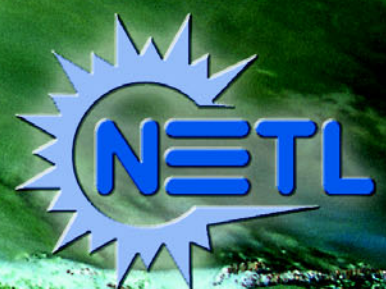
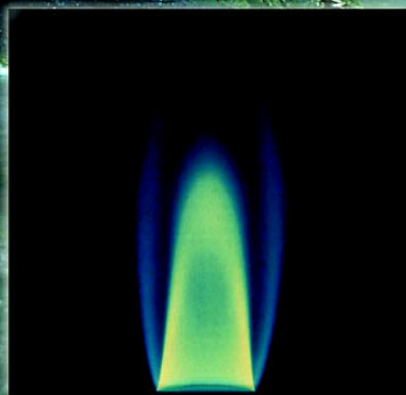


# National Energy Technology Laboratory Accomplishments FY 2001









**Rita A. Bajura**

Director  
National Energy Technology  
Laboratory

## Message From the Director

This was an eventful year for the National Energy Technology Laboratory (NETL). It was a year that reaffirmed the value of our work following the horrible terrorist attacks of September 11, 2001. It underscored the importance of energy research as a means to enhance national security. It demonstrated, once again, that technology development helps build a healthy environment, a strong economy, and a brighter future for our Nation and the world.

Shortly after President Bush was inaugurated in January 2001, his Administration began crafting a new energy policy. The *National Energy Policy* report was issued in May 2001. This 170-page plan urges action to meet five specific national goals:

- Modernize (increase) conