Design*
CWLP, Dallman Scrubber Expansion, Springfield *FGD*
D B Riley, LEBS Phase IV, Elkhart* *Combustion*

*Co-funded by the U.S. DOE

Appendix II

Page 119 PREV PAGE TOP OF DOC Segment 1 Of 7

State of Illinois Clean Coal Research Projects

Identification of Cost Cutting Strategies for Underground Mines in Illinois, *Y. Chugh*

Development of Sorbents for a Fluid Bed Process to Control SO**X** and NO**X**, *J. Abbasian*

The Advantage of Illinois Coal for FGD Removal of Mercury, *B. Gullett*

Role of Coal Chlorine and Fly Ash on Mercury Species in Coal Combustion Flue Gas, *M. De Vito*

Demonstration of Sorbent Injection Process for Illinois Coal Mercury Control, *M. Rostam-Abadi*

Commercialization of High-Carbon Fly Ash in Cement Manufacture, *J. Bhatty*

A Proposal to Commercialize a Sintered Coal Ash/Flux Material for Building Panels, *C. Dry*

Field Evaluation of Precast Concrete Piles Using Illinois PCC Coal By-Products, *S. Kumar*

Implementation of Technology for Controlled Low-Strength Materials Using Illinois Coal Combustion Products, *T. Naik*

Page 120 PREV PAGE TOP OF DOC Segment 1 Of 7

Utilization of Illinois Fly Ash in Manufacturing of Ceramic Tiles, *S. Bhattacharja*

Manufacturing Commercial Brick with Fly-Ash from Illinois Coals, *M. Chou*

Paperless FGD Scrubber Sludge Structural Materials, *V. Malhotra*

Evaluation of New Coal Sizing Technologies to Improve Plant Profitability, *M. Mohanty*

Appendix III

Projects Funded by the Clean Coal Review Board Year 2000

The following are summaries of funded projects by technology area:

Pre-Combustion Coal Cleaning

Central Processing and Coal Handling—near Harrisburg, IL
Arclar Company

Arclar Company, LLC is currently investing capital to construct a large mining complex in southern Illinois. The goal of the project is to create a state-of-the-art mine complex that will employ approximately 400 people at the mining company level and up to approximately 150 transportation jobs. Additionally, the job creation potential could be as high as six times this number as the benefit of this huge economic investment ripples through the southern Illinois economy and makes a dormant Illinois resource a viable product for today's coal markets. To accomplish this goal, a coal preparation plant is essential. The preparation plant produces a viable product in today's competitive coal market environment. It does this by beneficiating the coal from dilution created in the mining cycle, reducing the amount of inherent ash and sulfur content of the coal, and increasing the Btu content.

Page 121 PREV PAGE TOP OF DOC Segment 1 Of 7

The coal preparation plant will use state-of-the-art technologies to clean coal before shipping to the open market. Included in these technologies will be heavy media cyclones circuits, filter presses and froth floatation circuits. These technologies allow the maximum yield of a non-renewable Illinois resource and

substantially decrease the amount of refuse produced over the life of the reserve by reducing coal losses during beneficiation.

The preparation plant will be centrally located to accommodate coal production from adjacent underground and surface mineable reserves. The underground mine will extract coal from the Illinois #5 seam and the surface mine will extract coal from the Illinois #6 seam. Both mines will be located in Saline and Gallatin Counties north of Equality, Illinois.

Total Project: $11,300,000
Board Commitment: $2,000,000

Installation of Advanced Fine Coal Cleaning Equipment Pattiki Mine Preparation Plant Modification Project—White County, IL
Alliance Coal Company

The two-year project involves the removal of conventional coal cleaning equipment and the installation of a 200 ton/hr advanced fine coal cleaning circuit into White County Coal, LLC's Pattiki Preparation Plant. The Pattiki processing plant is located near Carmi in southeastern Illinois and treats coal extracted from the Illinois No. 6 coal seam. The advanced circuit will employ spiral concentrators to treat the 16 × 100 mesh coal, an enhanced gravity separator (Falcon Concentrator) and an advanced flotation system (Jameson Cell) to clean the 100 × 325 mesh material, and a novel Cyclowash system to efficiently reject the –325 mesh fraction to the final refuse. Based on preliminary projections, the advanced fine coal circuit will provide the ability to produce a substantially cleaner coal product while increasing the overall plant mass yield to the product stream. Specific objectives of the proposed project include:

Page 122 PREV PAGE TOP OF DOC Segment 1 Of 7

Reducing the sulfur dioxide emission rating of the clean coal product by 8 percent in terms of SO/MBtu.

Increasing the overall plant mass yield to the product stream by 2 percent weight units while achieving the desired product quality.

Quantifying the technical and economical benefits resulting from the installation of an optimized advanced fine coal cleaning circuit, which will include those benefits resulting from reduced tailings disposal efforts.

Comparing the separation performances achieved by an advanced froth flotation technology (Jameson Cell) and an enhanced gravity concentrator (Falcon Concentrator) for the cleaning of 100 × 325 mesh fine coal using full-scale industrial units.

Evaluating the application of an enhanced gravity separator (Falcon Concentrator) for the recovery of fine coal from a high pyretic sulfur stream.

Quantifying the improvements in classification efficiency achieved from the use of a Krebs Cyclowash system and the benefits realized upon integration into the fine coal cleaning circuit.

It is projected that successful realization of the project objectives will result in an annual clean coal production increase of 80,000 tons, which equates to an increase in annual revenue of $1,640,000 for the Pattiki mining operation. The project will also represent the first commercial application of a full-scale 50 ton/hr enhanced gravity separator (EGS) for fine coal cleaning. Several research projects have found EGS units to be very effective in reducing the total sulfur content of fine coal as well as providing a significant rejection of ash-forming material.

Page 123 PREV PAGE TOP OF DOC Segment 1 Of 7

Total Project: $3,639,714
Board Commitment: $1,000,000

Innovative Combustion Systems

Ashworth Combustor Demonstration—Lincoln, IL
C1earStack Combustion Corporation

CIearStack Combustion Corporation is developing a novel "break-through" combustion technique, called the Ashworth Combustor*TM* that uses three-stages of combustion. The innovation with this technique is that the three major air emission pollutants (SO, NO**X**, and particulate) from coal combustion can be reduced with just one system. What makes the technology profound is its simplicity. With the successful demonstration of the Ashworth Combustor, power plants will have the option of not becoming chemical plants to meet the stringent post Year 2000 environmental regulations. The technology may be used to retrofit all types of coal-fired boilers; wall-fired pulverized coal units will be the easiest to retrofit.

Two-stage slagging combustor tests show that under deeply reducing conditions coal sulfur (as CaS) can be captured in a molten slag eutectic and also that low NO**X**, levels can be achieved (<0.301b NO**X** /106 Btu). Further, kinetic modeling shows that if three rather than two stages of combustion are used, NO**X** emissions can be reduced below the promulgated U.S. EPA Year 2003 ozone season (0.151b NO**X** /106 Btu) limit for eastern and mid-western States. Because the Ashworth Combustor system includes the addition of a slagging combustion to the boiler furnace, most of the coal ash is removed before it enters the boiler, thus less particulate enters the atmosphere from the downstream electrostatic precipitators (constant efficiency removal devices).

Page 124 PREV PAGE TOP OF DOC Segment 1 Of 7

The host site of the technology demonstration is the Illinois Department of Human Service's Lincoln Development Center located in Lincoln, Illinois. The combustor will be retrofitted to Lincoln Boiler Unit #2, a coal-fired stoker that was converted to burn natural gas. The project objective is to demonstrate its three-stage combustion technique at the Lincoln Development Center—a scale that will ensure its viability for commercialization before the year 2003.

Total Project: $3,340,613

Board Commitment: $1,000,000

Marion Circulating Fluidized Bed Boiler Repowering Project—Marion, IL
Southern Illinois Power Cooperative

Southern Illinois Power Cooperative (SIPC) will build and operate a circulating fluidized bed boiler (CFB) power generation facility at the existing Marion Generating Station in Williamson County, Illinois.

The proposed facility consists of one atmospheric circulating fluidized bed boiler, which will produce enough steam to serve three existing steam turbines with a total nominal generating capacity of 120 MW (gross). The CFB is estimated to cost $89,622 million and is scheduled to be in service in March of 2003.

The fluidized bed boiler will burn primarily bituminous coal and bituminous coal refuse, supplemented at times with small amounts of petroleum coke, sub-bituminous coal, tire-derived fuel, waste oil, and wood chips.

Page 125 PREV PAGE TOP OF DOC Segment 1 Of 7

Limestone will be used to control SO emissions while NO**X** control will be accomplished by minimizing the high temperature that cause NO**X** to be formed within the boiler. The CFB will also have a selective non-catalytic reduction (SNCR) system for use if needed to remove additional NO**X**.

Supplying and using raw materials should result in over 1350 jobs in southern Illinois. In addition, since economic principles indicate that each dollar turns seven times, SIPC will be adding over $215 million to the southern Illinois economy each year or over $9 billion over the useful life of the projects. This is in addition to the initial $183 million combined cost of the projects.

Total Project: $89,622,000
Board Commitment: $1,000,000

Integrated Mining/Power Production Systems

Prairie Energy Project—Elkhart, IL
Corn Belt Energy Corporation

The Prairie Energy Project is a U.S. Department of Energy Project to enhance clean coal technology. The project started in 1992, and has progressed to the proof-of-concept phase. The host site is the Turris Mine located in Elkhart, Illinois. It will be a mine mouth plant utilizing Turris Coal.

Page 126 PREV PAGE TOP OF DOC Segment 1 Of 7

The objective of the project is to develop a slagging furnace that produces low NO**X**, and produce ash that has beneficial reuse. The ash produced is vitrified, and nearly 100 percent is bottom ash. Test results at a100 MMBtu/hr test facility has reduced typical NO**X** values from over 1.0 LB/MMBtu to approximately .2 LB/MMBtu burning Turns Coal. Prairie Energy will be a Nominal 90 MW facility. The plant will be designed

to have a 30+ year life producing clean reliable energy. The project will also be equipped with SCR and a Web Scrubber to meet the most stringent environmental conditions.

The project will increase the ability to burn Illinois coal, and is applicable to large Utility Grade Installations. The basic furnace design is one that has over 60 operating units in excess of 300 MW. This project will demonstrate the ability to build an efficient plant that will meet the new Environmental regulations. The Project will burn in excess of 300,000 tons of coal per year. Waste material that is not used for reuse applications will be disposed of at the Turris Mine.

Total Project: $137,000,000
Board Commitment: $2,000,000

Close Coupled Gasification Microgeneration Power Plants—Coulterville, IL
Coaltec Energy USA

The Project will build an 8 to 12 megawatt power plant at the Zeigler #11 mine near Coulterville, Illinois. The power plant will be fired by waste coal fines rejected by the coal preparation plant and is intended to provide the electric power demands of the host mine. The power plant is built around a small gasifier-combustor unit that has a long operating history with other fuels and has recently been demonstrated to be able to use coal. This modular unit is called a Close Coupled Gasifier (CCG) and is able to handle coal of higher moisture and ash contents than conventional boiler technologies or even Fluidized Bed Combustion units. This project will apply low cost gravity cleaning processes developed through SIUC research to provide modest upgrades in fine coal refuse. The greater ash and moisture tolerance of the CCG unit will be coupled with these processes to allow a strictly waste material to be used on-site for energy purposes. Other aspects of the electric generation system are based on modular package steam cycle generation equipment normally marketed for gas firing. This new configuration of factory built modular equipment allows CCG power plants to be built for approximately the same capital cost per kilowatt of capacity as a large central power station despite an almost two order of magnitude difference in size.

Page 127 PREV PAGE TOP OF DOC Segment 1 Of 7

Total Project: $33,500,000
Board Commitment: $2,000,000

Demonstration of a Coal Industrial Park Concept for Illinois Coal Industry Enhancement—Carbondale and Elkhart, IL
Southern Illinois University, Carbondale

A typical coal mining operation in Illinois mines the coal and processes it on-site for the market. The processed coal is transported by rail to a thermal power generation station where it is burnt to produce electricity. Most of the by-products of combustion (fly ash, bottom ash, and scrubber sludge) are disposed at the power plant on-site at a substantial cost. The cost of coal delivered to the power plant ranges $28–30 per ton. The power plants spend on the average $7–10 per ton to dispose of combustion by-products. Mining operations, as well as on-site mining and processing waste disposal, also have the potential to create negative environmental impacts on land, air, and water such as acid mine drainage, mine subsidence, etc.

This project will demonstrate the concept of a coal industrial part (CIP), which integrates mining, processing, coal processing waste, and combustion by-products management operation (to the extent possible) to improve coal company profitability and minimize negative environmental impacts. An integral part of the concept is an on-site or near mine-site, small size (25–35 MW) fluidized bed combustion (FBC) power plant, which utilizes a low value/waste coal stream from the processing plant. The power generated is sold to the mine as well as to the outside markets. The by-products of combustion are co-managed with mining and processing wastes to minimize negative environmental impacts. Some of the by-products may also be used to fabricate products for use in mines as well as for construction industries. More specifically, the CIP concept achieves the following:

Page 128 PREV PAGE TOP OF DOC Segment 1 Of 7

1. More fully recovers the energy of mined coal. About 95 percent of the mined coal energy may be utilized as compared to about 80 percent to 85 percent currently.

2. Minimizes negative environmental impacts associated with mining, and management of mining, and processing waste and coal combustion by-products.

3. Reduces the cost of power used at the mine site.

4. Generates and markets power generated from the use of coal waste at a competitive price.

5. Reduces the cost of coal received by the power plant and the sulfur emissions cost.

6. Fabricates and markets products from by-products of mining, processing, and combustion of coal for mining and construction industries.

A consortium organized by SIUC plans to demonstrate and commercialize these concepts at Turris Mine near Elkhart, Illinois over a six-year period (2001–2006). The "Coal Industrial Park" concept can be used at most mines in Illinois, with a life of about 20 years and availability of about 300 gallons per minute of water, to enhance coal production and employment.

Total Project: $731,962
Board Commitment: $250,000

Page 129 PREV PAGE TOP OF DOC Segment 1 Of 7

Appendix IV

Contacts

For more information on the State research projects, contact:

Ron Carty, Senior Scientist
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5776 Coal Drive, Suite 200
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E-mail: ronc@icci.org

For more information on the State development and demonstration projects, contact:

Gary Philo, Manager, Coal Demonstration and Marketing Section
Department of Commerce and Community Affairs
Office of Coal Development and Marketing
325 W. Adams Street, 3rd Floor
Springfield, IL 62704
Phone: 217–785–2780
Fax: 217–785–2618

E-mail: gphilo@commerce.state.il.us

For more information on the Clean Coal Review Board projects, contact:

John Mead, Director
Coal Research Center
Southern Illinois University
405 W. Grand Avenue
Carbondale, Illinois 62901–4623
Phone: 618–536–5521
Fax: 618–453–7346
E-mail: jmead@siu.edu

BIOGRAPHY FOR JOHN S. MEAD

Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, 405 West Grand Avenue, Carbondale, Illinois 62901–4623; Telephone: (618) 536–5521; E-mail: jmead@siu.edu

PERSONAL

Date of Birth: December 9, 1953; Indianapolis, IN
Marital Status: Married, two children
Citizenship: USA
Present Home Address: 78 Magnolia Lane, Carbondale, IL 62901

EDUCATION

J.D. University of Illinois at Urbana-Champaign, May 1979; Admitted to practice law in Illinois, November 1979
A.B. in Political Science, Indiana University of Bloomington, May 1976

EXPERIENCE

Director of the Coal Extraction and Utilization Research Center, Southern Illinois University at Carbondale, Carbondale, Illinois (March 1989 to present).

Responsible for the development, administration, coordination, and support of coal and energy-related programs at SIUC. Responsible for the management of a staff of 25 technical and managerial personnel employed by Coal Extraction and Utilization Research Center for the coordination of activities with faculty doing research. Coordinates the Clean Coal Review Board Program, a $25 million initiative designed to encourage the application of leading edge clean coal technologies. Leads university activities on international coal research and development and is responsible for the development of periodic coal and engineering conferences and workshops.

Director of the Office of Coal Development and Marketing, Illinois Department of Energy and Natural Resources, Springfield, Illinois (December 1986 to March 1989).

Administered the state's coal research and development, demonstration, marketing, and coordinated permit review programs. Directed the formulation of coal development policy for the department and the administration. Oversaw the expenditure of ten to twenty million dollars of state funds per year. Responsible for securing industrial and federal support for state coal development activities. Lead state efforts to attract large scale coal demonstration projects to Illinois sites. Served as a liaison between the department and state and federal agencies. Represented the state before congressional committees on coal related issues. Chaired meetings of the Illinois Coal Development Board in the absence of the department director. Recruited and directed professional and support staff.

Page 132 PREV PAGE TOP OF DOC Segment 1 Of 7

Manager of the Coal Research Program, Illinois Department of Energy and Natural Resources, Springfield, Illinois (March 1985 to December 1986).

Planned and coordinated the state support of scientific coal research. Responsible for the selection of research priorities and the development of procedures for project selection and management. Directed the preparation of reports related to research on coal. Coordinated the development of an effective state-wide coal research organization based on the resources of Illinois universities and research institutions. Recommended substantive and budget legislation to stimulate coal research in Illinois. Maintained liaison between the department and the Illinois General Assembly, state and federal agencies, universities and industries involved in coal research. Recruited and directed professional staff.

Staff Director, Energy Resources Commission, Illinois General Assembly, Springfield, Illinois (April 1982 to March 1985).

Responsible for providing research, legislative recommendations and technical advice to the Illinois General Assembly. Coordinated the Commission review of proposals for funding under the Coal and Energy Development Bond Act and the Coal Technology Development Assistance Act. Represented the Commission before legislative and congressional committees. Participated in the planning of state and regional conferences. Developed and managed the Commission budget. Recruited and directed professional and support staff.

Staff Attorney, Energy Resources Commission, Illinois General Assembly, Springfield, Illinois (June 1979 to April 1982).

Recommended and drafted legislative proposals. Developed positions on state and federal energy issues. Researched and evaluated legal, scientific, financial and business developments related to energy. Prepared and presented background papers and testimony in support of legislative proposals.

Page 133 PREV PAGE TOP OF DOC Segment 1 Of 7

OTHER PROFESSIONAL ACTIVITIES

General Chair, American Society of Surface Mining and Reclamation National Conference (1998).
General Chair, International Conference on Engineering Education (1997).
Member, Illinois Board of Natural Resources and Conservation (1997 to present).
Chair, Industrial Advisory Committee, Department of Mining Engineering, Southern Illinois University at Carbondale, (1987 to 1989).
Member, Program Committee, Illinois Clean Coal Institute (1986 to present); Chairman (1986 to 1989).
Member of the U.S. Department of Energy Innovative Control Technology Assessment Panel (1988–1989).
Member of the Illinois State Building Energy Advisory Council (1983–1985).
Member of the Interstate Coal Task Force (1982–1985).

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Page 134 PREV PAGE TOP OF DOC Segment 1 Of 7

Panel I Discussion

Chairman **BARTLETT.** Thank you very much for your testimony. I want to thank all of the witnesses for their testimony. Obviously, some differences of opinion. I hope we will have a chance to explore those. And later on in the hearing, I will invite members of the Panel to pose questions for other members of the Panel because we want a full airing of all of the issues today. And a whole lot more wisdom is represented at the

witness table than represented here at the dais. So we will invite you to ask questions of each other later.

I want to note now that we have been joined by my colleague, Ms. Hart, and by our Full Committee Chair. And I would like to yield my first-round questioning time to our Full Committee Chair.

Mr. **BOEHLERT.** Mr. Chairman, I appreciate the courtesy, but I prefer to take my turn. That is the way we operate in the Full Committee, first come, first serve, and those of you who have been through the entire hearing deserve to have their questions asked first. I will be the clean-up batter.

Chairman **BARTLETT.** Well, thank you, and I will follow you as clean-up batter then. So let me now turn to Mr. Costello.

Benefits of the Clean Coal Technology Program

Mr. **COSTELLO.** Mr. Chairman, thank you. Mr. Kripowicz, one is, you have testified, as some of the other members of the panel have testified, that the Clean Coal Technology Program has worked. How do you see the $2 billion proposal that the President has submitted to the Congress and to the American people for a clean coal technology impacting the future of technology in the area of clean coal?

Mr. **KRIPOWICZ.** Mr. Costello, I think it builds on what is already a successful program. You know, since the program was introduced, several things have happened. One, there have been tighter environmental controls put in place and there are prospective environmental controls, for instance, on mercury that are going to be put in place and in ozone coming up in the future. These things were not addressed in the original program.

Secondly, there is a large requirement for power plant construction that did not occur in the original period of the Clean Coal Program. Actually, over the past 10 years, there were only about 10,000 megawatts of coal capacity built in the United States. And so with the requirement for power we would expect a large increase in that requirement.

And, thirdly, there is a lot of new technology that is in the development stage now that was not available in the early '90's when this program was initiated. So the demonstration of that technology, which will lead to higher efficiency and lower pollution from coal plants is what the attempt of the new Clean Coal Program would be.

Mr. **COSTELLO.** On page 5 of your testimony, Mr., Kripowicz, you indicate the cost benefits of clean coal technology. And I guess I have two questions. One, you say that the American people pay over 200 billion a year for electricity and you attribute the low cost of electricity to, in fact, coal in the Clean Coal Technology Programs. In fact, you say the lower cost clean coal technologies that have become available in the '90's are one reason why the Nation's utilities could meet new environmental standards without imposing harsh price hikes on rate payers.

I wonder if you might put to rest two issues here. One is, what initiatives are we currently working on as far as clean coal technology? And, number two, as Ms. Abend has suggested, we know that over 50 percent of the electricity generation today through power plants is—that are coal-powered plants. And I am wondering if we stopped the use of coal tomorrow, one, do we have something to replace it with, and, number two, what would happen to the rate payers?

Replacing Coal With Other Fuel Sources

Mr. **KRIPOWICZ.** Well, to answer the second question first, it is apparent currently that with the large amount of construction of natural gas-fired power plants, which are, I will admit, somewhat cleaner than coal plants are currently, we have run into a problem of natural gas supply. If you remove the 50 percent of electricity that is generated from coal, there would not be any substitute on an immediate basis for that. So it wouldn't be a question of a rate hike and cap, it would be a question of not having enough electricity, particularly in the short term.

In the long run you need a balance. It is clear that the utility industry is still going to build a lot of natural gas plants. As much as they can get a cheap natural gas-fired facility, they will go to that rather than building a slightly more expensive coal plant—for two reasons. One, because of the economics, and, two, because it is easier to meet the environmental requirements.

But in addition to coal and natural gas, you also have to look to nuclear and renewables and hydro and other things in order to meet the overall electricity requirements of the country. You need a balance—not just clean coal, not just natural gas. You need to do all those things.

Page 137 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **COSTELLO.** And——

Mr. **KRIPOWICZ.** I would also say you need to—in reference to some of the testimony, you do need to increase efficiency. The Administration, and their National Energy Policy has quite a few initiatives in that area.

New Clean Coal Research Projects

Mr. **COSTELLO.** And the last question—what initiative are you currently working on that will improve the current clean coal technologies?

Mr. **KRIPOWICZ.** Our largest research and development initiative right now is what we call Vision 21, which is a flexible coal-fired power plant, which would, in the future, double the efficiency of coal plants and decrease the emissions of pollutants to well below the new source performance standards there are now. In addition, we are developing carbon sequestration technology and coal-burning technologies that would be compatible with that so that, in addition to reducing CO emissions by increasing efficiency, we would also be able to capture the remaining CO at reasonable costs.

Mr. **COSTELLO.** Mr. Chairman, I have other questions, but I see I am out of time. So hopefully we will have another round or two. Thank you.

Chairman **BARTLETT.** We will, indeed. Thank you very much. We will recognize witnesses who were here at gavel fall in the order of their seniority. For those who appeared after gavel fall, in the order of their appearance at the Committee. So, Mr. Smith, you are recognized.

Page 138 PREV PAGE TOP OF DOC Segment 1 Of 7

Potential Reductions in Emissions From Coal-fired Plants

Mr. **SMITH.** Mr. Chairman, thank you very much. You know, I am sorry I missed some of it. In the clean coal technology, if we were to be more aggressive with our research funding and our efforts, is it—could you foresee an effort where we could reduce 95 to 98 percent of the pollutants and cut in half the CO discharge? What are the possibilities technologically if we were to put our shoulder to the research wheel?

Mr. **KRIPOWICZ.** Mr. Smith, those are exactly the kind of targets that we have—is to reduce the pollution by 95 to 98 percent and also to double the efficiency of coal-fired power plants. The time frame in which that can be done, it depends a lot on the existing coal-fired fleet. You just can't—you can't economically replace that fleet all at one time, so it will be done over a considerable period of time. But by the year 2010 or 2015, we should be well on our way to replacing a lot of that capacity which much higher efficiency technology and lower polluting technology.

Mr. **SMITH.** Mr. Mead, any other comments?

Mr. **MEAD.** Yeah. I think it is a goal that science can achieve. And research and further development in a variety of energy sources is critical for this country. But the investment in increasing the efficiency and the cleanliness of coal, I think, is crucial because we are using so much coal today and are likely to continue to for some time. The reduction of greenhouse gases, such as carbon dioxide, that is one of the great issues in terms of technology today and energy. But advances are being made. There are now concepts out there that are past the point of just being discussed. They are not being looked at in the laboratory. That is a very good sign. The development of energy processes is a slow task because of the size of the power plants. But I think with government help we can accelerate that effort.

Page 139 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **SMITH.** The Chairman said earlier—Mr. Yamagata, did you have a comment?

Mr. **YAMAGATA.** Thank you, Mr. Smith. Yes. In my testimony, I referenced a number to answer your shoulder-to-the-wheel question, of about $10 billion over the next 20 years, which is, at least in our estimation, a cost-share arrangement between the public sector and the private sector. And that kind of an aggressive program, that is time and money, over that period of time, will, we think, achieve the kind of performance criteria that you outlined, that is, cost competitive, certainly exceeding the emission requirements and regulations that we have today and into the future, and also addressing issues like CO

emissions.

Mr. **SMITH.** And would this—then does it become less relevant whether it is high sulfur coal or whether it is the cleaner, lower-sulfur coal? I mean, will the technology be so that it doesn't make that difference—really much difference on what coal you use?

Mr. **YAMAGATA.** That is correct. It is nondiscriminatory to the type of coal that you use.

Programs to Reduce Dependence on Oil Produced by the OPEC

Mr. **SMITH.** In terms of our—the other areas becoming less dependent, the Chairman said earlier that it is a national security issue being—having this kind of dependency, especially on the OPEC suppliers for our petroleum energy. Are we looking—and I am trying to see whom ought to answer this question—it might be the next panel. Are we aggressively looking at developing the kind of infrastructure and laws in some of the other areas of the world in terms of importing some of our petroleum energy from those other countries rather than from the OPEC countries? Does anybody know that answer? Mr. Chairman, you probably know that answer.

Page 140 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **KRIPOWICZ.** Yes, sir. The Department of Energy, over the years, has worked a lot with countries outside of OPEC and is working very hard, for instance, with countries in this hemisphere also, Canada and Mexico, in particular, to develop their sources of oil so that we won't be entirely dependent on OPEC. There is no question that we need to develop diverse sources of oil in the world as well as our own resources.

Mr. **SMITH.** Do we—do I understand we have the technology now and it is simply making it more cost effective in utilizing that technology, or is it developing new technology? And I see my time has expired.

Mr. **KRIPOWICZ.** Mr. Smith, I think it is a combination of both. Some of it needs to be made more economic, but I am willing to bet that we will find new technologies, as we go along, that we don't have in place right now.

Mr. **SMITH.** Thank you for the opportunity, Mr. Chairman.

Chairman **BARTLETT.** Thank you. Ms. Biggert.

Ms. **BIGGERT.** Thank you, Mr. Chairman. Ms. Abend—is that right—Abend?

Ms. **ABEND.** Yes. Abend.

Alternatives to Fossil Fuels

Page 141 PREV PAGE TOP OF DOC Segment 1 Of 7

Ms. **BIGGERT.** All right. Thank you. It seems that we are in a technological revolution in most everything in our lives and yet we are still in the dark ages as far as some our technology for energy is and we have spent nothing really in the last 10 years probably with the energy policy. Does PIRG see a way to continue our economic and technology expansion and continue to improve our standard of living and provide for an increased population without gaining access to additional fossil fuel supplies?

Ms. **ABEND.** I think what we need to focus on right now is finding a smarter, cleaner energy future. We can meet 60 percent of our Nation's future energy needs through energy efficiency and renewable energy by 2020. Forty-eight percent of the 1,300 plants that President Bush proposes for his energy plan are already under construction. So I think that we do have adequate options for meeting our future energy needs.

Ms. **BIGGERT.** But—well, you talked about like 100 square miles of solar power would produce how much——

Ms. **ABEND.** Would produce as much energy as the United States used—uses annually.

Ms. **BIGGERT.** Why—if that was possible, why wouldn't be doing that now? You know, I have driven by those windmills in Palm Springs and they seem to be going like mad, but that is a huge area that only powers such a small part of California.

Ms. **ABEND.** Right. Well, these programs don't receive sufficient funding. And compared with the funding that fossil fuel programs receive, they are not on a level playing field. The Bush Administration cut funding for renewables by nearly 50 percent from 376 million to 186 million in its budget proposal. That is why we strongly support DOE's energy programs, but we encourage these programs to be expanded.

Page 142 PREV PAGE TOP OF DOC Segment 1 Of 7

Ms. **BIGGERT.** But——

Ms. **ABEND.** And DOE should increase funding for those to $750 million a year.

Ms. **BIGGERT.** And how long would that take to develop such a plan? And we—only two percent of our energy is——

Ms. **ABEND.** Well, the technology is already available. For example, wind power is already competitive with fossil fuel in some situations. Other countries are way ahead of this on this, and we should be the leaders of this technology. For example, Denmark, very soon is going to be having 50 percent of its power coming from wind. So these aren't things that need to be so far off in the future if we increase funding for these programs.

Ms. **BIGGERT.** Well, I think we really need to look at renewables, but, you know, the size of Denmark compared to the size of the United States in trying—I don't know, coming from Chicago, where we didn't ——

Ms. **ABEND.** Right.

Ms. **BIGGERT** [continuing]. See the sun for at least three weeks in a row. How do you——

Ms. **ABEND.** Right. Well——

Page 143 PREV PAGE TOP OF DOC Segment 1 Of 7

Ms. **BIGGERT.** How do you store that power?

Ms. **ABEND.**—six percent would be—yeah, six percent of the contiguous United States land area could actually produce 1g the amount of electricity that the United States used in 1999. So it is just really a matter of focusing on these programs.

Cooperation Between State and Federal Clean Coal Programs

Ms. **BIGGERT.** Mr. Mead, in your presentation, you talked about Governor Ryan's initiative and what is going on. How can—can you suggest ways in which the state programs and Federal programs can increase their coordination and collaboration? Do you think there is enough of that right now or are there impediments in the Federal program to really provide the benefit and usefulness to the—to Illinois and other states?

Mr. **MEAD.** There has been a lot off cooperation and collaboration over the years, as I address in my testimony. One of the factors that I think would be very useful is that both programs operate often on a competitive selection basis and independently. And so that a project selected through review by a Federal agency may be different than one that is chosen at a state level. There could be, perhaps, greater examination of the common issues and needs in a region where projects that would have particular value for Illinois or the Midwest could be factored into the Federal program.

In addition, I want to emphasize again the critical need for advanced research and development on issues that we do not face today with our current regulation, but issues that we expect to face in the future. The overall reduction of all emissions is going to be crucial for the life of the coal industry, such as Illinois. We have experienced this with the sulfur issue. Now, we look ahead and see other issues for the future.

Page 144 PREV PAGE TOP OF DOC Segment 1 Of 7

This is where, I believe, the Federal Government can really dovetail with state economic development efforts and nearer-term state efforts.

Ms. **BIGGERT.** Thank you. Thank you, Mr. Chairman.

Chairman **BARTLETT.** Thank you very much. Ms. Hart.

Ramifications of Fuel Switching Between Coal and Natural Gas

Ms. **HART.** Thank you, Mr. Chairman. I am glad to see a hearing being held on this issue. I—and I am sure a lot of other members represent some very interesting technology organizations. And I have a company in my district, actually, called Export Tech that some of you may be familiar with. It is developing and continuing to research advanced form of clean coal technology—one that cleans the coal removing mineral impurities using magnets resulting in a coal waste that can be returned to the environment without being hazardous and also, obviously, a cleaner burning coal.

I know that there are a lot of other technologies out there and I am glad to see them. I think it has been a long time in coming and I am also pleased to see some of the progress, you know, made by organizations within the government and some of the research.

I think I have a general question, basically, for the Panel. As far as, you know, we are focused on the first Panel pretty much on clean coal technology, but I am interested in a general question of future resources to—future sources of energy, future sources of energy, especially electricity. And as we look to the future, unfortunately, I think, we have taken a turn toward using natural gas for electricity. And I would like your opinion on that as a direction. I would like to know if you think we made a wrong turn and if you think that we have to turn more heavily toward coal from natural gas.

Page 145 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **KRIPOWICZ.** I think the industry turned to natural gas because it was the cheapest available alternative and the industry will go to the most economic thing that they can do. And the problem with exclusively burning natural gas, of course, is that there—you run into supply problems. At least you do on any foreseeable basis that we can imagine. There is a very large supply of natural gas in the country, but demand, even with reasonable expansion of the electricity market, is supposed to go up by 60 percent by the year 2020. So there is a tremendous demand on natural gas, mainly from the utility business. And at that, natural gas would still only be about 25 percent of the installed utility capacity. So you need to continue to look at the other resources and coal is one of those.

Now, I would be the first to say that what we don't want to do is put in coal plants that are just like the ones that have been in existence for the past 25 years. We want to build cleaner, more efficient, coal plants, that have much less environmental impact. I think we also need to look at the nuclear option to see whether we can extend the existing nuclear plant life and increase the efficiency of those plants over a period of time.

And we also have to look at renewables. Not just hydro, but solar, as other panel members have said, because in certain circumstances, those kinds of technology will be economic. But I believe we need to look at all of those things.

Mr. **YAMAGATA.** Ms. Hart, if I may just add to that? Let me quote to you a quote from William Wise, the Chairman and CEO of the El Paso Corporation, which happens to be the world's largest natural gas pipeline company. He says—I quote—in the Utility Spotlight of March 5, 2001—"Conventional sources of natural gas in North America won't be able to produce enough deliverability to meet the kind of demands that power generation is going to drive." And I think the point that you made is absolutely right on.

I want to second what Mr. Kripowicz has said, and that is, it seems to me we need to be looking at and trying to develop all of our energy resources, as well as all of our energy efficiency and energy conservation and renewable endeavors that we have in mind. Frankly, we need them all.

One of the issues that has not yet been made in this panel discussion is, with respect to coal and with deference to my other panel colleagues here is, we are not just going to use coal in the United States where we have a 250-year supply and it supplies 51 percent of the current electrical base in this country. We are going to use it around the world. We are going to use it in China and India and other places like that. And the promise of better, cleaner coal technologies is something that we ought to be aware of. It is a technology transfer and an export opportunity for this country, but it is also something that is the resource itself, that is going to be used around the world. And we, perhaps, as stewards of the planet, have an obligation, it seems to me, to try and make that use as clean as possible.

Ms. **HART.** Go ahead, Mr. Wells.

Mr. **WELLS.** In terms of your resource question, whether it is $2 billion or the current proposal of the $10 or $20 billion, the niche in the market for GAO would be to look at whether these resources are spent effectively and efficiently and we are getting the biggest bang for the buck. I would agree with my panelists that history has shown us that you need a balance of energy sources, and much of what we have seen in the natural gas market right now would be the demand far exceeded the supply and it was driven by some policy considerations that put the market in and up and down situation. So future deliberations on energy sources should include a balance from all sources, including coal.

Ms. **HART.** Thank you. I see my time is up, Mr. Chairman.

Chairman **BARTLETT.** Thank you very much. And now, our Full Committee Chair, Mr. Boehlert.

Clean Coal Technology Aims and Environmental Groups

Mr. **BOEHLERT.** Thank you very much, Mr. Chairman. Ms. Abend, I agree with much of what you say and it probably will come as no surprise to anyone in this room, given where I come from, acid rain entered the Nation's vocabulary as a result of the havoc being wreaked on the beautiful Adirondacks in my neighborhood. And I certainly agree with your comments on global climate change. It is for real. It is not some vast left-wing conspiracy. And I also agree with your commentary about the need for a greater investment, not lesser investment, in renewable energy sources and energy efficiency. And I am trying my darnedest to convince the administration that they should take a different path in some of these areas as they address the energy problem we face in America.

But some of what you say gives me pause. You summarily dismiss clean coal technology almost out of hand. I don't think that is the right thing to do. I have been supportive in the past. I have been skeptical. I am

still supportive. I am still skeptical. I would like to think that this Committee would authorize programs where we have guaranteed success all the time. That is not the nature of research and development. We have to venture forward and with the best hopes and expectations.

Page 148 PREV PAGE TOP OF DOC Segment 1 Of 7

And as I look over some of the testimony, I—and I refer specifically to Professor Mead. And one part of his testimony says, the eventual application of ultra-clean systems will hold tremendous value to a Nation whose greatest fossil energy resource is coal. We can't escape the fact that coal now provides more than 50 percent of our electricity-generating capacity in America, nor should we ignore the potential for wind energy and solar energy and hydro energy and biomass.

I think what we have to do is come up with a balanced program, and I am trying very, very hard to convince the Administration of that. I think the initial proposal advanced by the Administration focused almost exclusively on supply. We can't drill our way out of this problem, but we can't conserve our way out of the problem. We need balance. And I am also mindful of the statement made by Mr. Wells as he looked at the Clean Coal Technology Program. And, among other things, he pointed out there have been successes and there have been failures, and some of those failures have been costly. But I would suggest that the investment, if very carefully monitored, can offer us what Mr. Mead wants and what we all want.

And, as Mr. Wells said in his testimony, this program serves as an example to other cost share programs in demonstrating how the government and the private sector can work effectively together to develop and demonstrate new technologies. That if my hope for this program.

You said there is no such thing as clean coal, and I would essentially agree. But there is such a thing as much cleaner coal, much lower emissions. And that is what I am driving at. I have the definitive bill in this session of Congress to deal not just with nitrogen oxide and sulfur dioxide, but also with mercury and CO, which is for real. And the President has now acknowledged that CO is for real. Those are the words—I would like to see some deeds follow. And I think working constructively with the Administration, we will see them.

Page 149 PREV PAGE TOP OF DOC Segment 1 Of 7

But I guess in this long commentary, I would just urge you and your associates in PIRG, not to summarily just dismiss something that has potential of doing the right thing for all the right reasons, but try to work with us to develop a program that is responsive to our needs, that is cost-effective, and moves us in the direction, I think, you and I would agree we should move on.

With that, let me just ask you if you—if there is any hope that we can convert you to have sort of a glimmer of hope that maybe, maybe, we could get something positive out of the Clean Coal Technology Program, given the proposition that I agree with you, more investments needed in renewable energy sources, more investments needed in energy efficiency. We have to forthrightly address CO. There are a lot of things we have to do and so there is a lot of area of agreement. But I will give you the opportunity now.

Ms. **ABEND.** Well, first of all, I would like to say that we strongly support your Clean Smokestacks Act of 2001 and, you know, that would reduce NO**X** and SO**X**, or smog and soot emissions, by 75 percent and mercury emissions by 90 percent and global warming pollution or CO pollution to 1990 levels. And I think the key there is that it imposes strong standards that will need to be met. The truth is, that burning coal will always produce pollution, especially carbon pollution, which causes global warming. Burning coal accounts for about g of global warming pollution, and we feel that the Federal Government should not be using taxpayer dollars to encourage its use.

Now, obviously, as you said, we would rather have cleaner coal than dirtier coal. But we believe that polluters, not the public, should pay for cleaning up pollution. That is why we——

Page 150 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **BOEHLERT.** Let me reclaim my time, if I may, because you got a nice prepared statement and I appreciate that. But I would agree with you that coal is a problem right now and your figures are probably very accurate. I haven't verified them, although I have trust—the g figure you used. But I don't like that. You shouldn't like it either. I don't accept that. You shouldn't either. And that is why we are talking in terms of investing important and scarce taxpayer dollars in the research and development that is going to lead us to a better day. And I would just hope that you would give some consideration to the possible—to the potential for this program if we do it the way we should do it.

And I want to thank you very much for your commitment. And I want to thank all the witnesses because you are stars here. You are resources for the Committee and we really appreciate it. In fairness, since I am calling for a balanced policy, Mr. Yamagata, maybe I ought to give you some time to comment on my little discourse here.

Mr. **YAMAGATA.** Mr. Chairman, thank you very much. I will just take a second of the Committee's time and note, if I may, that in the vein of the line of reasoning that you have so eloquently developed, it seems to me that our goal here ought to be to take issues about environmental concerns out of the question about whether or not we can and should use coal. And we need to do that, I think, by making a commitment to the development of those technologies that I believe both the government and industry believes is within the realm of the possible. It will take time. It will take a financial commitment. We have a history of having made real progress, really, since the 1970's in terms of emission reductions from the use of coal. It seems to me that is a better set of metrics from which to judge than one which simply says we shouldn't use it at all.

Page 151 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **BOEHLERT.** Thank you very much. Mr. Chairman, thank you for your indulgence.

Chairman **BARTLETT.** Thank you very much. Mr. Wu has joined us. Mr. Wu.

CO **EMISSIONS FROM CLEAN COAL AND CLEAN COAL ALTERNATIVES**

Mr. Wu. Thank you very much, Mr. Chairman. In some respects, I am catching up a little bit to testimony

which has been given earlier. But I would like the Panel to clarify for me that if we are not focused on clean coal or other clean technologies—let us just focus on clean coal. What would be the CO impact of alternative technologies to the coal technology that we are talking about?

Ms. **ABEND.** Obviously, there are a lot of renewable energy sources that don't produce any CO. We talked about wind technology, solar technology. And then I would just also like to stress that another alternative is just to improve efficiency. Like I said, we can meet 60 percent of our future energy needs by improving efficiency. One example of a way that we can do that is to improve auto fuel efficiency standards. If we increase those to 40 miles per gallon, we would save 15 times the oil in the Arctic National Wildlife Refuge. So there are a lot of viable solutions out there that don't produce any carbon dioxide, and we really need to focus on putting as much energy as we can into those solutions.

Mr. Wu. Let us come back to that in a second. Mr. Kripowicz.

Page 152 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **KRIPOWICZ.** Mr. Wu, one of the things about the clean coal technologies that we are developing is that we—in the long term, we expect them to be almost double the efficiency of existing power generation technologies. So we would be talking about reducing CO emissions just with that technology itself by around 50 percent. In addition, the Department is working to develop economic methods of sequestering carbon from the air. And if we can do that on an economic basis, then we could essentially have zero carbon emissions coal technology as well as other technology.

If we can get indirect sources of—indirect ways of capturing CO, we could actually help reduce the emissions from other sectors of the economy than electricity also. It doesn't have to be coal related. It is any kind of carbon. So you could also affect the CO emissions of the transportation industry, for example.

Mr. **YAMAGATA.** Mr. Wu, if I may, a rule of thumb, if you will, with respect to increased efficiency of coal plants, for each percentage increase in efficiency, say, going from a 30-percent conversion—I take a lump of coal and I get 30 percent of its useful energy out of that coal if I produce electricity, which is kind of today's technology. But if I could produce 60 percent out of that lump of coal, I also, at the same time, reduce on a percentage-basis the amount of CO that I would emit in the reverse order, just as a point of reference.

The second point, to get back to the question you originally raised, that nuclear energy is—has no CO emissions, just as a point of reference.

Page 153 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. Wu. Would you care to discuss any other benchmark technologies other than nuclear?

Mr. **YAMAGATA.** I think you can look across the board at hydro. You know, there—the point here is that all of these resources that we are blessed with have their own constraints, whether it is nuclear or hydro or renewables, frankly. One of the large problems with our wind energy, which happens to be economic

today, and we support it, is just the siting of wind systems, which you may well be familiar with. But they all have their problems.

Mr. **BOEHLERT.** I have got some locations in upstate New York for you, if you would like.

Mr. **YAMAGATA.** I know you do, Mr. Chairman.

Clean Coal and Distributed Generations

Mr. Wu. While we prize our hydro systems in the Pacific Northwest, we have become acutely aware of some of the downsides of renewables, whether it is wind or hydro or other sources. I guess leaving that fertile terrain behind for the moment, perhaps some of you could address the topic of burning, as you say, a lump of coal, and getting 30 percent energy—useful energy out and, I believe, primarily using that for electricity generation versus piping fuel directly to the site where the electricity would otherwise be used and the relative efficiency of those two different systems.

Mr. **KRIPOWICZ.** I—with distributed energy systems, which I think is what you are referring to, in most cases, the fuel you have to use is natural gas. You know, if you pump the fuel directly to a small electric generator, the fuel you have to use is natural gas. And the question then becomes how much natural gas do you have available. I would also point out that you can gasify coal and you can also use that to run fuel cells and other kinds of distributed generation also. So I mean, you know—and there are—there is a plant that has been in existence for a long time in the United States in North Dakota that produces pipeline quality gas that can do the same thing from coal.

Page 154 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **MEAD.** I think another factor is that coal is also a good source of other products, chemicals, carbon-based materials. So power generation with a co-production of other materials, is another way of gaining efficiency. And in some sense, co-generation is another type of distributed power generation. So coal, as our most plentiful source of carbon-based products, is a very important resource beyond energy. And the combination of energy and other products can really raise the efficiency of the overall system.

Mr. Wu. Mr. Chairman, thank you very much for recognizing me. I think in what feels to me like record time, but I see very quickly we are in the red-light zone already. Thank you very much. Thank you to the Panel.

Using Technology to Revitalize Spent Oil Wells

Chairman **BARTLETT.** Thank you very much. Mr. Kripowicz, did I hear correctly that new techniques in Southern California enabled them to find a million barrels of more oil? Was that the correct number?

Mr. **KRIPOWICZ.** Yes, sir. They had actually produced over the life of the field only about a million barrels. And——

Chairman **BARTLETT.** Now, they produced a million more. I just wanted to put that——

Mr. **KRIPOWICZ.** And then they produced in this 3- or 4-year period an additional million barrels. So the technique not only allowed them to go back——

Page 155 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** Yeah.

Mr. **KRIPOWICZ** [continuing]. To the kind of production levels they had before, but actually to exceed those levels.

Research & Development Funding and Tax Credits for Energy Efficiency and Renewable Energy

Chairman **BARTLETT.** That is a lot of oil. But I just wanted to put that in perspective. That is about 1/20 of one day's use of oil in this country. Ms. Abend, recently I met with the Vice President. I reminded him that this President is my President, of whom I am very fond, by the way. And I didn't want him to look dumb. And I asked the Vice President to explain to me why cutting the energy budget, when we face a potential energy crisis, particularly the budget for renewables, wasn't dumb? And the Vice President asked OMB to come to my office to brief me. And they came to my office and pointed out that although they had cut a lot of R&D from the renewables budget, that they had also put, in another part of their budget, some tax credits—almost a dollar-for-dollar offset tax credits for using renewables. Does this help?

Ms. **ABEND.** Obviously, tax credits can be an important tool in forwarding renewable energy and energy efficiency. I think that tax credits need to be accompanied by standards and goals. For example, for renewable energy, we suggest a goal of having 20 percent renewable energy by the year 2020. Simply by, you know, having tax credits doesn't ensure that we are going to get there. We also need to have sufficient funding for these programs for the research and development of these programs.

Page 156 PREV PAGE TOP OF DOC Segment 1 Of 7

In terms of energy efficiency, tax credits can be dangerous if they are not accompanied with actual standards for improving energy efficiency. For example, again, with automobiles, if you have tax credits without actually improving standards for auto fuel efficiency, then you can just have, at the other end of the spectrum, the industry is able to produce more polluting vehicles. So it is important to accompany these tax credits with improved standards.

CAFÉ and Hybrid Vehicles

Chairman **BARTLETT.** I am a big fan of renewables. I am also a big fan of efficiency. I was just told this morning that California has now reduced its electric consumption by 11 percent. Efficiency and conservation does work, doesn't it, if they have reduced their consumption by 11 percent.

I also agree with you on the CAFÉ standards. I was the first person in Maryland and the first Member of Congress to purchase a Prius hybrid electric car. We have now driven it over 16,000 miles. There is no

reason that most of the cars on the road shouldn't be this technology. Our auto manufacturers in this country have them on their drawing boards. They need to be in their showrooms. This car performs as well as any other car that we have owned and it pollutes as little as 1/10 as much as competing models. And for the last more than 500 miles, we have averaged 50 miles per gallon on the car. Now, the EPA mileage, if you don't pay any attention to how you drive, you will get 45. But it has a computer screen there that kind of coaches you to do efficient things in driving. If you do that, it is not very difficult at all to get 50 miles per gallon.

Page 157 PREV PAGE TOP OF DOC Segment 1 Of 7

I was disappointed they didn't export to us the model they built in Japan with a 1 liter engine. Ours has a liter-and-a-half engine. I guess we like muscle cars and—but I was disappointed they didn't export here the car that they market in Japan. It would have gotten about 60 miles per gallon. And I would note that safety is all very relative. There is no car on the road—there is no SUV that performs much better than the smallest car when they have a head-to-head confrontation with a tractor trailer. So it is all very relative. Isn't it? And the big SUV owner who now claims that he is safer—if all the cars were smaller, they would all have equal safety. And none of us are really all that safe if we are going to run into a big tractor trailer car.

Coal Versus Nuclear Energy

Ms. Abend, I noted your remarks about coal and its cost in terms of illness, its cost in terms of the environment. It is not free, you know. It produces the lowest cost to electricity. And that is a very compelling argument, don't you think, as to why we shouldn't go to nuclear?

Ms. **ABEND.** Well, coal actually has not produced a profit for the DOE. It has—the DOE has recouped only a small portion of taxpayers' money devoted to the program. A 1996 audit of DOE found that there was a potential loss of $133 million out of $151 million investment in six clean coal technology programs. So obviously, the money isn't really being spent in the most efficient way that we possibly could. And the point here is that we feel that the coal industry should be paying for its own research to reduce emissions.

Page 158 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** That is another question. In another round, I will ask you that question——

Ms. **ABEND.** Uh-huh.

Chairman **BARTLETT** [continuing]. Because Mr. Wells is the only, I think, relatively nonbiased person on the panel today. So I would like to ask him that—but my question to you was, doesn't your arguments about the problems of burning coal—aren't they very powerful arguments as to why we ought to use more nuclear? It doesn't have any of those negatives that you talked about with coal. You see, if we don't burn coal, we have got a big, big problem. We don't have anywhere near enough electricity since coal produces half of it. Every fifth home is now powered by nuclear. And the argument you made about the problems with coal, aren't they powerful arguments as to why we have got to look harder at nuclear?

Ms. **ABEND.** Nuclear energy is unsafe. It is expensive. And, in the past, it hasn't been successful. It has

required a huge amount of taxpayer bailouts. And so I just feel like that is—PIRG feels that that is not the solution to our energy problems. Obviously, energy efficiency is the quickest, cheapest, and cleanest way to save consumers money on energy bills to reduce pollution and also to help prevent rolling blackouts.

Chairman **BARTLETT.** Well, I am with you a hundred percent on conservation and efficiency. And we will get back in another round, but my time is now up. And let me turn again to Mr. Costello.

Mr. **COSTELLO.** Mr. Chairman, I really have no further questions. I had a couple of other questions, but they have already been asked by other members. I would just like to thank all of our witnesses for being here and to give them an opportunity, at this time, if they would like to respond to—or to add to any question that has been asked, starting with Mr. Kripowicz. Anything you want to add at this point?

Page 159 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **KRIPOWICZ.** Only one thing, Mr. Costello. And that is, that on balance—and even GAO agrees that on balance, I think that the clean—the original clean coal program was a model effort with industry to produce clean technology. And we would hope to avoid some of the mistakes and problems that we had in—to some extent, in the original program, whenever we go through the second clean coal technology initiative that the President has recommended. And we think we have the knowledge to be able to do that and to work with industry to produce clean technology—cleaner and more efficient technology than is available today for the country. Thank you.

Mr. **COSTELLO.** Mr. Yamagata.

Mr. **YAMAGATA.** Thank you, Mr. Costello. Just an observation that two percent of the 600,000 megawatts of currently installed electrical generation in this country comes from renewable energy; 51 percent comes from coal. We would be ecstatic if 20 percent of the 3 or 400,000 of additional capacity that the President has estimated could come from renewable energy and we endorse that if that can happen. But I think we need to be realistic.

Mr. **COSTELLO.** Mr. Wells.

Mr. **WELLS.** Not often as a GAO witness I get to talk about something that is really working well and done good. But for the Clean Coal Technology Program we did commend DOE and we should commend the Congress for putting together provisions that allowed a good cost-sharing agreement. The fact that the Congress appropriated money over a longer-term period gave confidence to the business world that the government was committed to supply the funding necessary for success. The fact that DOE gave clear instructions on the roles and responsibilities, in terms of their partnership—the fact that DOE came to the table and didn't pay for everything, but much of the industry supported greater cost shares. And once you learn that when industry puts more of their dollars in, there is a likelihood or a greater chance of success. A lot of things were done well and we think that much of that could serve for even better cost-sharing provisions in the future. So we commend DOE and the Congress for doing that sort of thing.

Page 160 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **COSTELLO.** Ms. Abend.

Ms. **ABEND.** I would like to just respond to Mr. Yamagata's comment on being realistic about alternative energies, because I did talk a lot about Clean Coal Technology Program being mismanaged in some ways. And I would just like to stress that in comparison to Clean Coal Technology Program, energy efficiency, the rate of return for those programs, has been staggering.

According to the American Council for an Energy-Efficient Economy, the DOE recently documented that 20 of its most successful energy efficiency projects have saved the Nation 5.5 quadrillion BTUs of energy over the past 20 years, which is worth about $30 billion in avoided energy costs. The cost to taxpayers for these activities over the past decade was $712 million, which is less than a three percent of the savings, and the savings are increasing every year. So just in terms of the rate of return for that program, it is pretty astounding.

Mr. **COSTELLO.** Mr. Mead.

Mr. **MEAD.** Well, certainly, I want to emphasize the energy mix that we have in this country. We need to invest in all of our resources. But coal represents the largest single source of electric energy and it is the best source for base-load power production. And we need investment in new technology to see to it that we continue to have that reliable base load for our electric economy for the coming years.

Mr. **COSTELLO.** I thank all of the panelists and thank you, Mr. Chairman.

Page 161 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** Thank you very much. I just wanted to make one quick observation in response to Ms. Abend's frequent references to the efficacy of efficiency. During the Carter years, we were using, each decade, as much energy—as much oil as had been used in all of previous history. Efficiency has changed that relationship so much. What that means is, of course, that when you have used half of all the oil in the world, you have only 10 years remaining if each decade you have used as much as has been used in all of previous history. We have now changed that, and it is due primarily to efficiency.

Worldwide now, we have now changed that dynamic, so that when we have used about half of all the oil in the world—and that is about now as we speak, by the way—or a few minutes ago or a few minutes in the future or years in the future or whatever—but when we reach that point, we will have about 30 years of oil remaining in the world. And that is all due to efficiency. So, you know, I am a big supporter of efficiency. We can do—we can live just as well and just as comfortably and be a whole lot more efficient, and we have demonstrated we can do that.

And just thinking about the problem—in California, they have now reduced their use by 11 percent. That is probably mostly conservation rather than efficiency, but I don't know how you tell the difference between conservation and efficiency. You end up using less and you either are more efficient in the way you use it or you just do without and end up using less.

But we really need to focus on all of these aspects if we are going to be successful in the future. And I think that renewables are too little appreciated and too little supported, and particularly renewables from agriculture. We have an enormous opportunity to get more energy from agriculture, and I would hope that we would focus on that.

Page 162 PREV PAGE TOP OF DOC Segment 1 Of 7

Let me ask other members of our Committee here if they have additional questions to the panelists.

Competitiveness Threshold for Alternative Energy

Mr. **SMITH.** Mr. Chairman, thank you. One short question, maybe in terms to Ms. Abend. If—in the existing environment, if there was no additional tax credits, if there was no additional Federal money, how much higher do you think energy prices would have to be for the private sector to come in and build wind or solar generating—additional wind or solar-generating capacity?

Ms. **ABEND.** I think that wind and solar technologies—it is a matter of building these programs on a large enough scale so that they can be cost competitive. Like I said——

Mr. **SMITH.** Why doesn't the——

Ms. **ABEND.** Like I said, wind energy actually is already——

Mr. **SMITH.** Why doesn't the private sector do it now?

Ms. **ABEND.** Well, one thing to think about is that energy efficiency—or renewable energy programs, rather, aren't receiving the same subsidies as fossil fuels and nuclear power have received historically. So there really isn't that level playing field there. Also, fossil fuel and energy—fossil fuel and nuclear energy are mature industries that are already—you know, have enough money to fund their own research. That is why the argument here is not that we don't want cleaner coal, but that——

Page 163 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **SMITH.** No. No. But still——

Ms. **ABEND** [continuing]. The coal industry should fund their research——

Mr. **SMITH** [continuing]. Back to my question. Again, for the private sector to do it, then they have got to have some assurance that they can make a profit. And if they—if energy prices were doubled—and I appreciate there is a significant variation of energy prices across the country—but if energy prices were doubled, would the private sector build more generating capacity through water or solar or wind?

Ms. **ABEND.** I don't know what the threshold point is in terms of the price of energy and increasing renewable energies, but we can't necessarily control that factor as well as we control how much funding that

we provide for these renewable energy sources in order to give them that boost, and, at the very least, take away the funding from the older, more mature industries and create that more level playing field.

Mr. **SMITH.** Mr. Kripowicz.

Mr. **KRIPOWICZ.** I am sorry. I don't know what that price would be except I would——

Mr. **SMITH.** I guess maybe the question is, if the price of energy went up as much nationally as it has in California, as a percentage increase, where would the—where would the private sector—how would the private sector move to generate energy?

Page 164 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **KRIPOWICZ.** The private sector would still build the cheapest thing available, so they would end up still building natural gas plants and coal plants and nuclear energy——

Mr. **SMITH.** But here again——

Mr. **KRIPOWICZ** [continuing]. And then possibly, renewable, if it is more expensive. Now, wind is a category that it fits in generically——

Mr. **SMITH.** Natural gas has almost tripled in the last year. I——

Mr. **KRIPOWICZ.** It is about doubled now. The price is about $4 compared to—it was down below $2 about a year-and-a-half ago.

Mr. **SMITH.** Well, I mean, that is part of the question. In terms of—and I appreciate the fact that we can subsidize some of the industries that might give them an advantage over the other sectors, but in the long run, it can't be a continuous government subsidy to generate electricity. Consumers are ultimately going to have to pay the price that motivates that kind of generation as we increase our usage and the customers are ultimately going to have to pay to assure that the environment is safeguarded in that generation. Thank you, Mr. Chairman.

Request for Breakout of $2 Billion in Proposed Clean Coal Spending

Page 165 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** Thank you. Mr. Kripowicz, you have recommended a $2 billion proposed spending on clean coal technology over the next 10 years.

Mr. **KRIPOWICZ.** The President has. Yes, sir. As of——

Chairman **BARTLETT.** The President. For this year, you have asked for $150 million. You are not going to ask for all the rest of it next year. Are you?

Mr. **KRIPOWICZ.** I—no, sir. We are right now in the process of constructing a 10-year program to review it with the Administration.

Chairman **BARTLETT.** Could you, for the record, provide that information for us so that we, in our planning, can look ahead to——

Mr. **KRIPOWICZ.** Whenever we have that information, we will make it available to the Committee. Yes, sir.

Chairman **BARTLETT.** Thank you very much. I had said earlier that I was going to invite members of the panel to pose questions to other members of the panel if the members of—on the Committee here have not asked those questions. Are there comments made by other members of the panel that need additional elucidation that pose a question from you? I would like to give you this opportunity now to pose such questions for the record or for answer here if they are short.

Page 166 PREV PAGE TOP OF DOC Segment 1 Of 7

Opinions on S. 60

Ms. **ABEND.** I would like to ask Mr. Yamagata—you talked about improving efficiency at coal-fired power plants and carbon dioxide pollution. If that is an option, then I would like to know whether you support—whether you support legislation like S. 60, which would—the Clean Air Act. Do you think that you be able to meet the standards of the Clean Air Act?

Mr. **YAMAGATA.** I know that the safe harbor provision that was applied in the first draft—that has been introduced—of S. 60, which is legislation that has been introduced on the Senate side by Senators Byrd, McConnell, and, as Ms. Abend said, I believe 23 other senators. And a provision in that bill was with reference to those plants, particularly advanced coal technology plants, to have a safe harbor from provisions of the Clean Air Act. What I can say is that the concerns that have been expressed by the environmental community and others are in the process of being considered and also that provision is being redrafted. How it is being redrafted, I don't know.

But it wasn't an intent to skirt the provisions of the Clean Air Act. It was an intent to say, we may have some difficulties, as we do new technology, that is going to run up against requirements in the Clean Air Act and that we need to try and take away that uncertainty for a period of time so that someone will, or that developers will, in fact, go forward with those technologies. There was never an intent to simply place the Clean Air Act on hold for the life of those facilities.

Chairman **BARTLETT.** Thank you very much. I would just like to note, Ms. Abend, that not only am I a supporter of renewables, I am a user of photovoltaic and for a number of years now and very familiar with that technology and very encouraged about its future. Once made and in place, you have about 30 years absolutely trouble-free and totally pollution-free performance from photovoltaics. And I would like to see them a much bigger part of our electric generation.

Page 167 PREV PAGE TOP OF DOC Segment 1 Of 7

By the way, another big advantage is that they are, by definition, distributed—they are dispersed a little here and a little there so that we do away with a lot of line losses. When you have big power plants sending power for a long distance, that is a lot of line loss. Which is, by the way, the reason that Saudi Arabia was—and I suspect they may still be—the world's largest purchaser of solar cells with all of that oil. And the reason is, they have small communities widely separated and building a big power plant with all the line losses doesn't make any sense for them. So they sell the oil to us and buy from us the solar cells. It just makes a whole lot more sense for them. And that distributed production generation will pay big benefits in this country from reduced line losses also.

Let me now thank this panel and excuse them. And Mr. Kripowicz will stay with us because he has given his opening statement for the next Panel, but he is a participant also in that next Panel. Thank you very much for your testimony.

Panel II

And now, members of our second Panel. In addition to Mr. Kripowicz, who is staying on from our first panel. We have Mr. Lazenby.

Ms. **LAZENBY.** Ms!

Chairman **BARTLETT.** Ms. Oh. I am sorry. Ms. Lazenby. Gigi, the queen of the strippers, is with us today. And Mr. Cuneo, Vice President and Chief Information Officer of Equiva Services, LLC, Houston, Texas. And he is here on behalf of the American Petroleum Institute. Dr. Craig Van Kirk, Professor of Petroleum Engineering and Head of the Department of Petroleum Engineering, Colorado School of Mines, Golden, Colorado; and Alan Huffman, Manager of Seismic Imaging Technology Center, Conoco, Incorporated, Houston, Texas. Thank you very much for joining us. And Mr. Kripowicz has already given his testimony in the prior panel. So we will turn now to GiGi.

Page 168 PREV PAGE TOP OF DOC Segment 1 Of 7

STATEMENT OF VIRGINIA B. LAZENBY, CHAIRMAN AND CEO, BRETAGNE, GP, NASHVILLE, TENNESSEE, ON BEHALF OF THE INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA

Ms. **LAZENBY.** Good morning, Chairman Bartlett, members of the Subcommittee. My name is Virginia Lazenby and I am the Chairman of Bretagne, an oil and gas-producing company in Kentucky. I am pleased to be here today on behalf of the Independent Petroleum Association of America and the National Stripper Well Association. We represent 5,000 oil and natural gas producers in 35 states. IPAA and NSWA welcome the opportunity to testify on the important role we believe oil and natural gas research and development programs play in the advancement of a viable, sustainable national energy policy.

IPAA's membership constitutes both large and small independents contributing 50 to 65 percent, respectively, of domestic petroleum and natural gas production in the lower 48 states, and we employ 336,000 people. My company produces from high—from low volume, high-cost stripper or marginal wells

and we employ 36 employees and have a payroll of approximately $850,000 annually.

The report issued on May 17 by Vice President Cheney's Task Force on National Energy Policy Development, addressed both the Nation's short- and long-term energy needs. The report cites the Energy Information Administration estimate that by the year 2020, the United States will need about 50 percent more natural gas and g more oil to meet growing demand. I am sorry—to meet growing demand.

Page 169 PREV PAGE TOP OF DOC Segment 1 Of 7

Meeting this formidable set of challenges will be complicated by events in the recent past. The damage to the industry from extremely low oil and natural gas prices in '98 and '99 is affecting supply today and will continue to do so until the industry has a chance to recover. It will take time to build new drilling rigs and provide the skilled services that are necessary to rejuvenate the industry.

Research and development, in many instances, are the last to receive support. Ironically, it is the strides made within the R&D community in recent years through programs such as those administered to the Department of Energy's Office of Fuel—of Fossil Energy that can be critical to many producers' economic survival. The current price of oil is helpful, but price alone does not save fields. Technology was and is a necessity.

Many exploration and production R&D advancements are documented in the Department of Energy's report, "Environmental Benefits of Advanced Oil and Gas Exploration and Production Technology." Quoting from the report, "In the past 3 decades, the petroleum industry has transformed itself into a high-technology industry. Ongoing advances in E&P productivity are essential if producers are to keep pace with steadily growing demands for oil and gas. Progressively cleaner, less intrusive, and more efficient technology will be instrumental in enhancing environmental protection in the future."

According to the National Energy Report, anywhere from 30 to 70 percent of the oil and 10 to 20 percent of natural gas is not recovered in initial field development. Enhanced oil recovery projects could add about 60 billion barrels of oil nationwide through the use of existing fields.

Page 170 PREV PAGE TOP OF DOC Segment 1 Of 7

My company has utilized nitrogen huff-and-puff process to increase production from a mature Appalachian oil field and we have increased production from 100 barrels of oil per day to 500 barrels of oil per day. And, Mr. Chairman, we have recovered, in our project, 240,000 barrels from this field and we expect to get an additional million—a total of 1,700,000 barrels. That is 4.5 percent of the oil in place.

Bretagne developed and owns the patent on this process, but we need more refinements in technology to keep costs down. And to that end, Bretagne has partnered with Penn State, through the Stripper Well Consortium, in the development of a chamber lift technology to produce stripper—to—for producing stripper wells that requires no expensive pump jack and significantly less electricity, which goes to the point of conservation that you discussed earlier.

The Stripper Well Consortium is an industry-driven organization that receives base funding and guidance

from the Department of Energy's Office of Fuel—of Fossil Energy—excuse me—and the New York State Energy Research and Development Authority. By pooling financial and human resources, the Stripper Well Consortium can economically develop technologies that would extend the life and production of the Nation's stripper wells.

Programs such as the Petroleum Technology Transfer Council, a joint public-private partnership between the entire independent producing community and the Department of Energy, and the Stripper Well Consortium, provide badly needed research and development capital.

For the foreseeable future, the Nation will be dependent on fossil fuels. Petroleum and natural gas currently account for approximately 65 percent of the Nation's energy supply and will continue to be the significant energy source. The development of any domestic energy policy must recognize this reality. Oil and natural gas research and development holds the key to the maximum utilization of the Nation's energy resource base in a manner that represents as few environmental consequences as possible. Technology can help us get there and the public-private projects sponsored by the industry and the Department of Energy are an excellent way to encourage the development of the technology our Nation needs to develop a viable, sustainable energy future. Thank you.

Page 171 PREV PAGE TOP OF DOC Segment 1 Of 7

[The prepared statement of Ms. Lazenby follows:]

PREPARED STATEMENT OF VIRGINIA B. LAZENBY

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Independent Petroleum Association of America

and the

National Stripper Well Association

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Good morning, Chairman Bartlett, Members of the Subcommittee. My name is Virginia Lazenby, Chairman and CEO of Bretagne G.P., and I am delighted to be here today on behalf of the Independent Petroleum Association of America (IPAA), the National Stripper Well Association (NSWA), and 33 cooperating state and regional oil and gas associations representing over 5,000 oil and natural gas producers in 35 states. IPAA welcomes the opportunity to testify on the important role we believe oil and natural gas research and development programs play in the advancement of a viable, sustainable national energy policy.

Page 172 PREV PAGE TOP OF DOC Segment 1 Of 7

To put our story in the proper context, IPAA's membership constitutes both large and small independents. IPAA focuses exclusively on exploration and production. The independent producing community contributed 50 and 65 percent, respectively of domestic petroleum and natural gas production in the lower 48 states, both on-shore and offshore. Nationwide, the U.S. oil and gas "upstream" or exploration and production industry employed 336,400 as of May 1st of this year. My company, Bretagne G.P., produces from low volume, high cost stripper or marginal wells. We are one of the largest employers in Lee County, Kentucky with 36 employees, with a payroll of $850,000 annually, providing full health insurance, dental insurance and a 401(k) for all employees. I personally have been in the oil and gas business formally since 1977, but really "grew up" in the business (my father served as President of Spur Oil).

Ensuing Industry Challenges

The recently released report issued on May 17th by Vice President Cheney's Task Force on National Energy Policy Development (NEPD), addressed both the nation's short and long term energy needs. We believe the report adequately portrays the challenges the oil and natural gas industry will face in the ensuing years, in meeting estimated supply and demand. The report quotes numbers issued by the Energy Information Administration (EIA) estimating that by the year 2020, the United States will need about 50 percent more natural gas and one third more oil to meet growing demand. The report further suggests that, "the remaining U.S. oil reserves are becoming increasingly costly to produce because much of the lower-cost oil has already been largely recovered. The remaining resources have higher exploration and production costs and greater technical challenges because they are located in geologically complex reservoirs (e.g., deepwater and harsh environments). The report goes on to say that, ". . .the Nation will have to rely on natural gas from unconventional resources, such as tight sands, deep formations, deepwater and gas hydrates. Also, many resources are in environmentally sensitive areas that require use of less intrusive technologies."

Page 173 PREV PAGE TOP OF DOC Segment 1 Of 7

Meeting this formidable set of challenges will be complicated by events in the recent past that dramatically affected the producing community. Due to the plummet in oil and gas prices in 1998 and 1999, many independents who fought to stay in production were ultimately forced to cap their wells (domestic production was cut by half a million barrels per day), victims of low market prices and lack of adequate investment capital.

This collateral damage of low oil and natural gas prices on the industry is affecting supply today and will continue to do so, until the industry has a chance to recover. For example, the upstream industry lost 65,000 jobs in 1998–99. While about 65 percent of those losses have been recovered, skilled workers, burned buy the '98–'99 downturn and the volatility of the related job market are slow to return. Less obvious, but equally significant, during the low price crisis equipment was cannibalized to keep operating and support industries from being decimated. Although the producing community is currently on the rebound, it will take time to develop the infrastructure again to build new drilling rigs and provide the skilled services that are necessary to rejuvenate the industry, which leaves areas such as research and development in many instances the last to receive support, financial or otherwise. Ironically, it is strides made within the R&D community in recent years, through programs such as those administered through the Department of Energy's (DOE) Office of

Fossil Energy that can be critical to many producers' economic survival. My personal experience and that of many of my marginal, or "stripper" well colleagues in the industry is that the current price of oil is most helpful, but price alone does not save fields—technology was and is a necessity.

The application of new techniques has allowed oil and gas production in geological areas never previously thought accessible: increased accuracy of drilling operations not only provides opportunities for increased recovery of product, but allows the drilling procedure to be conducted in a much cleaner and environmentally sensitive manner. Areas of advancement, including "slimhole" drilling, directional drilling, 3–D seismic technology, deepwater drilling technology, and including such "futuristic" advances as high powered lasers and directional drilling (enabling wells to be drilled long horizontal distances from the drilling site) are being fully utilized today.

Page 174 PREV PAGE TOP OF DOC Segment 1 Of 7

Many exploration and production R&D advancements are documented in the Department of Energy's report, "Environmental Benefits of Advanced Oil and Gas Exploration and Production Technology." Quoting from the report: "In the past three decades, the petroleum industry has transformed itself into a high-technology industry. Dramatic advances in technology for exploration, drilling and completion, production, and site restoration have enabled the industry to keep up with the ever-increasing demand for reliable supplies of oil and natural gas at reasonable prices." The report further states, ". . .the domestic oil and gas industry will be challenged to continue extending the frontiers of technology. On going advances in E&P productivity are essential if producers are to keep pace with steadily growing demand for oil and gas, both in the United States and worldwide. Continuing innovation will also be needed to sustain the industry's leadership in the intensely competitive international arena, and to retain high-paying oil and gas industry jobs at home. Progressively cleaner, less intrusive, and more efficient technology will be instrumental in enhancing environmental protection in the future."

Stepping Up to the Plate

According to the *National Energy Policy* report, "anywhere from 30 to 70 percent of oil and 10 to 20 percent of natural gas is not recovered in field development. It is estimated that enhanced oil recovery projects, including development of new recovery techniques could add about 60 billion barrels of oil nationwide through incremental use of existing fields." Bretagne is a prime example of the contribution that wisely invested R&D dollars can make in the advancement of enhanced oil recovery technologies. For example: utilizing a nitrogen "huff and puff" (cyclic) process. Bretagne increased production from a mature Appalachian basin reservoir from 200 bopd to 500 bopd with no significant increase in water production, breathing "new life" into an old field. The cumulative recovery through May 2000 was 115,000 bbl of oil from cumulative injection of 342 MMcf of nitrogen. The conventional huff and puff applications have concentrated on using a solvent (such as steam or carbon dioxide). Applications often are limited by two factors—economic availability of the primary injectant and the mechanisms of the huff and puff process itself. This patent—pending huff and puff process using nitrogen addresses both concerns, allowing for full extraction of the resource, but in a cost affective manner. Our nitrogen project has recovered 240,000 additional barrels of oil and we expect to recover 1,700,000 barrels which is 4.5 percent of original oil in place (this patent is owned by Bretagne) Most recently, Bretagne has partnered with Penn State in the

development of a "chamber lift," a technology for producing stripper oil wells. The technology addresses the problem faced by the operator of how to upgrade the production systems at a low enough capital cost that the typical well can show a reasonable economic return on investment. It accomplishes this by injecting gas into the oil column via a small diameter tubing string that is set in the production tubing: the gas then displaces the accumulated fluid to the surface via the annular space between the injection string and the production string. The process is controlled using a sensor and motor valve located at the surface. Using a laboratory prototype of the system as a test, pressure and flow measurements obtained will be used as input data to a hydrodynamic computer model that will provide to the well operator insights with respect to the field test, demonstrating the viability of the process.

Page 175 PREV PAGE TOP OF DOC Segment 1 Of 7

Bretagne has successfully participated through the years in public—private partnership efforts, through groups such as the Stripper Well Consortium (SWC), an industry—driven entity that is focused on the development, demonstration and deployment of new technologies needed to improve the production performance of natural gas and petroleum stripper wells. The SWC is comprised of natural gas and petroleum producers, service companies, industry consultants, universities, and industrial trade organizations. The Strategic Center for Natural Gas, the National Petroleum Technology Office (both under the purview of DOE's Office of Fossil Energy) and the New York State Energy Research and Development Authority provide base funding and guidance to the consortium. By pooling financial and human resources, the SWC can economically develop technologies that will extend the life and production of the nation's stripper wells.

Programs such as the Petroleum Technology Transfer Council (PTTC), a joint public-private partnership between the independent producing community and DOE, and the SWC provide badly needed research and development capital, facilitating the development and application of tools the industry needs to pursue a commodity that produces the lifeblood of our Nation's overall economic health and security, domestic oil and natural gas.

The "bottom line"

For the foreseeable future, the Nation will be dependent on fossil fuels. In particular, petroleum and natural gas currently account for approximately 65 percent of the Nation's energy supply—and will continue to be the significant energy source. Natural gas demand, for example, is expected to increase by more than 30 percent over the next decade. The development of any domestic energy policy must recognize this reality. Therefore, in order to meet the Nation's projected growth and demand estimates the oil and gas industry must be allowed to utilize the tools necessary to meet the public's consumptive needs. Oil and natural gas research and development holds the key to the maximum utilization of the resource base, in a manner that represents as few environmental consequences as possible. We believe that these goals are not mutually exclusive: a viable, sustainable energy future can and must include environment compatibility as a key component, in order to enjoy any sort of future at all: we believe it all can be within our reach.

Page 176 PREV PAGE TOP OF DOC Segment 1 Of 7

BIOGRAPHY FOR VIRGINIA B. LAZENBY

Born June 28, 1945, Virginia H. Lazenby is a life-long resident of Nashville, Tennessee. She is the daughter of the late Paul Banks, Jr., who served as President of Spur Oil Company, now a division of Murphy Oil Company, and Southern States Asphalt, a division of Marathon Ashland Petroleum, P.L.C.

Mrs. Lazenby is the Chairman, Chief Executive Officer and 100% shareholder of Bretagne G.P., an independent oil and gas production company. Previously, Mrs. Lazenby served as President of Transatlantic Exploration LTD and Chief Operating Officer of Hooker Investments, Ltd. with responsibility for management of investments and supervision of the Treasury, Engineering and Operations Departments. Along with her management responsibilities, she assisted the general partner in raising capital in the United States and Europe and negotiated the safe of a barrel denominated production payment which created a significant price hedge for the company.

Mrs. Lazenby received a B.A. in history from Vanderbilt University and an MBA in finance from the Owen Graduate School of Management at Vanderbilt. Her thesis was a three-year strategic plan for PASCO, Inc., an integrated oil company with 20,000 barrels per day of production along with refining and marketing properties.

Mrs. Lazenby formed Bretagne G.P. in 1987. Bretagne purchased the Transatlantic production payment and acquired the Wiser Oil Company, Big Sinking oil and gas properties in Lee County, Kentucky. Bretagne G.P. has implemented a successful nitrogen injection huff and puff project in its Big Sinking oil field. The process is patent pending.

Page 177 PREV PAGE TOP OF DOC Segment 1 Of 7

Mrs. Lazenby is a Past President of the National Stripper Well Association; member of the Board of Governors, Independent Petroleum Association of America; Board of Directors, American Petroleum Institute; Member, National Petroleum Council; Member, Kentucky Oil & Gas Association.

Mrs. Lazenby is married to Fred W. Lazenby, a life insurance executive and private investor. She enjoys horseback riding, hiking, gardening, travel and, now, golf.

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Chairman **BARTLETT.** Thank you very much. Mr. Cuneo.

STATEMENT OF PAUL L. CUNEO, VICE PRESIDENT AND CHIEF INFORMATION OFFICER, EQUIVA SERVICES, LLC, HOUSTON, TEXAS, ON BEHALF OF THE AMERICAN PETROLEUM INSTITUTE

Mr. **CUNEO.** Mr. Chairman, thank you for inviting me to testify today on the remarkable technological developments that have been made over the past several years in the downstream sector of the petroleum industry. I am testifying today on behalf of the American Petroleum Institute, a national trade association

whose members are engaged in all aspects of the petroleum industry, including exploration, production, refining, distribution, and marketing.

Americans depend on our industry to keep the U.S. economy moving as never before. In our expanding economy, we provide hundreds of products made from petroleum in volumes that would not be possible if we were not for developing new technologies that have made our industry more productive, more efficient, and more economically viable.

Page 178 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. Chairman, I would like to focus on three areas of technology advancements with my testimony today. First in the area of refineries, then pipelines, and then in fuel for vehicles of the future.

In the areas of refining, as you know, demand for gasoline this year is at record levels. To meet it, refineries have been running all out, around 97 percent of capacity. Just a few years ago, this feat would have been difficult, if not impossible, but development of new computerized process control and online optimization technologies make it possible for refineries to run harder and make more products than at any other time in our history while improving safety and environmental performance.

In 1981, just two decades ago, there were 315 refineries in the United States. Today, that number is 155. Two decades ago, we produced 6.4 million barrels a day of gasoline and today we are producing 8.5 million barrels a day of gasoline to meet the American public's demand. And we continue to produce additional products, such as jet fuel, heating oil, diesel fuel, and other much-needed products which fuel not only our transportation sector, but our chemical industry as well.

The industry has had to invent new refining processes to meet current and future product specifications and to meet environmental regulations. One example of that is the industry has developed successfully a catalytic distillation process to commercialize and produce MTBE. And you also use this technology in order to reduce sulfur in gasoline to make the future low-sulfur gasoline required by environmental regulations. Another example are flue-gas scrubbing processes which have been applied to catalytic cracking units that reduce SO**X** and particulate emissions while enabling our existing plants to process a wider variety of feed stocks.

Page 179 PREV PAGE TOP OF DOC Segment 1 Of 7

Petroleum refining is one of the most energy-intensive of our manufacturing processes in America. And, yet, today, many refineries are running and have seen their own energy consumption drop by 30 percent. Still, there is more opportunity and more activities to be undertaken to reduce energy consumption in the refining sector, and greenhouse gas emissions as well.

One goal in improving technology is to take advantage of the by-products produced in the refining processes and ensure that they are fully upgraded and converted through our modern clean-burning gasoline and diesel fuels. The refining industry has been a real example of using by-products from refineries to

produce excess steam and hydrogen and even energy—in many cases, electrical energy.

Those of us in the refining industry take pride in a holistic approach to the future. And by that, I mean we consider the environmental benefits side by side with decisions on increasing capacity and improving efficiencies.

New technologies have been developed to monitor so-called fugitive emissions from refinery valves, pumps, compressors, and other critical areas. A refinery worker will soon be able to walk around with a portable device based on an infrared laser and an imaging system to pinpoint unwanted hydrocarbon emissions and correct the leaks.

Information technology is enabling refiners to develop online sensors to analyze the chemical makeup of crude oil as it arrives at the refinery, making it possible to turn it into various products faster and more efficiently with reduced emissions.

Page 180 PREV PAGE TOP OF DOC Segment 1 Of 7

In recent years, there have been dramatic advances in the use of catalysts. Catalysts today are converting materials into low sulfur gasoline and diesel components from poor quality crude in ways that have never been done in the past.

We are also refining used lubricating oil needed for today's vehicles and for many other applications in today's industrial economy. Today's modern lubricants contain synthetic components that reduce vehicle gasoline consumption and do an even better job of reducing engine wear than naturally occurring components. We have developed better processes to take out solvents that sharply reduce the amount of heat used in the lubricant manufacturing process.

Mr. Chairman, our industry is pleased to see the President's National Energy Plan include proposals designed to overcome regulatory obstacles that often make it difficult for the refining industry to install new equipment that incorporates the type of technological advances we are discussing here today.

In the arena of pipelines, computers have also transformed the pipelines that carry gasoline and other fuels from refineries to distribution points all over the country. Instantaneous communications along hundreds of miles of pipeline keep a variety of fuels flowing smoothly and permit an instant shutdown should a break in the line occur. The reaction is so fast that little liquid escapes before the flow is stopped. Information travels by satellite, microwave, and fiber optic wiring to centralized control centers.

"Smart pigs," computerized sensors that look like giant rubber bullets, travel through pipelines to detect thinning caused by corrosion and construction gouges that could, in turn, eventually mean a broken line. The most advanced kind of smart pigs contain ultrasonic sensors that identify the tiniest of cracks, dents, and gouges on the interior of the pipeline. Some of these devices can even change size permitting them to move through different-sized pipelines and past gate valves.

Page 181 PREV PAGE TOP OF DOC Segment 1 Of 7

When we look to the future for fuels and advanced vehicle technologies, we believe that ultimately one of the most significant parts of this story will be a new chapter on fuel cells. No one is certain what the fuels and cars of the future are going to look like, but a pattern is emerging. Our children and grandchildren will be driving vehicles that are safer, cleaner, and more efficient than any in history. In the next 5 to 15 years, they will probably be powered by an internal combustion engine that is much cleaner and more efficient today, and long term by fuel cells. Either propulsion system will use an advanced, ultra-clean gasoline provided by the U.S. refining industry.

Mr. Chairman, what I have offered here today has been a taste of the many fast-moving technological developments in our industry. There are two thoughts that I would like to leave with you. First, new technologies will continue to allow our industry to be more productive and efficient, while at the same time improving our environmental performance. And, second, that industry and government should cooperate in research in these areas. Thank you for inviting me here today.

[The prepared statement of Mr. Cuneo follows:]

PREPARED STATEMENT OF PAUL L. CUNEO

Mr. Chairman, my name is Paul Cuneo, Vice President and Chief Information Officer of Equiva Services LLC.

Thank you for inviting me to testify today on the remarkable technological developments that have been made over the last several years in the downstream sector of the petroleum industry. I am testifying today on behalf of the American Petroleum Institute, a national trade association whose members are engaged in all aspects of the petroleum industry including exploration, production, refining, distribution and marketing.

Page 182 PREV PAGE TOP OF DOC Segment 1 Of 7

Americans depend on our industry to keep the U.S. economy moving as never before. In our expanding economy, we provide hundreds of products made from petroleum in volumes that would not be possible if we were not developing the new technologies that have made our industry more productive and efficient.

Mr. Chairman, in our focus on technology advancements, I will discuss refineries, pipelines and fuel for vehicles of the future.

Refineries

Petroleum refining is one of the most energy-intensive manufacturing industries. And yet, many refineries today are technological wonders. Sophisticated computer software, instrumentation and process controls help refineries operate at greater and greater efficiency with environmental controls that minimize emissions into the air. We are proud of our improving record on the environment and our ability to use and reuse raw materials more efficiently within the refinery processes.

As you know, demand for gasoline this year is at record levels. To meet it, refineries have been running

all out, at about 97 percent capacity. That feat would have been much more difficult only a few years ago. The new computerized process control and online optimization technologies make it possible for refineries to run harder and make more products than at any time in our history while improving the safety and environmental performance of the industry.

Page 183 PREV PAGE TOP OF DOC Segment 1 Of 7

In 1981, just two decades ago, there were 315 refineries in the United States. In that year, those refineries produced 6.4 million barrels of gasoline daily. In 1999, there were 155 refineries producing 8.5 million barrels a day. And we continue to increase production of heating oil, diesel fuel and other much-needed products.

The industry has also invented new refining processes to meet current and future product specifications for clean fuels. One example is the development of catalytic distillation, which has successfully been commercialized to produce MTBE and low sulfur gasoline components. Another example is flue gas scrubbing for catalytic cracking units (FCC or CCU) that reduce SO**X** and particulate emissions while enabling existing plants to process a wider variety of feedstocks.

Over the last two decades, the oil industry has reduced its own energy consumption by 30 percent. That is another result of the introduction of new technologies in the downstream, along with shutting down smaller, less efficient refineries. Still more energy conservation activities are available to be undertaken in refineries to further reduce energy consumption and greenhouse gas emissions as very few refineries have been designed for today's fuel prices.

One goal in improving technology is to take advantage of by-products produced in refining processes and recycle them for other purposes. For example, some refinery processes produce excess steam or hydrogen that are useful in other parts of the operation. Today's modern refineries upgrade even the heaviest residual components to clean burning gasoline and diesel fuels.

Page 184 PREV PAGE TOP OF DOC Segment 1 Of 7

Those of us in the refining industry take pride in taking a holistic approach to the future. By that, I mean that we consider environmental improvements side-by-side with decisions on increasing capacity and seeking greater efficiencies.

New technologies help monitor so-called fugitive emissions from refinery valves, pumps, compressors and other critical areas of each refinery. A refinery worker will soon be able to walk around the facility with a portable infrared laser with an advanced imaging system to pinpoint unwanted hydrocarbon emissions. A video monitor will instantly show what the laser has found.

Information technology is enabling refiners to develop online sensors to analyze the chemical makeup of crude oil as it arrives at the refinery, making it possible to turn it into various products faster and more efficiently with reduced environmental emissions.

In recent years, there have been dramatic advances in the use of catalysts, which help. break down crude

oil into components that make up the wide variety of products made in a refinery. The life of some catalysts is now 50 percent longer, which saves money, reduces emissions and increases production. Better catalysts also enable refiners to make high quality clean-burning fuels from poor quality crude.

There is also a new method for refining used lubricating oil needed for cars and many other applications in today's industrialized economy. Today's modern lubricants contain synthetic components that reduce vehicle gasoline consumption and do an even better job of reducing engine wear. We have developed a better way to take out solvents that sharply reduce the amount of heat used in the process. The result is the ability to use one-third the amount of energy in the production of lubricating oil.

Page 185 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. Chairman, our industry is pleased to see the President's National Energy Plan includes proposals designed to overcome regulatory obstacles that often make it difficult for the refining industry to install new equipment that incorporates the types of technological advances we have been discussing here today.

Pipelines

Computers have also transformed the pipelines that carry gasoline and other fuels from refineries to distribution points all over the country. Instantaneous communications along hundreds of miles of pipelines keep a variety of kinds of fuels flowing smoothly.

Computerized controls also permit an instant shutdown should a break in the line occur. The reaction is so fast that little liquid escapes before the flow is stopped. Information travels by satellite, microwave and fiber optic wiring.

"Smart pigs"—computerized sensors that look like giant rubber bullets—travel through pipelines detecting thinning caused by corrosion and construction gouges that could in turn mean a broken line. The most advanced kind of smart pigs contain ultrasonic sensors that identify the tiniest of cracks, dents and gouges on the interior of the pipeline. Some can change size permitting them to move through different-sized pipelines and past gate valves.

Planes carrying infrared cameras also fly over pipelines looking for problems and detecting leaks before they actually happen.

Page 186 PREV PAGE TOP OF DOC Segment 1 Of 7

Fuel Cells and Advanced Vehicle Technologies

Ultimately, one of the most significant parts of this technology story will be the new chapter on fuel cells. No one is sure what the fuels and cars of the future are going to look like. But a likely pattern is emerging. Our children and grandchildren will be driving vehicles that are safer, cleaner and more efficient than any in history. In the next 5–15 years, they will probably be powered by an internal combustion engine that is much cleaner and more efficient than today, and long term by fuel cells. Either propulsion system will use

an advanced, ultra-clean gasoline provided by the U.S. refining industry.

It is possible, indeed likely, that such fuel cell cars will be economically viable within the next 10–15 years. That will mean dramatic environmental improvement because fuel cells have near-zero regulated emissions—the kind we still struggle with today.

There are already several strong partnerships in place between the oil and auto companies to develop fuel cell cars that run on ultra-clean hydrocarbon based fuels.

That leaves gasoline, which has the advantage of a delivery infrastructure already in place, namely 182,000 gas stations around the country. This will allow consumers to drive fuel cell cars without concern for where they will get the ultra-clean fuel.

Mr. Chairman, what I have offered here today is but a taste of the many fast-moving technological developments in our industry. There are two thoughts that I would like to leave with you. First that new technologies will continue to allow our industry to be more productive and efficient while at the same time improving our environmental performance and second that industry and government should cooperate in research in these areas. Thank you very much for inviting me here today.

Page 187 PREV PAGE TOP OF DOC Segment 1 Of 7

BIOGRAPHY FOR PAUL L. CUNEO

Paul L. Cuneo is currently Chief Information Officer, Equiva Services LLC. He oversees the Information Technology area for the Alliance.

Mr. Cuneo is a Chemical Engineering graduate of the Colorado School of Mines and was employed by Shell for more than 28 years before assuming a position with Equilon Enterprises, LLC, a joint venture between Shell and Texaco. He served as Vice President, Technology at the Westhollow Technology Center. In this position he was responsible for managing Equilon's R&D for both refining processes and oil products and for providing technical support to operating refineries.

Mr. Cuneo's Shell experience includes positions in four refineries, in the corporate office doing facilities planning for refineries, and as Director Technology at the Westhollow Technology Center. He is past Chairman of the American Petroleum Institute Technology Committee and past President of the Coordinating Research Council Board of Directors. He is currently on the Executive Committee of the API General Committee on Information Management Technology.

Chairman **BARTLETT.** Thank you very much. Mr. Van Kirk.

STATEMENT OF DR. CRAIG W. VAN KIRK, PROFESSOR OF PETROLEUM ENGINEERING AND HEAD OF DEPARTMENT OF PETROLEUM ENGINEERING, COLORADO SCHOOL OF MINES, GOLDEN, COLORADO

Page 188 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **VAN KIRK.** Is that about the right distance for the microphone? Thank you very much for the invitation to come here today to be of some assistance. My name is Craig Van Kirk. I am a Professor and Head of the Petroleum Engineering Department at the Colorado School of Mines and have been for 21 years.

Just last week, Monday and Tuesday, I was in Houston for a first-of-a-kind, invitation-only meeting of international, American oil companies and American universities and international universities also and a representative of the Department of Energy. And we met for two days to discuss today's and near-term and long-term research needs of the oil industry, upstream, exploration and production. The oil companies and the service companies shared their needs with us representing the universities and we shared our needs and our capabilities and our areas of interest and expertise with them. As I say, this was the first time a meeting called for this particular kind of venue and we had an excellent conversation and plan to meet again in October to further these discussions and have some more concrete plans.

Imagine our abilities in the petroleum industry and petroleum engineering, in particular. We can drill seven miles into the earth. We can drill in one to two miles deep oceans around the earth. We produce products for the benefit of society and have for many, many decades, all over the world. And not just energy. I appreciate that the major concern of today's discussions are energy, but petroleum and crude oil and natural gas production go into the manufacture of many things in this room—the paints, the—probably the curtains, the carpet, the plastic cups, the containers for the water we are drinking. These things are made from the production of petroleum. Sometimes people ask if we are going to run out of petroleum soon or stop producing soon. No. The world will need plastics and materials made from petroleum for hundreds of years. We will continue to produce for hundreds of years for those reasons.

Page 189 PREV PAGE TOP OF DOC Segment 1 Of 7

Now, some people think that the petroleum industry is not very high-tech because all they see are big pieces of equipment—offshore drilling platforms or drilling rigs or pumping units. Well, as a matter of fact, the high-tech level of development in the petroleum industry and application is extremely high. And I have included some examples in the written testimony that I submitted to you earlier, and I will just repeat a few right now.

For example, in the area of seismic investigations into the earth's surface, we can see down several miles into the earth and we can create three-dimensional images of what the earth's subsurface looks like. And this helps us find new resources of oil and gas, new reservoirs. And when we do the 3–D seismic, three-dimensional seismic, over a period of time, we get a time-lapse photograph, if you like, to see where fluids are moving. We call this 4–D, the fourth dimension being time. So we can watch fluids moving around underground, whether it be a shallow movement or a great depth, a mile or two or three miles deep. We can watch fluids move and we can distinguish between types of fluids. This 4–D visualization is a major new endeavor.

Also, horizontal drilling. We can drill directionally from one surface location seven miles laterally, seven miles in another direction. So we can cover an area of 14 miles from one location. Now, this is not routine and we don't do this every day. But directional drilling, to drill several thousand feet or several miles in

different directions, to exploit a very large reservoir from a very small footprint, this is a new development that continues to improve with our research.

Now, the fact is that oil and gas do not exist underground in big open pools or rooms like this room. They exist in the pores, small pores of rocks. But at several thousand psi, fluids can flow quite well. Now, based on our technical developments and research and experience through the years—is that a buzzer I need to be concerned about? And even with—is this daily?

Page 190 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** Excuse me. The buzzer going off is simply informing you that we aren't doing anything on the Floor.

Mr. **VAN KIRK.** Will the lights go out if there is no signs of intelligent life in here? Is that an automatic switch? We have been producing oil for more than 100 years and unfortunately we can recover today only approximately g on average, and we have h of oil left in the ground. Enhanced oil recovery, cooperative efforts with industry, universities, and the government, have been essential to us in the past and continue to be essential to us in the future.

And, in fact, I would say, based on my experience and working with industry for all these years and government representatives, that the support for oil and gas exploration and production research should be increased, not decreased at this time. I thank you very much for the opportunity to serve you today, and I will be happy to answer any questions.

[The prepared statement of Mr. Van Kirk follows:]

PREPARED STATEMENT OF CRAIG W. VAN KIRK

My name is Craig W. Van Kirk. I am a professor of petroleum engineering and head of the Department of Petroleum Engineering at the Colorado School of Mines in Golden, Colorado. My specialty is reservoir management, which has permitted me to conduct both practical and theoretical research on complex reservoirs throughout the world. I appreciate this subcommittee's interest in the subject of technology in the energy field.

Page 191 PREV PAGE TOP OF DOC Segment 1 Of 7

INTRODUCTION

The United States is a very mature petroleum producing area. Oil has been produced here continuously for more than 130 years. While exhaustion of this resource has been predicted since the earliest days of the industry, these predictions of the industry's imminent demise have proven repeatedly to be exaggerated. There have been two reasons for this extended life: technologies that increase the recoverable oil from known fields and technologies that extend the frontiers of exploration and development to entirely new areas. Technology development has been important to the industry throughout its history, but in recent years

it has served to fundamentally transform the industry. The effects of this technological revolution are readily apparent and the expectation is that technology will continue to sustain domestic production in the future.

Not only has research and new technology expanded the frontiers of our domestic energy resources, these developments have put U.S. firms in the position of global leadership in the area of exploration and production technologies with broad applicability worldwide. U.S. companies export 40 percent of the world's petroleum equipment and services, with sales of $5.9 billion in 1997.

Research and development spending by government and industry is the key to continued technology development. Faced with a technological challenge, the response of industry is to bring together an interdisciplinary team to find solutions. But once new ideas are identified, they must be developed, tested and proven, then transferred throughout the industry to increase oil and gas supplies. Money for this R&D has traditionally come from companies themselves, supplemented by government funding. As major companies have increasingly focused their research on finding new sources of oil and gas and developing those found in challenging environments, funding from the Department of Energy and other government sources has become increasingly important to improving the recovery from our country's many mature producing provinces.

Page 192 PREV PAGE TOP OF DOC Segment 1 Of 7

TECHNOLOGY ADVANCES KEY TO CURRENT AND FUTURE SUPPLY

Technological innovation has been a hallmark of the petroleum industry throughout its development. From the first discovery of oil at Colonel Drake's Pennsylvania well in 1859 through today, our industry has dedicated itself to finding better ways to identify and recover that part of our Nation's bounty that lies thousands of feet below ground. Improved technologies allow us to "see" through the land and ocean to identify, characterize, and produce the oil and gas that fuels our cars and our economy, heats our homes and schools, and produces thousands of other products we use daily.

There are so many technological success stories, that I could go on and on. But I believe that I can convey the important contributions made by research and technology to our industry with a few highlights. As our industry continues to work to meet the Nation's energy demands, technological innovation has allowed us to:

Locate more oil and gas,

Develop resources found in challenging environments,

Improve the recovery from known oil and gas reservoirs, and

Conduct safer, more efficient operations.

Locating More Oil and Gas

Page 193 PREV PAGE TOP OF DOC Segment 1 Of 7

You've heard for years that the world has a finite amount of oil and gas. While that may be true over the long term, that certainly doesn't mean that we have found all that is out there. One of the keys to maintaining production levels and increasing them to meet growing demand is to identify new sources of oil and gas. Without the technology advances of the 1960s and 1970s, much of today's oil and gas supply would not exist. Technology advances during the 1980s and 1990s will likewise contribute to tomorrow's oil and gas supply.

Forbes and Zampelli estimate that technological change increased the success rate over the period from 1986 to 1995 in the Gulf of Mexico at an average annual rate of 8.3 percent. In general, U.S. industrial technology innovation has improved efficiency by approximately 2 percent annually. Our experience in the Gulf of Mexico is just one indication of the potential of technological innovation.

3D and 4D Seismic Technology

Seismic information is essential in the search for oil and gas. It provides a view of the geological formations below the earth's surface and provides clues as to where hydrocarbons may be trapped or have moved. Until the 1960s, seismic information was inaccurate, low-resolution analog data. Two-dimensional seismic techniques improved during the 1970s, but it wasn't until the 1990s that several major technological breakthroughs allowed seismic information to be viewed in three dimensions.

Three-dimensional seismic (3–D) technology has been developing over the past 25 years. It creates a 3–D image of underground geological structures by gathering information not just from the grid area of interest, but also all of the areas around that specific grid area. Only in the last decade has there been adequate computing power available at an economically attractive price to gather, store, and process the massive quantities of data required to render a new generation of 3–D images.

Page 194 PREV PAGE TOP OF DOC Segment 1 Of 7

Improvements in computer technology reduced computing time by 30 to 40 percent between 1990 and 1995. It used to take six months to a year to process the data from a seismic shoot. By 1995 it was taking only two or three months. Between 1980 and 1990, costs dropped from $8 million to $1 million for a 50-square mile survey using 3–D seismic. By 2000, the same survey could be performed for $100,000. This reduction in time and cost has encouraged more widespread application of 3D seismic technology.

Between 1989 and 1996, the percentage of wells in the Gulf of Mexico drilled based on 3D seismic analysis rose from 5 percent to nearly 80 percent. Having a better view of the subsurface through 3D seismic technology has significantly improved the success rate for exploratory wells, yielding fewer dry holes, lower costs, less waste, and less impact on the environment.

The newest development is 4D visualization, through the application of time-lapse monitoring of 3D data. This technique is proving highly successful in identifying bypassed reserves in existing formations. Identifying bypassed reserves is particularly valuable. Since they are in existing fields where production infrastructure is in place, these additional reserves can more rapidly contribute to meeting energy needs. In areas where production has been declining, 3D seismic techniques have enabled the discovery of new

reservoirs lying below those that are the source of current production, such as the current activity in central New York State.

Subsalt Imaging

Much of the Gulf of Mexico is underlain by salt formations. Seismic imaging relies on the transmission of sound waves and analysis of the energy that bounces back. But salt formations can make seismic interpretation difficult because they absorb much of the energy, giving an incomplete picture of what lies beneath them.

Page 195 PREV PAGE TOP OF DOC Segment 1 Of 7

Technology developed by the U.S. Navy during the Cold War for stealth submarines has been applied successfully to enhance seismic images, giving a much clearer picture of possible oil and gas traps within and below the salt. Application of this technology yielded an exploratory success rate for subsalt prospects in the Gulf of Mexico of a phenomenal 35 percent between 1990 and 1996. An estimated 650 million barrels of oil equivalent, which includes natural gas converted to oil equivalent based on heating values, have been discovered in subsalt plays. These are resources that would likely not have been discovered without the addition of this new seismic technology.

Remote Sensing

Satellite imaging already contributes to our efforts to locate oil and gas deposits, but newer radar satellites hold even greater potential. Radar imaging satellites are able to work in nearly any atmospheric condition. Combining the images with sophisticated digital imaging processing can produce maps that can help identify oil and gas deposits. Aeromagnetic surveying employs technology originally developed for military applications to recognize the magnetic signature formations which might indicate oil and gas accumulation from altitudes over 10,000 feet. Gravity surveys are another technique that can help geoscientists identify areas of possible oil and gas deposits for further analysis. These remote sensing techniques have their greatest application in unproven areas of the world, but can still be helpful in many exploration provinces of the U.S., including Alaska and deepwater areas offshore. These technologies can also be applied to identification of leaks and spills along pipelines in remote areas.

Developing Resources in Challenging Environments

Page 196 PREV PAGE TOP OF DOC Segment 1 Of 7

Technology has allowed the oil and gas industry to exploit deposits located in harsh, deep, and otherwise difficult environments, adding those resources to our Nation's supply. In the Gulf of Mexico, drilling currently takes place in water as much as a mile and a half deep, with the wellbore extending another one and a half miles beneath the sea floor. Exploring for and producing oil and gas in such deep water would not have been possible even a few years ago. The impact of new technologies is most obvious offshore, but they have made possible many new onshore developments as well.

Advanced Offshore Platforms

Traditionally, offshore resources were developed from a fixed structure attached to the sea floor. At 1,500 feet of water, fixed platforms become unwieldy and too expensive. For example, to construct a fixed platform in the Mars field in 2,933 feet of water in the Gulf of Mexico would have resulted in a derrick-like structure the size of two Sears Towers end to end, using 640 million pounds of steel and costing an estimated $3 billion. The answer for tapping resources in deeper water was found in floating platform technology.

There are three main types of floating platforms. A "spar" platform consists of a single, large diameter, vertical cylinder supporting a deck. Six to twenty lines anchor the spar to the seafloor. A floating production system (FPS) consists of a semi-submersible unit equipped with drilling and production equipment. Older FPS are held in place with wire rope and chain. Some of the newer FPS maintain their position with rotating thrusters. The FPS is used in conjunction with subsea completions.

Page 197 PREV PAGE TOP OF DOC Segment 1 Of 7

By far the most popular floating platform in the Gulf of Mexico is the tension leg platform (TLP), and this is what was used for the Mars field development. The TLP is a floating structure that is vertically moored to the ocean floor using steel pipe known as tendons. The tendons are designed to pull down on the floating platform so they are always under tension. The tendons are connected to the sea floor by pile-secured templates.

These new platform designs offer the advantages of fixed platforms with faster construction time, lower investment costs, less impact to marine habitats, and the capability to operate in deeper waters. Less costly mini-TLPs can be constructed and deployed swiftly to develop marginal deepwater fields. Spars, which can be easily relocated and reused, are also attractive for developing marginal fields.

Deepwater/Subsea Completions

Subsea completions involve placing the Christmas tree, the assembly of valves mounted on the casing head through which a well is produced, on the seabed. The first subsea completion in the Gulf of Mexico was installed in 1972. By connecting subsea wells to host facilities, such as a less expensive platform in shallower waters or an existing platform, operators are able to develop discoveries that otherwise would not be economic.

Subsea completions and tiebacks to floaters and existing field platforms have decreased the size of the "minimum reserves" necessary to develop a new field. This has allowed the development of satellite fields that would not have been developed otherwise. Subsea completions with tiebacks to existing platforms have sometimes eliminated the need for a new platform, even for a major field.

Page 198 PREV PAGE TOP OF DOC Segment 1 Of 7

Dynamic Positioning Systems

Dynamic positioning systems compensate for the effects of wind, waves, and current, enabling mobile offshore drilling units to hold position over the borehole, maintaining within operational limits lateral loads on the drill stem and marine riser. At a water depth of 5,000 feet, for example, dynamic positioning systems can maintain a 200-yard long, 30-story high drillship within 50 feet of station. These systems expand the range of water depths and environmental conditions within which drilling operations can be safely conducted. Greater environmental protection and worker safety are among the biggest advantages of dynamic positioning systems.

Synthetic-Based Drilling Fluids

Drilling fluids—or muds—are essential to carry rock cuttings to the surface, maintain pressure balance and stability in the borehole, lubricate and clear the drillstring and bit, and prevent the influx of other fluids. Current advanced offshore drilling practices (including deep, extended-reach, high-angle, and high-temperature drilling) require high-performance muds. The water-based fluids traditionally used simply cannot provide the needed performance.

Oil-based drilling fluids can address many of the high-performance needs, but they are not very environmentally friendly. The solution was the development of synthetic-based drilling muds (SBMs). Synthetic-based muds not only effectively minimize drilling problems, they are reusable and therefore generate less waste than other drilling muds. Compared to oil-based fluids, synthetic fluids have low-toxicity and low-irritant properties that significantly enhance worker and environmental health and safety.

Page 199 PREV PAGE TOP OF DOC Segment 1 Of 7

Even though they are more expensive, SBMs can actually reduce total drilling expenses through greater drilling efficiency and reduced waste disposal cost. The Environmental Protection Agency has just completed a rulemaking on the discharge of cuttings generated using SBMs offshore, and in it, they found SBMs to be environmentally preferable to other mud types for deepwater offshore wells.

Unconventional Gas Recovery

According to the National Petroleum Council, 25 percent of our Nation's remaining gas resources are in unconventional formations. These include coalbeds, shales, and low permeability formations. Each of these resources holds substantial potential, but all require advanced technologies to recover the natural gas. Low permeability, or "tight," formations are often located deep below ground and it is very difficult for the gas to flow through the tight rocks to reach a producing well.

The key to producing unconventional gas resources is a technology called hydraulic fracturing. Developed in 1947 and constantly being improved, this technology has enabled the production of more than 8 billion barrels of oil and substantial volumes of natural gas that otherwise would not have been recoverable. Hydraulic fracturing involves the injection of water or other fluids at high pressure to create cracks in the producing formation. Proppants, such as sand or small pellets, are typically used to prop open the fractures to provide a pathway for the oil or gas to flow to the wellbore.

Recent enhancements in hydraulic fracturing technology include improved fluids to reduce the potential for formation damage and new techniques for mapping the direction and location of fractures, which lead to greater ultimate oil and gas recovery. New fluid formulations are less toxic, reducing potential environmental impacts and enhancing worker safety.

Page 200 PREV PAGE TOP OF DOC Segment 1 Of 7

The Energy Information Administration, in its *Annual Energy Outlook* for 2000, estimated that employing a range of new technologies for enhancing unconventional gas production would increase gas production by 24.7 trillion cubic feet through 2020, while lowering the price of natural gas in 2020 by 78 cents.

Ice Roads and Drilling Pads

When oil and gas exploration began in the Arctic in the 1920s, roads were bulldozed directly onto the tundra—which thawed the underlying permafrost, rendering the route impassable after one season. Road construction techniques rapidly evolved as more was learned about the environment. Crews now construct temporary ice roads. Temporary ice roads allow the construction of oil field pipelines during the winter months, thus largely eliminating the need for permanent gravel roads adjacent to pipelines. Ice-road building techniques are also used to create ice runways and ice pads to support exploratory drilling. Ice roads and pads melt in the spring and leave no significant damage to the tundra.

Ice roads are suitable for all conventional wheeled vehicles, from pickups to dump trucks. Ice road construction involves first compacting snow already on the tundra; the tundra is not scraped or removed. Tanker trucks apply either seawater from the ocean or freshwater from nearby lakes, chosen for minimum impact to fish, to create a firm crust. Chipped or crushed ice is then laid down to build thickness and create a smooth surface. The crushed ice is watered and allowed to freeze. When the ice road has reached a thickness of 12 to 18 inches, a road grader scars the surface; at very low temperatures this rough surface creates excellent traction for tires. All spills or releases on ice roads and pads are removed during operations and before the ice melts. Snow roads are also occasionally constructed using snow rather than ice to thicken the roadbed.

Page 201 PREV PAGE TOP OF DOC Segment 1 Of 7

Ice pads have been used for years to support the drilling of exploration wells across Alaska's North Slope. Construction of ice pads uses the same techniques as ice roads. When an exploration well is completed, the drill rig and other facilities are removed; after the pad melts in the summer, it is difficult to see where the site was located. Recently, new, prefabricated insulating panels are being used to extend the exploratory drilling season by as much as 50 percent. This means drilling can be completed in fewer seasons, reducing seasonal equipment mobilizations and minimizing environmental disruptions.

Recovering More Oil and Gas From Known Reservoirs

Even with our current advanced technology and experience, we can currently extract only a portion of the

oil and gas that we find in each reservoir. For oil reservoirs, past technology has recovered only a third of the oil-in-place, on average, leaving two-thirds of the U.S. oil resource base—approximately 350 billion barrels—still in the ground. For natural gas, generally the recovery percentage is higher, but still tops out at 90 percent of original gas-in-place in the reservoir. The remainder is entrained in the rock pores and is challenging to remove. Technologies aimed at improving recovery from these known reservoirs holds substantial promise for adding to domestic reserves. Each one-percentage point of additional recovery from known oil reservoirs has the potential to add 5 billion barrels of oil to our producible reserves.

Horizontal and Directional Drilling

Horizontal drilling technology replaces vertical wellbores with ones that begin vertical, but then turn to run horizontally through the formation containing the oil or gas. By contacting more of the resource with the wellbore, the hydrocarbons don't have to "travel" as far to be produced. When used for infill drilling in older fields, horizontal wells have a demonstrated performance of up to 20 times the production of conventional vertical wells in the same field. On average, DOE estimates that horizontal wells are more than three times as productive as their vertical counterparts, and they are twice as expensive to drill. Horizontal wells account for 5 to 8 percent of wells drilled over the past few years.

Directionally drilled wells have less deviation from vertical than their horizontal counterparts, but they have much wider applicability. Directional drilling allows for several bottomhole locations to be reached from a single well pad, by angling the well directly to where the oil or gas can be found. In older fields, existing wells near the end of their productive life can be reentered and deviated to reach new locations without drilling a completely new well. This reduces the surface disturbance and waste, as well as taking advantage of existing infrastructure. For new developments in sensitive environments, such as wetlands or wildlife habitats, directional drilling techniques mean that the drilling rig does not have to be placed directly over the oil or gas reservoir, but can be placed in a less sensitive location while the well still reaches the desired bottomhole location.

Improved Completion Technologies

Completion of a well involves removing the drilling equipment, installing the production equipment, and perforating the casing to allow oil or gas to flow into the wellbore. During drilling, a certain amount of damage to the formation is inescapable, but newer completion techniques allow producers to overcome the damage that may exist. New completion technologies create small flowpaths in the immediate vicinity (2–5 feet) around the wellbore. These improved pathways allow the oil and gas to flow to the wellbore more readily. Since any damage done to the formation during drilling is limited to the area immediately around the hole, this technique essentially expands the flow area beyond the damaged zone, enhancing production rates. Field application of this technology has shown that per well production can be increased by 50 to 100 percent over wells that do not employ advanced completion technologies.

Enhanced Oil Recovery Technologies

Enhanced oil recovery, or EOR, is a shorthand term for a wide range of technologies designed to improve the recovery from existing oil *and* gas wells. Some of these techniques, such as steamflooding, have been in use for decades; others, such as CO-sand fracturing are more recent. EOR injection techniques add fluids such as hot water, steam, nitrogen, CO, surfactants, or polymer to the reservoir. These substances interact with the oil, mobilizing it to a producing well. The number of active EOR projects in the United States totaled 170 in 2000, according to the *Oil & Gas Journal.* These projects produce a total of nearly 750,000 barrels per day, or 12 percent of current domestic oil production. Much of that oil would not be produced without the application of these EOR techniques.

For gas wells, hydraulic fracturing technology has enabled substantially increased recovery. Newer fracturing techniques hold additional promise. One new technique replaces water with liquid CO, eliminating some of the potential for formation damage from conventional fracturing techniques (where water can cause clay to swell and plug the formation). While hydraulic fracturing can be important to initiating production in many formations, it can greatly increase production in older wells as well. Demonstrations of newer fracturing technologies sponsored by DOE have produced initial production increases of as much as 1,000 times pre-fracturing rates. After 18 months, these wells are still maintaining production of 250 times their prior rates.

Recently, several utilities have experimented with separating and capturing the CO emissions from their flue gases. In many cases, the CO is pressurized in the removal process. This CO could potentially be used for enhancing recovery in oil and gas fields. The increased availability of commercial CO could significantly increase the amount of oil and natural gas recovered. At a recent conference, DOE suggested that if the power plants in Appalachia used their CO for enhanced coalbed methane recovery, production could increase enough that the region could be natural gas self-sufficient. Using captured CO for EOR has the advantage of decreasing greenhouse gas emissions and increasing production of valuable hydrocarbons.

Page 204 PREV PAGE TOP OF DOC Segment 1 Of 7

Conducting Safer, More Efficient Operations

Numerous technological innovations have combined to make current drilling and production operations safer and more efficient than just a few years earlier. As oil and gas is discovered in more remote and sensitive locations, industry has met the challenge to find new operational techniques that minimize the disturbance to people and wildlife while maximizing the potential recovery of oil and gas resources.

More Efficient Drilling Techniques

The efficiency of current drilling operations has been greatly improved through the combination of a number of small innovations. Advances in materials technology and bit hydraulics have allowed new drill bits to be developed that can reduce drilling time by up to SO percent. New corrosion-resistant alloys and composites have improved drill bits and equipment designed to operate in deep, hot, and sour (high hydrogen sulfide content) wells. Measurement-while-drilling (MWD) systems provide precise, real-time data on bottomhole conditions that improve not only drilling efficiency, but also worker safety. MWD

systems have been critical to the deployment of horizontal and directional drilling techniques.

Slimhole and coiled tubing drilling create smaller diameter wells, which can be drilled faster, with less surface impact, and lower volumes of drilling waste. These drilling techniques are also quieter, making them particularly applicable near wildlife habitats. Air percussion drilling, also known as pneumatic drilling, eliminates the need for drilling fluids, which can be very useful in mature fields and formations with low downhole pressures. Air drilling also reduces the volume of drilling wastes generated.

Page 205 PREV PAGE TOP OF DOC Segment 1 Of 7

Environmental Improvements

Many of the technological innovations of the industry have spawned substantial environmental benefits. The recovery of coalbed methane, for example, not only adds a very clean-burning fuel to our Nation's energy supply, but also greatly enhances the safety of coal miners. The use of directional drilling and new techniques such as slimhole or coiled tubing have reduced the footprint, or surface area required, to tap into oil and gas resources. Greater drilling efficiency reduces fuel use and emissions and time spent at the location (noise, aesthetics).

Some technologies have been developed specifically to enhance environmental performance. A good example of this is downhole oil-water separation technology. Producing oil often means producing substantial volumes of water that must be treated or disposed. By separating the oil from the water in the wellbore and reinjecting the water to another subsurface formation, this technology eliminates the production of water and its attendant environmental concerns. New leak detection and emission control technologies have also been developed to minimize the environmental impacts of supplying our country's oil and gas needs.

WHAT THE FUTURE HOLDS

Many of the technologies on the horizon are reminiscent of science fiction novels, yet hold the potential for significant contributions to future supply. Some of these new and exciting areas of research are underway now, some are on the drawing boards, and some are yet to be addressed. Let me provide a few examples:

Page 206 PREV PAGE TOP OF DOC Segment 1 Of 7

Use of lasers to replace conventional drilling techniques holds the potential to reduce drilling time, decrease waste volumes, and have a significantly smaller "footprint." My university is currently active in investigating the potential of this new technology.

Smart wells could be equipped with downhole sensors measuring pressures, temperatures, and production rates with continuous data transmission. These innovations have the capability for making adjustments automatically and immediately to enhance efficiency and safety.

Downhole processing of fluids into a better formulation has wide-ranging potential. Viscous heavy oil could be converted into better quality oil. Unwanted water or hazardous constituents could be removed before fluids are brought to the surface. Ultimately, it may be possible to convert the natural hydrocarbon resource within the reservoir into electricity and bring only the electricity to the surface.

Future technology developments might enable us to explore and produce the significant gas hydrate resources that currently exist deep beneath the ocean floor and in the Arctic. Gas hydrates are methane gas trapped inside a cage of frozen water. The U.S. Geological Survey's mean estimate of U.S. hydrate resources is 320,000 trillion cubic feet, or more than 2,000 times current natural gas reserves. Conventional production methods will not work for hydrates, given the low pressure of hydrate reservoirs and the fact that they exist in solid form. But several technologies for separating the water and gas show promise for extracting the methane from these vast resources.

Just as we have applied technologies originally developed for the military, oil and gas related research has benefits and applications reaching far beyond the petroleum industry. For example, my university is currently working with NASA to develop miniaturized drilling equipment for future drilling operations on the Moon and on Mars to assist in furthering scientific understanding of the Lunar and Martian subsurface. Also, we are assisting the National Science Foundation in ice coring operations in the Antarctic in the study of earth's climate history.

Page 207 PREV PAGE TOP OF DOC Segment 1 Of 7

HOW DO WE MAKE THE FUTURE A REALITY?

Continued research and technological innovation are crucial to meeting our Nation's energy demands. Demand for natural gas is expected to increase by more than 30 percent by 2010, with much of the new demand used for cleaner electricity generation. Increasing natural gas production to meet that demand will require the full deployment of research and advanced technologies. Yet technology alone will not get us there. As the National Petroleum Council reported, there are adequate resources, but restricted access limits the availability of supply, and a healthy industry is needed to make the necessary investments in exploration and production technology.

Given the ambitious agenda for technological change in the petroleum industry, one might expect to see growing expenditures on R&D to promote those changes. In fact, private investment by the major energy producers in R&D for oil and gas declined from $1.3 billion in 1990 to less than $800 million in 1999. On the other hand, industry was rapidly reorganizing the way it did research to exploit ever greater economies from joint efforts, partnerships, consortia, and a general migration of the R&D function from the producers to the service industry and universities. Of course, technological advances do not occur in a vacuum. Continued and increased funding, cooperative measures, and application of new techniques by producers are all needed to meet the challenges that lie ahead. The synergies created by many smaller technology improvements can leverage their way into major advances in oil and gas drilling and production.

DOE has played a crucial role in funding the development or field demonstration of many technologies that are currently contributing to added supplies. DOE has also taken an active role in the transfer of technology to the producers for use in the field to improve recovery. DOE support for oil and gas

technology development must continue if we are to meet our goals. DOE participation in a research effort can reduce the risk for an individual company by leveraging funding, as well as assuring that the results of the research receive wide distribution. Similarly, other federal agencies, such as the Minerals Management Service for offshore, can also make important contributions. Continued, and increased, government funding for oil and gas recovery research is important.

Page 208 PREV PAGE TOP OF DOC Segment 1 Of 7

The U.S. petroleum industry historically works closely with universities in researching and developing many new technologies. My university, the Colorado School of Mines, and other leading research universities across the country which combine petroleum engineering, geology, geophysics, and environmental science regularly engage in research designed to advance the frontiers of exploration and production technology.

A technologically advanced, well-trained work force is also important. Universities play a crucial role in training the future leaders of the oil and gas industry. The Department of Education has a grant program that supports the work of graduate students, who perform a significant portion of current university research. I would like to see the government continue and expand programs such as these. Also, I strongly recommend that support for science education should extend to the elementary grades, assuring that we have a scientifically grounded, technologically capable work force in the future.

The NPC was correct that success will necessitate government, industry, universities, and others working together. Solutions to today's problems are often found through interdisciplinary cooperation. Bringing together the insights of various parties with the resources to follow through on promising ideas is our best path to success in meeting the Nation's energy needs.

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Page 209 PREV PAGE TOP OF DOC Segment 1 Of 7

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Technology, 1999.
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BIOGRAPHY FOR CRAIG W. VAN KIRK

Craig W. Van Kirk is a practicing petroleum engineer and a professor of Petroleum Engineering at the Colorado School of Mines. He holds advanced degrees in Petroleum Engineering, including the Doctorate. Prior to his present position at CSM, he spent more than eleven years in the industry in the areas of reservoir engineering and simulation, supplemental recovery, reservoir characterization and management. He is involved in several areas of research, has published articles and monographs on reservoir engineering and related topics, and is active in several professional organizations.

Page 210 PREV PAGE TOP OF DOC Segment 1 Of 7

EDUCATION:

Ph.D. Petroleum Engineering, Colorado School of Mines, Golden, Colorado, May, 1972. Specialized in reservoir engineering and simulation. Minor in mathematics. Thesis: "Effect of Pressure-Dependent Variables in Gas-Well Numerical Simulation and Gas-Well Test Analysis." Constructed numerical finite-difference simulator.

M.S. Petroleum Engineering, University of Southern California, Los Angeles, California, June, 1969; Emphasis in reservoir engineering. Thesis: "Effects of the Water-Oil Viscosity Ratio on the Relative Permeability to Oil."

B.S. Petroleum Engineering, University of Southern California, Los Angeles, California, February 1968.

WORK EXPERIENCE:

1980–Present: Head of Petroleum Engineering Department at Colorado School of Mines, Golden, Colorado. Teaches and conducts research on reservoir engineering, simulation, management, improved oil recovery, and how to conduct reservoir studies.

1978–Present: Professor in Petroleum Engineering Department, Colorado School of Mines, Golden, Colorado.

1977–1978: Manager, Calgary Branch Office, and Member of Board of Directors, Scientific Software Corporation of Canada, Ltd. Manager of Reservoir Studies.

Page 211 PREV PAGE TOP OF DOC Segment 1 Of 7

1974–1977: Manager of Reservoir Engineering, Scientific Software Corporation, Denver, Colorado. Managed a staff of engineers and geologists conducting reservoir engineering and simulation studies worldwide. Responsibilities included major project coordination and scheduling, ensuring technical quality of all work, preparation and presentation of final reports, and presentations to private companies,

government agencies and national corporations. Taught courses in reservoir engineering and simulation in Denver and throughout the rest of the United States and internationally. In 1977, became the Manager of the Calgary Branch Office and served on the Board of Directors of Scientific Software of Canada, Ltd. Responsible for the profit and loss of professional consulting services in the oil and gas industry. Heavily involved in training new employees and clients and in teaching short courses in reservoir engineering and simulation and other related topics.

1969–1974: Reservoir Engineer, Shell Oil Company, Denver, Colorado. Involved with reservoir engineering and simulation, economic analysis, well log and total formation evaluation, drilling operations, workover and stimulation operations, and exploration geology. Studied oil and gas reservoirs throughout the Rocky Mountain states, as well as designing, supervising and analyzing well tests. Evaluated potential for waterfloods, infill drilling, and field development.

1967–1969: Production Engineer, Humble Oil and Refining Company, Long Beach, California. Gained experience in offshore platform operations including directional drilling, artificial lift, compressor design, and production handling facilities. Conducted economic studies for well workovers, surface facilities, and expansion for waterfloods.

Summers, 1965 & 1966: Test Engineer Assistant and Gas Plant Trainee, Continental Oil Company, Casper, Wyoming (1966); Roustabout/Roughneck/Engineer's Assistant, Continental Oil Company, Ventura, CA (1965).

Dr. Van Kirk has written numerous reports of a confidential nature for the United States Government, private industry, and national oil companies throughout the world. These studies have included every oil and gas producing continent on earth, numerous geologic basins onshore and offshore, and all types of reservoir rocks and fluids. The types of oil field studies conducted include black oil and volatile oil recovery optimization giving consideration to multiple scenarios of supplemental recovery, well spacing, and completion practices.

Numerous studies have focused on producing gas fields and gas storage facilities, including the largest gas storage field in the world. These gas-oriented studies addressed individual well deliverability, capacity, and the effects of curtailment. Frequently the studies have incorporated the simulation of surface facilities (e. g., compressors), wellbores, and the reservoir into one comprehensive computer model.

SHORT COURSES AND TRAINING:

Throughout the past twenty-five years, Dr. Van Kirk has conducted numerous short courses for private industry and government agencies throughout the world. This training, has covered subjects such as reservoir development and management, optimization of recovery and economics, simulation, well testing, waterflooding and gas injection, multidisciplinary teamwork, and many others.

INVITED SPEAKER:

Dr. Van Kirk has enjoyed being an invited speaker for SPE events, private companies, and government agencies throughout the world. The subjects have included education, research, practical application of technology, and organizational structures.

Page 213 PREV PAGE TOP OF DOC Segment 1 Of 7

AWARDS/HONORS:

Honored by the Society of Petroleum Engineers in 1998 with the "Rocky Mountain Service Award."

Society of Petroleum Engineers Distinguished Member, elected 1997, less than one percent of the membership.

Society of Petroleum Engineers Board of Directors, 1990–93. Also, served as representative to this Board from group of university petroleum engineering department heads throughout the United States. From 1989 to 1993.

Long Range Plan Committee, Society of Petroleum Engineers (first such committee since 1985). Fall, 1989. Served as the only university member and the only member from outside the states of Texas and Oklahoma.

Who's Who in Engineering in America.

Professional Societies:

1965–Present: Society of Petroleum Engineers since 1965; Board of Directors, 1990–93.

1987–1989: Technical Editor of SPE's *Journal of Petroleum Technology;* National ad hoc committee member on Petroleum Engineering Education.

Page 214 PREV PAGE TOP OF DOC Segment 1 Of 7

1985–1986: Chairman, SPE National Education and Professionalism Committee. Responsible for organizing and running SPE Annual Technical Conference in October 1986, session on Education and Professionalism in Petroleum Engineering. Registered Professional Engineer in the State of Colorado National Society of Professional Engineers Colorado Society of Professional Engineers.

RESEARCH:

Areas of research activities include: *Reservoir Simulation* (Development of simulators for research, teaching, training, general application and special topics; methods for simulating geologic depositional structures; improvement of history matching methodology; techniques for handling dispersion and diffusion); *Reservoir Behavior* (Migration of fluids in porous media; depositional environments and geological influences on flow behavior, reservoir characterization, tied closely to geological conditions; reservoir and field development for optimizing recovery); *Supplemental Recovery* (Enhanced oil recovery

and waterflooding and gas injection). *Reservoir Management* (Integrated multidisciplinary teams to optimize the value of oil and gas reservoirs).

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Chairman **BARTLETT.** Thank you very much. Mr. Huffman.

STATEMENT OF ALAN R. HUFFMAN, MANAGER, SEISMIC IMAGING TECHNOLOGY CENTER, CONOCO, INC., HOUSTON, TEXAS

Page 215 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **HUFFMAN.** Thank you, Mr. Chairman, and good morning to you and the members of the Committee. I would like to thank you for the opportunity to testify today as a concerned technology leader in the petroleum industry. The United States faces a significant challenge over the next 10 years in the area of safe and environmentally sustainable energy development. The recent power problems in California and other parts of the United States, along with the simultaneous critical supply and infrastructure problems in the electricity, gas, and oil markets, indicate that the Nation is entering a period of sustained energy challenges that could cause serious damage to the national and global economies if significant steps are not taken soon to address the problem.

During the 1960's, the United States demonstrated the vision, courage, and commitment that was required to put a man on the moon. This effort took significant resources and a coordinated effort from all of the stakeholders in space exploration to assure success. As we enter the new millennium, our Nation faces an energy challenge that is much greater than space in the level of technology that is required for success. It is my belief that this crisis requires a technology effort of similar scope and scale to what America committed to winning the space race.

During the next few minutes, I would like to enroll you in a new vision for a national technology program that will allow government to work closely and collaboratively with industry and academia to help solve our national energy crisis. This program will focus on the development, deployment, and commercialization of innovative technologies that will increase domestic energy supplies, reduce domestic energy costs to the consumers, and will be revenue positive to the Federal Government.

Page 216 PREV PAGE TOP OF DOC Segment 1 Of 7

I propose that the Congress, as part of the National Energy Plan, authorize the creation and funding of a national energy technology effort which, for illustrative purposes, I have called the United States Energy Center, or USEC. USEC will act as the catalyst for the next generation of innovative energy solutions that are required to achieve a secure energy future for the United States. The Center will be the focal point for industry collaboration with government and academia and will bridge the gap between research and development of new technologies and the commercial world by focusing on the development, first field deployment, and commercialization of major energy technologies.

USEC should be established using a model similar to the Joint Oceanographic Institutions, which manages the ocean drilling program. The Center should be overseen by an expanded interagency working group that includes representatives from the key agencies with an interest in safe and environmentally sustainable energy supplies, including the DOE, Minerals Management Service, NSF, the United States Geological Survey, NOAA, NASA, EPA, the Naval Research Lab, and the Coast Guard. The oversight mechanism should be through an Advisory Board consisting of the Federal stakeholders and the Center corporate, and academic and NGO members.

The Center should be closely aligned with the DOE Gas and Oil Technology Partnership Program at the National Labs to assure maximum leveraging and transfer of technology from DOE to USEC programs. Close coordination with other Federal science programs should also be encouraged to achieve economies of scope and scale where possible. Center programs should provide timely information to regulatory agencies, including the MMS and EPA so that new regulations can be developed using the latest technical information and input from all stakeholders.

Page 217 PREV PAGE TOP OF DOC Segment 1 Of 7

The first major program undertaken by USEC should be a technology effort called the Offshore Technology Program. In contrast to many petroleum regions of the United States, the deepwater and ultra-deepwater Gulf of Mexico hold very large reserves of oil and gas that should be included as a critical component of a future comprehensive U.S. energy strategy. One way to stem the decline in U.S. oil and gas production is to begin a massive development of the reserves contained in the deepwater environment. This development would produce an increase in domestic production similar to when the North Slope of Alaska was brought on line in the 1970's and '80's.

One of the great challenges facing the industry is how to execute such an aggressive deepwater development campaign when many of the technologies required for the effort are still in their infancy. The scale of operations in deepwater is so massive that no single operator can afford to spend the money required and take the risks involved without support and risk sharing from other stakeholders in deepwater. Individual technology development and field trial costs for some of the technologies can exceed $100 million, which is clearly out of the reach of even the largest operators. This type of massive development challenge lends itself very well to a cooperative effort by government and industry.

The Office of Natural Gas and Petroleum Technology of DOE has been working with industry and academia to formulate a technology strategy to accelerate deepwater development in the Gulf of Mexico. This strategy, called the Offshore Technology Roadmap, or OSTR, was assembled through a closely coordinated partnership with the DOE labs, the MMS, the operating, service, and engineering companies, and academia. The OPT implements the OSTR by lowering critical technology barriers, enabling deepwater developments to proceed at a faster pace, and allowing development of many smaller fields in deepwater that are not commercial today.

Page 218 PREV PAGE TOP OF DOC Segment 1 Of 7

The potential of this program is very significant and could provide several million barrels per day of

incremental production in future years. OTP's key components would include a high-intensity design competition for the next generation of ultra deepwater facilities that will allow dramatic cost reductions in deepwater operations, component technology programs for those technologies that will allow major cost reductions in specific operational areas and development programs that will integrate the expertise of the industry, academia, and the U.S. National Labs.

I recommend that the Congress appropriate a minimum of $25 million in funding for 2002 to support the Center operations and first year of the OTP. With industry-matching funds of 25 million, this would result in full funding of $50 million for the first year of the program. Preliminary economic models indicate that a properly funded and managed OTP effort will be revenue positive to the Federal Government with approximately 3.5 billion in new revenue generated in the first 10 years of the effort.

These budget amounts should be put in perspective with the energy needs of the United States. The initial 25 million in 2002 Federal funding for the Center and OTP would be equivalent to purchasing one million barrels of crude oil for the strategic petroleum reserve at $25 a barrel. This is equal, as was mentioned earlier, to about 1 hour of oil consumption in the United States. If the program is successful, the increase in deepwater production after a few years, would provide this same benefit in 1 day at significantly reduced cost to the consumer.

The U.S. Energy Center has been structured to be a win-win for all parties that will address the Nation's energy needs while reducing energy costs and generating incremental revenue for the taxpayers through the rapid deployment of new technologies. All of the details of the Center and OTP concepts, structure, and funding requirements are described in the USEC business overview that was provided to you along with my written testimony. Work is currently underway to enroll the entire energy industry in the USEC vision, and we will keep you informed as this support grows.

Page 219 PREV PAGE TOP OF DOC Segment 1 Of 7

I encourage the Committee to vigorously support this exciting new concept as part of the comprehensive national energy strategy. Thank you for you attention, and I would be happy to answer any questions.

[The prepared statement of Mr. Huffman follows:]

PREPARED STATEMENT OF ALAN R. HUFFMAN

Dear Ladies and Gentlemen of the Committee:

It is my pleasure to testify before you today as a concerned leader in the petroleum industry. The United States faces a significant challenge over the next ten years in the area of sustainable energy development. The recent power problems in California and other parts of the U.S., along with simultaneous critical supply and infrastructure problems in the electricity, gas and oil markets, indicate that the Nation is entering a period of sustained energy challenges that could cause serious damage to the national and global economies if significant steps are not taken to address the problem in the near future. In a recent series of articles and speeches, Matt Simmons, President of Simmons and Company International and a member of the National Petroleum Council, has stated that the solution to this long-term energy crisis will require a massive

mobilization of resources on a scale similar to the Marshall Plan of the post World War II period. Such a plan will require a long-term, large-scale coordinated response from all stakeholders in the Nation's energy future including the energy industry, academia, government and Non-Governmental Organizations. This effort will require new models for how government works together with a wide range of stakeholders to assure safe and sustainable supplies of energy for the Nation.

Page 220 PREV PAGE TOP OF DOC Segment 1 Of 7

During the 1960's, The United States demonstrated the vision, courage and commitment that was required to put a man on the moon. This effort took significant resources and a coordinated effort from all of the stakeholders in space exploration to assure success. America committed the resources that allowed our Nation to succeed in one of the greatest challenges ever undertaken by a single country. As we enter the new millennium, our Nation faces an energy challenge that is of the same magnitude as the space race. It is my belief that this crisis requires an effort of similar scope and scale to what America committed to winning the space race. The technological challenges facing the energy industry are enormous, and the technical and financial barriers to our success in supplying the Nation's energy needs are even more severe than the barrier of space.

I would like to enroll you in a new vision for how government can work closely and collaboratively with industry and academia to help solve the energy crisis that our Nation faces, while generating revenue for the taxpayers through the innovative deployment and commercialization of new technology.

The United States Energy Center (USEC)

I propose that the Congress, as part of the National Energy Plan (NEP), authorize the creation and funding of a United States Energy Center (USEC) that will act as the catalyst for the next generation of innovative energy solutions that are required to achieve a secure energy future for the United States. The USEC will be the focal point for industry collaboration with government and academia, and will bridge the gap between research and development of new technologies and the commercial world by focusing on the development, first field deployment and commercialization of major energy technologies that require funding beyond what most private companies can afford.

Page 221 PREV PAGE TOP OF DOC Segment 1 Of 7

The USEC should be established as a not-for-profit corporation using a model similar to the Joint Oceanographic Institutions (JOI) that manages the Ocean Drilling Program (ODP). USEC should be incorporated and managed by the industry partners to enable the execution of federally-supported energy programs. USEC should be overseen by an expanded interagency working group (IWG) that includes representatives from the key agencies with an interest in safe and environmentally-sustainable energy supplies including DOE, MMS, NSF, USGS, NOAA, NASA, EPA, the Naval Research Lab and the Coast Guard. The oversight mechanism should be through an Advisory Board consisting of the IWG, USEC corporate members, and USEC academic and NGO associate members.

The USEC should be closely aligned with the DOE Gas and Oil Technology Partnership program at the National Laboratories to assure maximum leveraging and transfer of technology from DOE to USEC programs. Close coordination with other federal science programs should also be encouraged to achieve economies of scope and scale where possible and to assure significant transfer of technology from government laboratories to the industrial sector. USEC programs should provide timely information to regulatory agencies including MMS and EPA so that new regulations can be developed using the latest technical information and input from all stakeholders. USEC will also seek working relationships with similar organizations in the international community including the Atlantic Canada Petroleum Institute (ACPI) and DEMO2000 in Norway. Collaboration with these programs will leverage the resources of all parties and will allow USEC to fund a larger number of projects per year.

The Offshore Technology Program (OTP)

Page 222 PREV PAGE TOP OF DOC Segment 1 Of 7

The first major program undertaken by the USEC will be a technology effort called the Offshore Technology Program (OTP). In contrast to many petroleum regions of the United States, the deepwater and ultra-deepwater Gulf of Mexico hold very large reserves of oil and gas that should be included as a critical component of any future comprehensive U.S. energy strategy. One way to stem the decline in U.S. oil and gas production is to begin a massive development of the reserves contained in the deepwater environment. This development will produce an increase in domestic production similar to when the North Slope of Alaska was brought on line in the 1970's and 1980's. One of the great challenges facing the industry is how to execute an aggressive deepwater development campaign when many of the technologies required for the effort are still in their infancy. The recent loss of the P–36 semi-submersible drilling platform in Brazil emphasizes the risk that deepwater operators are facing as we move into ever deeper and more hostile environments to find and produce the energy that our economy requires to grow in the future. The scale of operations in deepwater is so massive that no single operator can afford to spend the money required and take the risks involved without support and risk sharing from other stakeholders in deepwater. Thus, many new deepwater technologies are not being developed because of the enormous cost and risk associated with many of these new concepts. Individual technology development and field trial costs for some of these technologies can exceed $100 million, which is clearly out of the reach of even the largest operators. This type of massive development challenge lends itself very well to a cooperative effort by government and industry.

As the energy markets have tightened over the last year, the Office of Natural Gas and Petroleum Technology of the Department of Energy has been working with industry and academia to formulate a technology strategy to accelerate deepwater development in the Gulf of Mexico. This strategy, called the Offshore Technology Roadmap (OSTR), was assembled through a closely coordinated partnership with the DOE laboratories, MMS, the operating, service, and engineering companies and academia. The result was an integrated map detailing the range of new technologies that are critical to achieve the cost reductions necessary to allow accelerated safe and environmentally-sustainable development of the deepwater Gulf of Mexico. Many of these technologies are in the design stage and require significant support if they are to be implemented and commercialized in time to make a positive impact on near-term energy needs. Some of these technologies might not make it to market because of cost, implementation or regulatory barriers to first use. The OTP responds to the OSTR by lowering critical technology barriers, enabling deepwater

developments to proceed at a faster pace and allowing development of many smaller fields that are not commercial today. The potential of this program is very significant and could provide several million barrels per day of incremental production in future years that could be used to offset imports of foreign crude oil and natural gas. OTP's key components will include (1) a high-intensity design competition for the next generation of ultra-deepwater facilities that will allow dramatic cost reductions in deepwater operations, (2) component technology programs for those technologies that will allow major cost reductions in specific operational areas, and (3) development programs that will integrate the expertise of the industry, academia and the U.S. National Laboratories.

Page 223 PREV PAGE TOP OF DOC Segment 1 Of 7

Program Funding: The OTP will ultimately require significant federal funding and matching funds from industry and the investment community to create a leveraged program with a total funding target of $400 to 500 million per year over a 10-year period. I recommend that the Congress appropriate $25 million in funding for 2002 including $5 Million to support USEC operations and $20 Million for the first year of the OTP. With industry matching funds of $25 million, this would result in full funding of $50 million for the first year of the program. Preliminary economic models indicate that a properly managed OTP effort will be revenue positive to the Federal Government over the 10-year lifetime of the program with approximately $3.5 Billion in new revenue generated in the first 10 years of the effort.

These budget amounts should be put in perspective with the energy needs of the United States. The initial $25 million in 2002 federal funding for both USEC and OTP would be equivalent to purchasing one (1) million barrels of crude oil for the SPR at $25 per barrel. This is equal to about one (1) hour of oil consumption in the United States. If the program is successful, the increase in deepwater production after a few years would provide this same benefit in one day at significantly reduced cost to the consumer. A fully funded and successful OTP program would be equivalent to purchasing 20 million barrels of crude oil for the SPR at current prices, or about one day of U.S. energy demand, which would be less than one month of the projected incremental deepwater production in the success case. The value creation potential of this highly leveraged technology program is very significant, and could lead to a dramatic improvement in the national energy supply picture within a few years.

Programs managed under the OTP will have specific technical and commercial requirements, and will include repayment schedules for the federal funds provided for each project. The success of the OTP will also hinge on how the partners are incentivized to participate. Specific tax incentives should be put in place for the OTP to encourage smaller companies to participate in the program. This tax credit would be limited to the amounts spent by the industry partners in developing and commercializing specific technologies through OTP. This tax credit would be an incentive both to participate in OTP and to deploy the technologies from OTP rapidly in order to receive the tax credit. This feedback loop of tax incentives will also assist in commercializing key technologies and will assure that the OTP is successful by maximizing the industrial matching component of the program. The OTP has been structured to be a "Win-Win" for all parties that will address the Nation's energy needs while generating incremental revenue for the taxpayers through the rapid deployment of new technology. All of the details of the USEC and OTP concepts, structure and funding requirements are described in the USEC Business Overview that is being provided for your review along with this testimony. Work is currently underway to enroll the entire energy industry in the

USEC vision, and we will keep you informed as this support grows.

Page 224 PREV PAGE TOP OF DOC Segment 1 Of 7

Closing Remarks: As the Administration and Congress consider all aspects of the Nation's energy policy, it is imperative that the USEC and OTP be considered seriously in the legislative and appropriations process as a critical component of a successful comprehensive U.S. energy policy. The USEC and OTP present a unique opportunity to demonstrate that government can work effectively with industry and academia to solve critical national challenges. I encourage the Committee to vigorously support this exciting new concept as part of the comprehensive national energy strategy. Thank you for your attention, and I will be happy to address any questions that you may have.

BIOGRAPHY FOR ALAN R. HUFFMAN

The Seismic Imaging Technology Center, Exploration Production Technology, CONOCO Inc., 600 N. Dairy Ashford Road, Lobo 3056, Houston, TX 77079; 281–293–6718.

CAREER INTEREST

To use my unique combination of technical, business, leadership, communication and interpersonal skills to lead a technology organization and enable it to outperform the competition while providing top quartile returns to the shareholder.

CAREER SUMMARY

Over 15 years of experience in technology development and application, computer software design and implementation, project management, technology management and general management in the petroleum industry, engineering and environmental geophysics, and the medical industry. Experience includes recognition as an industry leader in several key technology areas including shock wave effects in materials, seismic analysis technologies, and wellbore geophysics. Personal traits include excellent leadership, communication, and interpersonal skills.

Page 225 PREV PAGE TOP OF DOC Segment 1 Of 7

EDUCATION

1990; Ph.D, Geophysics, Texas A&M University

1983; B.A., Geology, Franklin and Marshall College

EMPLOYMENT HISTORY

Conoco Inc., 1997 to Present: ***Manager, Seismic Imaging Technology Center.*** *Duties include management of the geophysical technology division of Conoco, including responsibility for worldwide*

technology development and technical service work in seismic acquisition, seismic data processing, seismic analysis, and gravity and magnetics. Organization includes 80 staff in these disciplines located in Ponca City, Houston and other Conoco locations worldwide. Responsible for Conoco global geophysical technology strategy and planning, coordination of recruiting for geophysicists for the corporation, and integration of technology into the business process for finding and developing oil and gas reserves. Duties include management of a $20MM annual budget with direct impact on Conoco's $500MM global exploration program and worldwide production programs. Reports directly to the Vice President of Upstream Exploration Production Technology.

Exxon Corporation, 1990 to 1997: ***Exploration Geophysicist, Exxon Exploration Company (1996–1997).*** *Geophysical Applications Group, Houston, TX. Duties include rock physics and physical properties analysis, specialized seismic data processing (2D and 3D, controlled amplitude and phase), direct detection of hydrocarbons using DHI and AVO technology, abnormal pressure prediction, geophysical modeling and inversion, velocity analysis, time-depth conversion, wildcat and appraisal well planning and management of the Exxon Global Physical Properties Database. Assigned to Africa/Middle East Business Unit for Ventures in Offshore Nigeria. Also provide expertise for ventures in Far East, Russia and U.S.A. Main emphasis on the application and integration of technology with 3D seismic data to optimize exploration results and appraisal. Senior Petroleum Geophysicist, Exxon Exploration Company (1992–1996).* Geophysical Applications Group, Houston, TX. Duties basically the same as above. Assignments included three years stewarding geophysical programs for Exxon exploration ventures in China and Vietnam, and one year stewarding programs in Offshore West Africa. Also provide expertise for ventures in Russia and U.S.A. *Senior Geophysicist, Exxon Company U.S.A. (1990–1991).* Offshore/Alaska Division, Seismic Applications Group, Houston, TX. Duties include physical properties analysis and database management, specialized seismic data processing, AVO and DHI analysis, velocity survey trade negotiation, abnormal pressure prediction, and chance of success estimation for drilling.

Page 226 PREV PAGE TOP OF DOC Segment 1 Of 7

Drilling, Observation and Sampling of Earth's Continental Crust, 1989 to 1990: ***Science and Database Manager,*** *DOSECC Continental Scientific Drilling Office, Texas A&M University. Duties included the organization and science management of the drilling program office after it was transferred from Washington, D.C. to College Station, TX.*

Texas A&M University, 1983 to 1990: ***Doctoral Research Fellow,*** *Department of Geophysics, Texas A&M University. Pursued a wide range of research topics and taught undergraduate and graduate courses and labs. Provided the earthquake and seismic stability analysis for the site proposal for the Superconducting Supercollider for Waxahachie, TX. The main focus of the graduate research was on rock physics and rock mechanics and earthquake seismology. Research topics are listed under recent research.*

The Medical College of Pennsylvania, 1978 to 1983: ***Unit Manager/Supervisor, Medical College of Pennsylvania Hospital (1981–1983),*** *Philadelphia, PA. Supervised clerical and non-nursing staff in the Department of Nursing, including represented employees of the 1199C Teamsters Hospital Workers Union. Unit Secretary, Medical College of Pennsylvania Hospital (1978–1980),* Philadelphia, PA. Duties included management of the nurses station, patient records, and supervision of non-nursing functions on the unit.

MAJOR INTERESTS

Petroleum Exploration & Production Geophysics
Rock Physics, Mechanics, and Deformation
Applications of Pulsed Power to the Petroleum Industry

Page 227 PREV PAGE TOP OF DOC Segment 1 Of 7

Earthquake Seismology and Hazard Reduction
Engineering & Environmental Geophysics

PROFESSIONAL AFFILIATIONS

American Association of Petroleum Geologists
Society of Exploration Geophysicists
American Geophysical Union
Geological Society of America
Association of Engineering Geologists

PROFESSIONAL ACTIVITIES

2001; Executive Committee, Midcontinent Oil and Gas Association

2000–2001; Session Chairman, Pore Pressure Prediction Using Geophysical Methods, Offshore Technology Conference, May, 2001

1999–Present; Board of Directors, United States Oil and Gas Association

2000; Co-Chairman and Sponsor, ODP Drilling Workshop on Geopressure in Sedimentary Basins

2000; Session Chairman, Shallow Water Flow Hazards, Offshore Technology Conference

Page 228 PREV PAGE TOP OF DOC Segment 1 Of 7

2000; Organizing Committee, SPE Forum on Deepwater Appraisal and Development

1999; Chairman, Pennwell Forum on Shallow Water Flows, October 7–8, 1999

1999; Editor, AAPG Special Volume on Pressure Regimes in Sedimentary Basin and Their Prediction, to be published in late 1999

1999–Present; Board of Directors, Mid Continent Oil and Gas Association

1999; Session Chairman, SEG D&P Forum, Kananaskis, Alberta, Canada, July 11–16, 1999

1998–2000; Member, Scientific Measurements Panel, Ocean Drilling Program, 3 year term from 1999–2001

1998; General Chairman, American Association of Drilling Engineers Industry Forum on Pressure Regimes in Sedimentary Basins and Their Prediction, held September 2–4, 1998

1998; Expert Panel Member, SEG Workshop on Deepwater Challenges in Exploration and Production, New Orleans, LA, September 18 1998

1998; Organizing Committee Member and Expert Panel Member, DEA/AADE Workshop on Shallow Flows, held at The Woodlands Conference Center, July 24–25, 1998

1997; Invited Speaker, SEG Workshop on Pressure Prediction, Dallas, Texas, November 1997

Page 229 PREV PAGE TOP OF DOC Segment 1 Of 7

1997–Present; Member, American Association of Drilling Engineers Disciplinary Standing Committee on Abnormal Pressure Drilling Technology

1994–Present; Astrogeology Committee, American Association of Petroleum Geologists

1987–88; Secretary to Steering Committee, Texas A&M University Petroleum Recovery Research Program

1987; Secretary to the Steering Committee, DOE/OBES Workshop on Not Visible or Recoverable Hydrocarbons

1987; Technical Secretary, DOE/OBES Workshop on Not Yet Visible or Recoverable Hydrocarbons

1986–87; President, Lone Star Chapter, Association of Engineering Geologists

1986; Executive Secretary to the Department of Energy, Office of Basic Energy Sciences Geoscience Research Council

1985; Texas Section, Association of Engineering Geologists, Annual Meeting Chairman.

PROFESSIONAL EXPERIENCE

Business and Technology Management, Strategy, Development and Planning

Page 230 PREV PAGE TOP OF DOC Segment 1 Of 7

Geophysical Technology Project Management

Direct detection of hydrocarbons using DHI and AVO methods

Seismic and geophysical data processing

Geophysical log and VSP planning and log analysis

D and 3D seismic interpretation

Geophysical modeling and inversion

Seismic attribute analysis for direct hydrocarbon detection

Detection of abnormal pressure using geophysical methods

Velocity analysis and time-depth conversion

Geophysical database management

Design, placement and operations of microseismic arrays, land refraction surveys, marine and land reflection seismic surveys, and gravity surveys

Geochemical and geophysical field investigations

Design and operation of high-pressure and high-temperature experimental apparatus

Geochemical analysis, including XRD, XRF, EDS, VMS, and INAA

Scanning and transmission electron microscopy

Design and implementation of shock recovery experiments

Development of pulsed power applications in geophysics, mining, and petroleum.

TEACHING AND LECTURES

2001; Reservoir Technologies That Will Be Critical To The Industry Of The Future; invited talk at SEG Development and Production Forum, Taos, NM, June 25–29, 2001

2000; What Technologies Will Impact Deepwater Appraisal and Development Ten Years From Now?; invited talk at SPE Forum on Deepwater Appraisal and Development, Breckenridge, CO, July 9–14, 2000

2000; Where Will We Be In Deepwater Appraisal and Development Ten Years From Now?; invited talk at SPE Forum on Deepwater Appraisal and Development, Breckenridge, CO, July 9–14, 2000, co-authored with Christine Economides

1998; July, Conoco Pore Pressure School taught in Maioli, Taiwan

1998; May, Conoco Pore Pressure School taught in Lafayette, LA

1996; September, Exxon Basic Geophysical Applications Workshop for Interpreters, "Physical Properties Issues For Geophysical Applications"

1996; September, Exxon Basic Geophysical Applications Workshop for Interpreters, "Theory and Applications of Amplitude Versus Offset Technology"

1996; September, Exxon Basic Geophysical Applications Workshop for Interpreters, "PHYPROPS+, The Exxon Global Physical Properties Database System"

1996; September, Exxon Basic Geophysical Applications Workshop for Interpreters, "Quality Control and Editing of Geophysical Logs"

1996; April, Exxon Operations Geology School, "Abnormal Pressure Prediction Using Geophysical Methods"

1996; February, Exxon Basic Geophysical Applications Workshop for Interpreters, "Physical Properties Issues For Geophysical Applications"

1996; February, Exxon Basic Geophysical Applications Workshop for Interpreters, "Linking Geophysical Models To Seismic –1995; October, Exxon Geophysical Applications Symposium, "The Future of Direct Hydrocarbon Detection Methods in Exploration"

Page 233 PREV PAGE TOP OF DOC Segment 1 Of 7

1995; October, Exxon Geophysical Applications Symposium, "PHYPROPS+: EEC's Global Physical Properties Database System"

1995; October, Exxon Geophysical Applications Symposium, "Predicting Shear Wave Velocity Using Ultrasonic Laboratory Core Measurements"

1995; October, Exxon Geophysical Applications Symposium, "Adding Value With 2D Controlled Amplitude Reprocessing In Areas With 3D Seismic Data"

1994; May, Exxon Geophysical Applications Symposium, "Seismic Modeling and 2D Loss Corrections For Controlled Amplitude 3D AVO Processing Of Data From The South China Sea"

1994; May, Exxon Geophysical Applications Symposium, "Seismic Attribute Analysis of Controlled Amplitude, Prestack Migrated 3D Seismic Data From The South China Sea"

1994; May, Exxon Operations Geology School, "Abnormal Pressure Prediction Using Seismic Velocities"

1994; May, Texas A&M University Seismic Interpretation Workshop, "Introduction To Seismic Reflection Data"

1994; May, Texas A&M University Seismic Interpretation Workshop, "Linking Geology and Geophysics: Physical Properties and Direct Detection of Hydrocarbons"

Page 234 PREV PAGE TOP OF DOC Segment 1 Of 7

1993; October, Exxon Seismic Acquisition and Processing Techniques Symposium, "3D Prestack Time Migrated, Controlled Amplitude Processing of Seismic Data From The South China Sea"

1992; July, Exxon Velocity Interpretation and Analysis Workshop, "Abnormal Pressure Prediction Using Seismic Velocities," and "The Global Physical Properties Database"

1992; May, "Prediction of Abnormal Pressure Using Seismic Velocities," Exxon Operations Geology School

1992; May, Exxon DHI Symposium, "Physical Properties Database for the Gulf of Mexico," and "Low Gas Saturation Versus the False DHI"

1991; April, Duke University, Shell Distinguished Lecturer, "Impact Versus Volcano; The Search for the Dinosaur Killer"

1991; March, Exxon Production Research Company, "Earthquake Hazards in the Southern United States and the U.S. Oil Industry"

1989; November, University of Washington, Geological Sciences Seminar Series, 3 talks presented "The Cretaceous/Tertiary Boundary and the Origin(s) of Shocked Minerals," "Hot Spot Initiation and Flood Basalts as a Cause of Catastrophic Climatic Change and Mass Extinctions," and "The Rheology of the Upper Mantle"

1989; September, Texas A&M Oceanography Seminar; "The Search for The Dinosaur Killer"

Page 235 PREV PAGE TOP OF DOC Segment 1 Of 7

1989; September, Texas A&M Geophysics Seminar; "The Cretaceous-Tertiary Boundary and The Origins of Shocked Minerals"

1989; May, University of Washington Geological Sciences Seminar; "Volcano versus Impact: The Search for The K/T Killer"

1989; February, Texas A&M College of Geosciences Colloquium Lecture; "Volcano versus Impact: The Search for The K/T Killer"

1989; Taught a seminar series on the Cretaceous/Tertiary Boundary at Texas A&M University, spring semester, 1989

1987; April; Seminar given at Bryn Mawr College; "Rheology of The Upper Mantle"

1987; Fall Semester, Geophysics 441, "Solid Earth Geophysics," Laboratory Instructor and Substitute Lecturer

1986; December; Seminar given at Lawrence Livermore National Laboratory; "Grain-Boundary Dynamics During Annealing of Dunite"

1986; Fall Semester, Texas A&M Geophysics Seminar; "Rheology of the Upper Mantle"

CONTINUING EDUCATION

2001; CMC Trailblazer Program For Executive Development, Session 5, Conoco University in cooperation with London Business School and JMW

Page 236 PREV PAGE TOP OF DOC Segment 1 Of 7

2001; Communication That Matters: Engaging Others In Shaping The Future, Conoco University and Rick Ross Training Program

2000; Power Through Influence, Harvard Business School Executive Education Program

2000; Managing People: Power Through Influence, Wharton School of Business, University of Pennsylvania Executive Education Program

1996; IVP School, Western Geophysical

1996; 3D Seismic Interpretation, Exxon 5 day school

1996; GEOQUEST IESX Training

1996; Hampson-Russell AVO Workshop

1995; GXII Training School

1995; INTERWELL Inversion Training School

1994; Velocity Interpretation & Analysis Workshop

1992; Basic Well Logging, Exxon 10 day school

Page 237 PREV PAGE TOP OF DOC Segment 1 Of 7

1991; Seismic Data Gathering, Exxon 5 day school

1991; Applied Seismic Interpretation, Exxon 15 day school

1991; Exploration Economics, Exxon 2 day school

1991; Introduction to SAS for Geologists, Exxon 5 day school

1991; Direct Hydrocarbon Indicator Symposium, Exxon 5 day seminar

1990; Seismic Identification of Hydrocarbons, Exxon 5 day school

ACADEMIC HONORS

1989; Association of Former Students Award for Excellence in Doctoral Research, Texas A&M University

1989; Williford Dean's Scholarship, TAMU

1989; John and Francis Handin Fellowship, TAMU

1988–89; AMOCO Doctoral Fellowship, TAMU

1988; ARCO Doctoral Fellowship, TAMU

Page 238 PREV PAGE TOP OF DOC Segment 1 Of 7

1987–88; CONOCO Geophysics Fellowship, TAMU

1987–88; Williford Dean's Scholarship, TAMU

1986–87; Geophysics Dept. Fellowship, TAMU

1986–87; Teaching Assistant, Department of Geophysics, TAMU

1985–86; Faculty Doctoral Fellowship, TAMU

1984–85; ARCO Doctoral Fellowship, TAMU

1983–84; University Fellowship, TAMU

1982–83; Moss Scholarship, F & M College

RESEARCH WORK

High-pressure/temperature rheology of mafic and ultramafic rocks, including the effects of fluid phases.

Mathematical and numerical modeling of geophysical phenomena of the lower crust and upper mantle.

Microseismic and pattern recognition studies for earthquake hazard reduction along the Meers Fault, S. W. Oklahoma.

Page 239 PREV PAGE TOP OF DOC Segment 1 Of 7

Causes and effects of shock-wave propagation from natural phenomena including meteor impacts and volcanism.

Development of shock-induced microstructures in silicate minerals as a function of variables other than peak shock stress.

Pressure-solution effects as a function of fluid chemistry and its relation to oil-field consolidation problems and EOR.

Gravity effects of large mantle plumes and their relationship to other geophysical phenomena.

Physical properties of sediments and their relationship to seismic stratigraphy and seismic attributes.

Development and implementation of DHI and AVO technology using controlled amplitude 31) seismic processing.

Development and implementation of geophysical methods for the detection of abnormal fluid pressures.

Application of pulsed power to engineering, environmental, and oil production problems.

THESIS WORKS

Huffman, A.R., (1981), The Geology, Petrology, and Geochemistry of the N.W. Hambone and S.W. Medicine Lake Quadrangles, N. California, Bachelor's Thesis, Franklin and Marshall College, 72 pages.

Huffman, A.R., (1983), The Petrology of the Late Stage Lavas of The Medicine Lake Highlands, Bachelor's Thesis, Franklin and Marshall College, 156 pages.

Huffman, A.R., (1990), Shock Deformation and Volcanism Across The Cretaceous/Tertiary Transition, Ph. D. Dissertation, Texas A&M University, 347 pages.

ABSTRACTS

Doukhan, J.C., Goltrant, O., Cordier, P., Huffman, A.R., Carter, N.L., and Officer, C.B., (1990), Planar Features in Shocked Quartz: A Transmission Electron Microscope Investigation, EOS Trans, v. 71, no. 43:1655.

Gartner, S., Huffman, A.R., and Crocket, J.H., (1990), The Cretaceous-Tertiary Boundary At Brazos River, East Texas, GSA Abstracts with Programs, in press.

Huffman, A. R., (1998), The Future of Pressure Prediction Using Geophysical Methods, AADE Industry Forum on Pressure Regimes in Sedimentary Basins and Their Prediction, September 2–4, 1998.

Huffman, A.R., (1995), Experimental Constraints on Shock-Induced Microstructures in the Impact Deposits

of the Ames Crater, Industry Workshop on the Ames Impact Crater, Oklahoma, March 28–29, 1995, in press.

Page 241 PREV PAGE TOP OF DOC Segment 1 Of 7

Huffman, A.R., (1990), Grain-Boundary Dynamics During Annealing of Dunite, Texas Society for Electron Microscopy Annual Meeting, April 5–7, 1990.

Huffman, A.R., (1988), Seismicity and Faulting Studies for Siting the Superconducting Supercollider in Texas, invited paper abstract, Association of Engineering Geologists, Texas Section Meeting, April 16, 1988.

Huffman, A.R., (1987), Grain-Boundary Dynamics During Annealing of Dunite, EOS, *Trans. American Geophysical Union*, vol. 68, no. 16:404.

Huffman, A.R., (1984), Response of the Uppermost Mantle to Indo-Eurasian Collisional Tectonics, Texas A&M 6th Geodynamics Symposium, Abstracts, April, 1984.

Huffman, A.R., Carter, N.L., Brown, J.M., and Shaner, J., (1989), Temperature-dependence of Shock-induced Microstructures in Tectosilicates, Abstract, EOS Transactions, AGU, in press.

Huffman, A.R., Carter, N.L., and Brown, J.M., (1989), Temperature-dependence of Shock-induced Microstructures in Tectosilicates, Abstract, APS Topical Conference on Shock Compression of Condensed Matter, Albuquerque, NM, August 14–17, 1989.

Huffman, A.R., Carter, N.L., and Kronenberg, A.K., (1989), Can terrestrial processes produce shock microstructures, Abstract, GSA Abstracts with Programs, v. 21, no. 6.

Huffman, A.R., Carter, N.L., and Kronenberg, A.K., (1990), TEM-Scale Shock-Wave Damage in Silicates and The Cretaceous-Tertiary Boundary Event, Texas Society for Electron Microscopy Annual Meeting, April 5–7, 1990.

Page 242 PREV PAGE TOP OF DOC Segment 1 Of 7

Huffman, A.R., Carter, N.L., and Officer, C.B., (1989), Are Shocked Minerals Unique to Impact?, Abstract, 20th Lunar and Planetary Science Conference, Houston, TX, March 13–17, 1989, p. 426–427.

Huffman, A.R., and Castagna, J.P., 1999, Rock Physics and Mechanics Considerations for Shallow Water Flow Characterization, Pennwell Shallow Water Flow Forum, October 6–8, 1999.

Huffman, A.R., Castagna, J.P., Sahai, S.K., Cox, V.D., and Smith, K., 2000, Shallow Water Flow Prediction Using Analysis of Multicomponent Seismic Data, SEG Research Workshop, Boise ID, October 6–16, 2000.

Huffman, A.R., Crocket, J.H., and Carter, N.L., (1988), Iridium, Shocked Quartz, and Trace Elements Across the Cretaceous/Tertiary Boundary at Maud Rise, Wedell Sea, and Walvis Ridge, South Atlantic,

Abstract, Conference on Catastrophes in Earth History, Snowbird, Utah, Oct. 20–23, 1988.

Huffman, A.R., Crocket, J.H., and Gartner, S., (1989), The Cretaceous/Tertiary Boundary at Brazos River, East Texas, Abstract, 20th Lunar and Planetary Science Conference, Houston, TX, March 13–17, 1989, p. 428–429.

Huffman, A.R., Fahlquist, D.A., and McCartney, K., (1990), Gravity Effects of Large Mantle Plumes and The Correlation Between Hot-Spot Initiation, Mass Extinctions, and Sea-Level Change, GSA Abstracts with Programs, in press.

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Huffman, A.R., McCartney, K., and Loper, D.E., (1989), Hot Spot initiation and flood basalts as a cause of catastrophic climatic change and mass extinctions, Abstract, GSA Abstracts with Programs, v. 21, no. 6.

Kronenberg, A.K., Rossman, G.R., Yund, R.A., and Huffman, A.R., (1989), Stationary and mobile hydrogen defects in potassium feldspar, Abstract, EOS Trans, v. 70, in press.

Sharpton, V.L., Huffman, A.R., Murali, A.N., and Kronenberg, A.K., (1989), Shocked quartz at the base of the Deccan Traps: Fact or Fiction?, Abstract, GSA Abstracts with Programs, v. 21, no. 6.

Tilford, N.R., and Huffman, A.R., (1985), Pattern Recognition to Locate Renewed Movement on Basin-Bordering Faults, paper presented at the 80th Meeting, Seismological Society of America, Austin, Texas, April 15, 1985.

PUBLICATIONS

Flemings, P.B., and Huffman, A.R., (2000), Geo-Fluids of Passive Margins: At The Interface of The Practical and The Fundamental, Workshop Report for the Ocean Drilling Program, *JOI/USSAC Newsletter*, v. 13, no. 2:10–11.

Huffman, A.R., (2001), The Future of Pressure Prediction Using Geophysical Methods, Proceedings of The Offshore Technology Conference, April 30–May 3, 2001.

Huffman, A.R., (2001), What Technologies Will Impact Deepwater Appraisal and Development Ten Years From Now?, SEG *The Leading Edge Magazine*, volume 20, no. 4:372–384.

Page 244 PREV PAGE TOP OF DOC Segment 1 Of 7

Huffman, A.R., (2001), The Future of Pressure Prediction Using Geophysical Methods, AAPG Special Volume on Pressure Regimes in Sedimentary Basins and Their Prediction, in press.

Huffman, A.R., (1996). Shock-Induced Microstructures and Experimental Constraints on The Formation of The Ames Impact Crater, Oklahoma Geology Notes, in press.

Huffinan, A.R., (1994), Impact Versus Terrestrial Processes: Separating Fact From Fiction, *The Leading Edge,* Society of Exploration Geophysicists, vol. 13, no. 5:311–313.

Huffman, A.R., (1990), An Endogenous Mechanism for Extinctions, *Geotimes,* vol. 35, no. 8:16–17.

Huffman, A.R., (1987), Editor, Geological Studies for Nuclear Waste Repositories in The Texas Panhandle: A Symposium Volume, *AEG Bulletin,* vol. 24, no. 2:205–246.

Huffman, A.R., (1985), Response of the Uppermost Mantle to Indo-Eurasian Collisional Tectonics, *Tectonophysics,* vol. 119:119–136.

Huffman, A.R., and Castagna, J.P., (2000), Shallow Water Flow Prediction From Seismic Analysis Of Multicomponent Seismic Data, *Proceedings of the Offshore Technology Conference,* May, 2000.

Huffman, A.R., Brown, J.M., and Carter, N.L., (1990), Temperature-Dependence of Shock-induced Microstructures in Tectosilicates, in: S. C. Schmidt et al (editors), *Shock Compression of Condensed Matter,* 1989, Elsevier:649–652.

Huffman, A.R., Brown, J.M., Carter, N.L. and Reimold, W.U., (1993), The Microstructural Response of Quartz and Feldspar to Shock Loading at Variable Temperature, *Journal of Geoo. Res.,* vol. B98. no. 12:22171–22197.

Huffman, A.R., Crocket, J.H., Carter, N.L., Borella, P.E., and Officer, C.B., (1991), Chemistry and Mineralogy Across the Cretaceous/Tertiary Boundary at DSDP Site 527, Walvis Ridge, South Atlantic Ocean, in, V.L. Sharpton and P. Ward, editors, *Global Catastrophes in Earth History,* GSA Special Paper 247:319–334.

Huffinan, A.R., and Reimold, W.U. (1996), Experimental Constraints on Shock-Induced Microstructures In Naturally Deformed Silicates, *Tectonophysics,* vo1. 256:165–217.

McCartney, K., Huffman, A.R., and Tredoux, M., (1991), A Paradigm for Endogenous Causation of Mass Extinctions, in V.L. Sharpton and P. Ward, editors, *Global Catastrophes in Earth History,* GSA Special Paper 247:125–138.

Swarbick, R.E., Huffman, A.R., and Bowers, G.L., (1999), Summary of The AADE Forum: Pressure Regimes In Sedimentary Basins and Their Prediction, *The Leading Edge,* SEG, vol. 18, no. 4:511–513.

PERSONAL HISTORY

Born: March 7, 1960, Philadelphia, PA
Married: August 13, 1983, to Maria Beverly Nellett

Wife's Profession: Registered Nurse (BSN, RN, CCRN)
Children: One daughter, Andrea Lynn, age 13 years
Health: Excellent
Citizenship: U.S.

REFERENCES

Mr. Edward B. Reynolds, Manager, Emerging Technologies, Conoco Inc., 600 N. Dairy Ashford Road, Houston, TX; 281–293–6594.

Dr. Peter Flemings, Department of Earth Sciences, 442 Deike Building, The Pennsylvania State University, University Park, PA 16801; 814–865–2309.

Dr. Randolph J. Martin, President, New England Research, 76 Olcott Drive, White River Junction, VT; 802–296–2401.

Dr. Glenn Bowers, President, Applied Mechanics Technologies, 22 Summer Snow, Houston, TX; 713–896–8346.

Dr. Neville L. Carter, Professor Emeritus of Geophysics, Texas A&M University, 1485 Pebble Beach Drive, Crescent City, CA 95531–3230; 707–464–3828.

Dr. John P. Castagna, School of Geology and Geophysics, University of Oklahoma, 100 E. Boyd Street, Room 726, Norman, OK 73019; 405–325–6697.

Panel II Discussion

Proposed National Energy Research Center

Chairman **BARTLETT.** Thank you very much. I want to thank all of the witnesses for their testimony. And let me turn now to Mr. Costello for his questions and comments.

Mr. **COSTELLO.** Mr. Chairman, thank you. Mr. Huffman, let me follow up on your testimony. Did I hear you correct that you are recommending $25 million the first year?

Mr. **HUFFMAN.** The minimum requirement that I propose in the testimony is 25 million. Ultimately, as I said in the statement, this will require significantly larger amounts of money, not as much as the Space Program cost, but significant amounts of money that would have to be matched by industry and government working together to solve the problems that we face in deepwater on the technology side of our business.

Mr. **COSTELLO.** And five is for the Center and 20 is for the program. Is that correct?

Mr. **HUFFMAN.** That would be for the first year. Yes.

Mr. **COSTELLO.** And how do you see, looking down the road, 10 years—a 10-year plan? How much

would you expect the Congress to appropriate over a 10-year period?

Page 248 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **HUFFMAN.** If you look in the last page of the summary, the business overview that I have provided to you, there is actually a graph. The assumption in that economic model is that the program would ramp up to $250 million a year of Federal funding in the 4th year and then would stay stable at that level through the 10-year first phase of the program. And there are obviously different models that you can run, but that model is revenue-positive to the Federal Government over the lifetime of the program, including the tax credits that would be taken for R&D, the revenues from royalties, and not including the trickle-down effects from the income taxes and other industrial impacts of a large program like this.

Mr. **COSTELLO.** Let me ask you to direct your attention to the deepwater Gulf of Mexico. I know that little work has been done there. But, one, what do we know about the potential for oil and gas production from the deepwater in the Gulf at this time?

Mr. **HUFFMAN.** Based on the numbers that we have from our current exploration and production in the Gulf, it is probably one of the most prolific remaining frontiers within the United States for future production of oil and gas. There are, to my knowledge, no other areas that are currently being explored and developed that contain the scale of potential that the deepwater contains.

Mr. **COSTELLO.** And what might that scale of potential be? Do we have any idea?

Mr. **HUFFMAN.** In terms of production, it could be several million barrels a day of additional production over a 10- or 20-year lifetime. So a fairly significant total reserve base exists out there yet to be developed.

Page 249 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **COSTELLO.** And what is that potential reserve base—how did we determine that? What is that based upon?

Mr. **HUFFMAN.** That is based on the industry projections. And I can get you some detailed information on that later if you would like to see some more actual numbers. I didn't bring those with me today.

Fossil Energy Research Priorities

Mr. **COSTELLO.** Dr. Van Kirk, you mentioned in your testimony about the technology advances in the '60's and '70's, and that today's supplies of oil and natural gas would not be here today had it not been for the development of those technologies. And I just wonder how much of those technology advances were attributed to government oil and gas research versus the private sector?

Mr. **VAN KIRK.** I cannot quantify the distribution, whether it be 50 percent—I can't do that and I don't think anybody can, but it has been significant. Department of Energy participation with us in our research on university campuses and with private industry almost always are partnerships among three or four of our

groups—government, industry, and universities, and academia. And the funding is shared also. Usually, there is a requirement for cost sharing on the university's part and with private industry. Government's participation and contributing some funding is—has been essential and crucial and useful. And also the government participation guarantees distribution of the results on a broad basis to everyone in the country.

Page 250 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **COSTELLO.** I wonder if—and I realize you have—you said you cannot give a definitive answer. But did you have—is it 50/50, more than 50/50? Or, Mr. Kripowicz, would you know, during that period of time?

Mr. **KRIPOWICZ.** I would agree with Mr. Van Kirk. It would be very difficult to align the percentages. Industry, in general, spends a—you know, if what they count as R&D, a considerable amount more than the government does, but the government focuses on high-risk areas. And so, over time, the government research has more bang for the dollar than you would think because it looks at high-risk things that the industry might not look at immediately, and the industry picks it up and spends a great deal more money bringing that technology to market.

Mr. **VAN KIRK.** Mr. Costello, may I——

Mr. **COSTELLO.** Please.

Mr. **VAN KIRK** [continuing]. Proceed? Thank you. I hadn't thought of it this way before, but it occurs to me that if you are asking for a distribution, and we cannot quantify it, I think it is similar to considering an athletic team, a team sport, where the team is successful, and then to try to distribute the success among the team players. You can't do it just by how many points are scored or how much money somebody put in.

Mr. **COSTELLO.** I wish I could explain that to my constituents back home. They don't look at it that way. But let me ask a question about the oil companies—and it is my understanding that their R&D commitment has been reduced in the past few years. And I wonder if I might ask anyone who would like to answer the question why that has been. I am sure there are several obvious reasons, but I wonder if you would begin, Dr. Van Kirk.

Page 251 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **VAN KIRK.** Well, I am speaking on my perspective from the university standpoint and my close association with professionals in industry also—our professional societies and meetings and conferences. Over the past 15 years, there has been quite a consolidation in our industry. Depressed prices, 10, 15 years ago, consolidations, mergers, and the oil industry reducing its own internal research and development activities and evolving and migrating into a newer relationship with universities and the government and the DOE doing research and service companies also—major oil field service companies, doing joint-team research. So there has been an evolution in recent years. And, as a matter of fact, last week in our meeting in Houston, we talked about continuing that evolution even further.

Mr. **COSTELLO.** Mr. Huffman.

Mr. **HUFFMAN.** Well, that is the job that I do inside my company, is running a technology organization. And, yes, you are correct in the general statement that over the last, say, 10 to 15 years, the total amount of money spent by industry has dropped significantly. That has been partly, as Dr. Van Kirk said, to the long period of low energy prices and the resulting low return on capital that the industry was able to achieve in that environment.

The second thing that has occurred is the consolidations, as Dr. Van Kirk mentioned. And if you look at the industry research laboratories, some of the finest labs in the industry are now gone. Two of them, Amoco and Arco's research labs, for example. And those were legendary laboratories. And it is unfortunate that we have seen that happen, but that is what happens when you do consolidate. The R&D spending in the last year or so, as prices have gone up, has actually begun to increase again. But, as you can imagine, after 15 years of poor returns, the industry is hesitant to rapidly begin investing large amounts of money until we are sure that the return on capital employed is going to be sufficiently high enough to warrant those R&D expenditures.

Page 252 PREV PAGE TOP OF DOC Segment 1 Of 7

The other issue, and in particular to what I spoke of in deepwater, is the risk issue. And I think this is one of the reasons that the deepwater is an attractive area for us in getting government support and co-funding with industry, is that is a very risky environment.

Now, some of you may recall the recent incident in Brazil, where the P–36 semi-submersible rig, at Roncador Field sank in the South Atlantic. That incident was of sufficient magnitude in cost that it would break a smaller oil company than Petrobras. The total cost of that incident will be somewhere between a half a billion to a billion dollars against Petrobras' bottom line.

So we have to balance both the risk of our research, but I believe we are increasing the spending in the industry right now. I know our company is. We have seen significant increases in R&D expenditures in the last two years. So that is a positive trend that we are starting to see.

Benefits Derived From Government R&D

Mr. **COSTELLO.** Thank you. Mr. Cuneo, I wonder if you were setting the priorities for fossil—the Fossil Energy Program at DOE what your priorities would be.

Mr. **CUNEO.** When we look at the downstream business, we would say that the first priority is on pre-competitive technologies. We are working with DOE in the area of industries of the future to try and get some pre-competitive work done in a number of areas. Those would include behavior of materials, novel approaches for removing contaminants from crude oil, such as metals, sulfur, nitrogen. Our basic position is that we would like to see DOE very actively involved with the pre-competitive work and then we believe that industry funding is adequate to take that to commercialization.

When we look at this whole question, we also go beyond DOE. I was President of the Coordinating Research Council, which is joint between the auto and the oils, and we find needs within EPA to step up funding for environmental models, such as airshed modeling and things like that. In the past few years, our joint consortium has funded some very basic research that, in my mind, was done mostly by universities, but would have been appropriate to have the public fund. Such as the behavior of aromatic components in the atmosphere, behavior of alkenes, behavior of alkanes. And we do a lot of work to validate models as they come out. And I would think that that ought to be a priority for EPA as they think about their funding to step up what they do to contribute to this broad area for society.

Mr. **COSTELLO.** A final question and then a comment, I guess, for the panelists, other than Mr. Kripowicz. The President has been criticized in his Administration for his energy proposal, that it is too heavy on oil and not enough in the area of alternative fuels. And I wonder if the four of you might want to comment. If you agree with the criticism that the Administration has received, that it is too heavy on oil and not looking at alternative fuels. Whoever would like to take a stab at that.

Mr. **CUNEO.** I would like to take a quick stab at part of that. I think in a lot of areas what that criticism ignores is the economic realities. The fact of life is that the American public wants to pay a relatively low price for energy. And when we look at some of the alternative technologies—and I was enjoying the discussion about—that we had in the previous panel around solar investment. When solar becomes the most economic choice for the investor to put their money to get a return, that is when we will see a lot more wind power. Until that time, what you will see is using available, relatively clean fuels, like natural gas. And so I think there is a lot of technology already developed in the alternative fuel area, but in general, most of the alternative fuels require public subsidy to get them commercial. And in many cases, that can go on for decades.

Mr. **COSTELLO.** Ms. Lazenby, any other comments?

Ms. **LAZENBY.** I would just like to say that I think that in the realm of enhanced oil recovery that the Administration has made a strong point that we should increase that. And I think that is a—that the footprint for that energy is already there and the technology that the Department of Energy can help us with would be very beneficial. And I think the Administration recognizes that we need additional fossil fuel energy and that we also need to focus on renewables. But I don't think he has overemphasized it in any way. It is going to be there. It is a large part of our energy base. And to ignore it, and to ignore how we can improve it, both in an environmental way, is—would be the wrong thing to do. So I think he is doing the right thing and I think working on renewables is—should be—also be funded, but we can't ignore the facts.

Mr. **COSTELLO.** Any—Mr. Huffman.

Mr. **HUFFMAN.** Well, I guess I would add to that that the challenge that we face right now is that we have under-invested in our energy infrastructure and supply for most of the last 20 years. And part of that is

because energy prices have been cheap. There has been less incentive. And we must find a balance that includes oil and gas, coal, all forms of electrical generation, including alternative fuels. And we must grow our energy base in all of those areas, keeping the proper balance with the environmental concerns, to supply the energy that the Nation needs. And that is not going to be a trivial exercise and it is going to require a national effort and all the stakeholders in energy are going to have to work together to achieve that. And that is something that has always been a challenge, but I think we have to overcome that challenge if we want to have a stable economy and society in the future.

Page 255 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **VAN KIRK.** I agree. And, furthermore, just speaking of enhanced oil recovery, many, many years ago, we started injecting fluids into reservoirs to increase recovery—water, gases, steam, chemicals, thick vicious polymers, to increase oil recovery. And one of the newer techniques that has been researched and developed and proven in recent years is CO injection—carbon dioxide injection for enhanced oil recovery.

Ms. **LAZENBY.** We are doing that right now.

Mr. **VAN KIRK.** And we would love to have more CO to put into the ground underground for improving the recovery and perhaps sequestering the CO underground.

Mr. **COSTELLO.** Mr. Chairman, I thank you and I thank our witnesses. For the record, I would like to state that our colleague on this Subcommittee, Congresswoman Sheila Jackson Lee, wanted to be here today. She is a member of this Subcommittee, but as most of you probably know, about half of her district is under water. So she is at home trying to help her constituents. But she did call and wanted us to let you know that she is sorry that she could not be with us today. Mr. Chairman, thank you.

Oil Well Life-Extension Technologies and Reserves

Chairman **BARTLETT.** Thank you very much. Ms. Lazenby, you mentioned that enhanced recovery could produce 60 billion barrels more oil. Was that just in this country?

Page 256 PREV PAGE TOP OF DOC Segment 1 Of 7

Ms. **LAZENBY.** Yes. There—yes. There are about 350 billion barrels of oil in place that have not been recovered from existing wells. And you—the 60 billion is the percentage that we think is attainable within—with enhanced oil recovery techniques that are either in place now or could be developed with additional research and development. And it has been proven—I think we just heard this morning about a project in California, and I have just told about mine—we can do it. And it is out of existing wells. And, for example, we are putting CO in addition to nitrogen into our wells now and we have already gotten good response from CO and nitrogen in our wells. So that is one place to put the nitrogen—I mean, the CO also.

So there are a lot of positive benefits to taking the resource base that exist in existing wells that have already been drilled, that are already there, that are now producing approximately—both oil and gas, approximately g of our oil and oil equivalent needs in this country. And with just a little bit of extra R&D

we can really keep the—keep a good source of energy coming.

Chairman **BARTLETT.** These are big numbers and it is useful to put them in perspective so that you can get some idea of what they mean. In terms of oil consumption, at present use rates, and we ought to preface every statement relative to use at present use rates, because use rates are going up and—but at present use rates, that is about a two-year supply for this country. And so that is a meaningful amount of oil.

Mr. **VAN KIRK.** Mr. Chairman——

Chairman **BARTLETT.** Some of you mentioned the petrochemical industry. Mr. Cuneo, you mentioned that, and, Dr. Van Kirk, you mentioned that also.

Page 257 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **VAN KIRK.** I think you might have misquoted some numbers. If you are talking about 60 billion.

Chairman **BARTLETT.** Yeah. That is about a two-year supply.

Mr. **VAN KIRK.** No. We consume about two billion in crude oil per year—or we produce about two billion barrels per year—we produce. We consume——

Chairman **BARTLETT.** Oh. I am talking about our consumption.

Mr. **VAN KIRK.** We consume——

Chairman **BARTLETT.** We consume about 20 million barrels a day; the world about 80. If you multiply that by roughly 400 days in a year, you are somewhere in the neighborhood of 30 billion barrels a year and 60 billion——

Ms. **LAZENBY.** He means for the country.

Chairman **BARTLETT.** Oh. Okay. You are right. But that is world supply.

Ms. **LAZENBY.** World supply. Right.

Chairman **BARTLETT.** Yeah. We are a fourth—that is eight years for us and——

Page 258 PREV PAGE TOP OF DOC Segment 1 Of 7

Mr. **VAN KIRK.** Right.

Chairman **BARTLETT.** Thank you for correcting.

Mr. **VAN KIRK.** You are welcome.

Chairman **BARTLETT.** That is eight years for us and two years for the world. Thank you.

Mr. **VAN KIRK.** You are welcome.

The Future of the Petrochemical Industry

Chairman **BARTLETT.** Okay. Thank you. Thank you. Two of you mentioned petrochemical industry. I think there is too little appreciation of how important oil and natural gas are in this petrochemical industry, which is very large, as you have pointed out. We live in a plastic world. Our clothes, our automobiles, much of our automobiles, the television in front of you there, the plastic cups here, the containers for the water, the laminate on top of the desk here—these are all made from oil. What will we do when natural gas and oil are in really short supply, essentially gone? Could we make these things from agricultural products? Mr. Cuneo.

Mr. **CUNEO.** I would like to respond that, Mr. Chairman. There is technology today to make all of the products from what we call syngas, which is a mixture of carbon monoxide and hydrogen. Syngas can be made from coal. And, in fact, coal gasification does that before it converts it to electrical generation. That technology of being able to make these building blocks is commercial today. We have been producing detergents from syngas for years. We have been producing other components from syngas. So what we really need is—it is more expensive, obviously, in terms of total capital and operating costs to do it that way versus using the building blocks which occur in petroleum. But the technology is available today to continue to produce our chemical building blocks through the syngas and Fischer-Tropsch type technology.

Page 259 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** Another by-product—another product made from this is nitrogen fertilizer. Today, essentially all of the nitrogen fertilizer is made from natural gas. Before we learn how to mimic what nature does in a summer thunderstorm, we got our nitrogen fertilizer from the barnyard or from guano, from bat caves and islands where birds have nested for thousands of years. So the food we eat is, in a very real sense, petroleum and gas that powered the farm machinery that produced it and produced the nitrogen fertilizer. And, by the way, without nitrogen fertilizer, productivity of food and fiber would be drastically, drastically reduced. In a very real sense, natural gas, particularly, and oil, secondarily, aren't they really too good to burn?

Mr. **CUNEO.** In many ways that is true. On the other hand, there is nothing that provides the economic transportation fuel for the country with the mobility that people want, especially in vehicle systems, than petroleum. It is the most cost-effective out there today. And when you look at the overall theme that I think this panel and the previous panel had, this country needs a good mix of energy sources, including things like coal for stationary power generation. We have a large installed capital base in the power plant. But just imagine trying to translate that to petroleum fuels or fuels to fuel a vehicle. It is——

The Extent of Worldwide Petroleum Reserves

Chairman **BARTLETT.** Let me ask the panel a question. Is there general agreement—we had a hearing several weeks ago on the available fossil fuel resources in the world. And there was general consensus that there is about a thousand giga-barrels of oil remaining in the world. That maybe if you are wildly optimistic

about recovery that you might get almost that much more by recovery. But that thousand giga-barrels is not forever. That translates to roughly 30 years of use at present use rates. And if you factor in increased use rates, maybe that which we will find, maybe the enhanced recovery will give us enough to make up for the increased use rates.

Page 260 PREV PAGE TOP OF DOC Segment 1 Of 7

The point I am trying to make is that we should—and I am trying to think of an analogy that really explains it. It is true that these fossil fuels are very cheap today. But those that are of high quality, gas, particularly, and oil, there is roughly 30 years remaining in the world. Just because they are cheap today, does that mean we should use them all today and let our kids and our grandkids worry about tomorrow? Certainly, they are cheap. But this is a finite resource that we need to husband and I don't see us addressing that consideration hardly at all in our energy policy.

A better way of looking at the energy policy is that it is a giant hide-and-go-seek game. That God knew how profligate we would be in the use of fossil fuels, so he hid a very large amount out there and our only challenge is to go find where he hid it. I think that a rational national energy policy needs to reflect the fact that these high-quality, readily available, cheap fossil fuels are not going to be there forever and we need to consider that in our national policy. Do you agree?

Mr. **VAN KIRK.** Certainly, it has to be—certainly, it has to be considered and forecasts have to be made naturally. And, certainly, we don't want to leave our children and grandchildren to suffer because of what we have done and wasted. Excuse me. But as was mentioned a few minutes ago, hydrocarbons—we humans have a lot of hydrocarbons in our bodies. Coal, oil, gas, trees, plants, animals—it is a very common substance on earth. And scientifically, we can make—we can convert one to the other and back and forth in the laboratory and in the field. Most of these transformations are not profitable and they are not useful. But some time in the future it may be that the price of a particular resource might be such that competition from other possibilities becomes profitable and reasonable and takes over. I see oil and gas being produced for another few hundred years, but not to fuel transportation. Something else will fuel transportation and we will enjoy oil and gas to make medicines and plastics, artificial things, synthetic things, as we have talked about earlier today.

Page 261 PREV PAGE TOP OF DOC Segment 1 Of 7

Chairman **BARTLETT.** But at the rate of their consumption today, we need to have a policy which husbands them or they won't be available for the next 2 or 300 years as a feed stock for the industries that mentioned.

Mr. **VAN KIRK.** I think the policy needs to be balanced in forecasting realistic futures.

Use of Petroleum By-products

Chairman **BARTLETT.** How good a job are we doing at using by-products? The better we do of using

by-products, the lower the cost of the ultimate fuel will be and the kinder we will be to our environment. Do we have an aggressive program to develop uses for these by-products?

Mr. **HUFFMAN.** I guess I will try and speak to that, Mr. Chairman. Our company, for example, has developed a carbon fiber technology that uses what we call the bottom of the barrel, the pitch that comes out of the refining process. And many other companies are pursing similar technologies that will use the parts of the barrel of oil that in the past have considered debris or waste. We are seeing, as was mentioned earlier, gas-to-liquids technology, which allows us to actually separate in the Fischer-Tropsch process some of the impurities and by-products and separate them into quantities that can be sold and delivered to markets.

So we are seeing the industry move in the direction of modifying the hydrocarbon molecule and utilizing all the parts of that molecule as efficiently as possible. And I think we will continue to see that trend in the next 20 or 30 years, hopefully to the point where we are not burning gasoline in cars anymore and we are seeing other types of fuels that are by products of the hydrocarbon molecule. And we are using the carbon for certain things, such as carbon fibers, and composite materials. And I think that would be a very wise use in the long term.

The challenge we face, as you pointed out in the first panel, is, how do you make that transformation quickly without disrupting the economy. And I think that is the balance that we have to keep in making those kind of transformations, working with government and industry together.

Proposed U.S. Energy Research Center

Chairman **BARTLETT.** Mr. Huffman, I would like to comment briefly on your suggestion for the USE Center, the U.S. Energy Center. We have been concentrating here in these two hearings this morning—these two panels this morning, on the availability internationally of gas and oil and somewhat on the availability here in this country. I would like to point to another dimension that makes your U.S. Energy Center even more needed. We have two percent of the known reserves of oil in the world. We consume 25 percent of the world's oil. This is clearly a prescription for disaster. At the time of the Arab Oil Embargo when we, in effect, went screaming into the night because of the problems that we were facing. We imported 35 percent of our oil. Today, we import 56 or more percent of our oil. From a national security viewpoint, we desperately need the kind of a center that you point to.

And freeing ourselves from our dependence on these high-quality fossil fuels, gas and oil, isn't just an economic consideration. It is a national security consideration. We cannot afford to be held hostage by the rest of the world because we produce so little of the oil that we use in this country. With only two percent of the known reserves in this country, we clearly face a very uncertain energy future. And I would concur with you that we need the equivalent of the national effort that we put into putting a man on the moon.

By the way, there are 200-and-some industries in Maryland alone that wouldn't be there if it weren't for the spin-off that came to that. No longer does government push the envelope. We now are buying most of the stuff we put in our space and our military equipment, we are buying it what we call COTS, commercial-off-the-shelf. And I would like to see an effort equivalent to putting a man on the moon to do something about energy. We face a very uncertain energy future worldwide. And particularly in this country, with having only two percent of the known reserves of oil, we face a very, very uncertain energy future that impacts our national security. And I think that should be reason enough to justify a center of that magnitude.

Let me recognize my colleague if he has additional questions or comments.

Mr. **COSTELLO.** Mr. Chairman, I do not. I thank the witnesses for being here today and I thank you for calling the hearing.

Chairman **BARTLETT.** I want to thank the witnesses. Thank you very much for your testimony. This has been a productive hearing, I think. And we will now be in adjournment.

[Whereupon, at 12:55 p.m., the Subcommittee was adjourned.]

THE PRESIDENT'S NATIONAL ENERGY POLICY: HYDROGEN AND NUCLEAR ENERGY R&D LEGISLATION, PART 2

THURSDAY, JUNE 14, 2001

Page 264 PREV PAGE TOP OF DOC Segment 1 Of 7

House of Representatives,

Subcommittee on Energy,

Committee on Science,

Washington, DC.

The Subcommittee met, pursuant to call, at 10:02 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Roscoe G. Bartlett [Chairman of the Subcommittee] presiding.

Next Hearing Segment(2)

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SPEAKER INDEX Segment 1 of 7 Next Segment (2)
CONTENTS INSERTS
ABEND 96 140 141 142 143 149 151 155 157
158 160 162 163 166
BARTLETT 37 46 74 85 96 111 134 137

140
144 147 151 154 155 156 158 161
165
166 167 177 187 190 214 247 255
256
257 258 259 261 262 263
BIGGERT 140 141 142 143 144
BOEHLERT 134 147 150 151 153
CHARLES COOKE 5
COSTELLO 43 134 135 137 158 159 160 247
248
249 250 251 252 253 254 255 263
CUNEO 177 252 253 258 259
EMISSIONS FROM CLEAN COAL AND CLEAN COAL ALTERNATI 151
HARLAN WATSON 5
HART 144 146 147
HOW DO WE MAKE THE FUTURE A REALITY 207
HUFFMAN 215 247 248 249 251 254 261
INTRODUCTION 191
KRIPOWICZ 47 135 136 137 138 140 145 152
153
154 155 159 163 164 165 250
LAZENBY 167 168 254 255 256 257
MEAD 111 138 143 154 160
REFERENCES 208
SMITH 46 138 139 140 162 163 164
TECHNOLOGY ADVANCES KEY TO CURRENT AND FUTURE SUPPL 192
TOM HAMMOND 5
TOM VANEK, KAREN KIMBALL, JOHN DARNELL 5
VAN KIRK 188 190 249 250 251 255 256 257
258
260 261
WELLS 86 146 159
WHAT THE FUTURE HOLDS 205
X 27 29 48 49 58 59 97 102
103
119 123 125 126 149 178 183
X 58 118
YAMAGATA 74 139 145 150 152 153 159 166

CONTENTS SPEAKERS INSERTS

STATEMENT OF ROBERT S. KRIPOWICZ, ACTING ASSISTANT SECRETARY FOR FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY

PAGE 47

STATEMENT OF BEN YAMAGATA, EXECUTIVE DIRECTOR, COAL UTILIZATION RESEARCH COUNCIL (CURC), WASHINGTON, D.C.

PAGE 74

STATEMENT OF JAMES E. WELLS, DIRECTOR, NATURAL RESOURCES AND ENVIRONMENT, U.S. GENERAL ACCOUNTING OFFICE

PAGE 86

STATEMENT OF KATHERINE ABEND, GLOBAL WARMING ASSOCIATE, U.S. PUBLIC INTEREST RESEARCH GROUP, WASHINGTON, D.C.

PAGE 96

STATEMENT OF JOHN S. MEAD, DIRECTOR, COAL RESEARCH CENTER, SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE

PAGE 111

STATEMENT OF VIRGINIA B. LAZENBY, CHAIRMAN AND CEO, BRETAGNE, GP, NASHVILLE, TENNESSEE, ON BEHALF OF THE INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA

PAGE 168

STATEMENT OF PAUL L. CUNEO, VICE PRESIDENT AND CHIEF INFORMATION OFFICER, EQUIVA SERVICES, LLC, HOUSTON, TEXAS, ON BEHALF OF THE AMERICAN PETROLEUM INSTITUTE

PAGE 177

STATEMENT OF DR. CRAIG W. VAN KIRK, PROFESSOR OF PETROLEUM ENGINEERING

AND HEAD OF DEPARTMENT OF
PETROLEUM ENGINEERING, COLORADO SCHOOL OF MINES, GOLDEN, COLORADO
PAGE 187

STATEMENT OF ALAN R. HUFFMAN, MANAGER, SEISMIC IMAGING TECHNOLOGY CENTER, CONOCO, INC., HOUSTON,
TEXAS
PAGE 214

INSERTS SPEAKERS CONTENTS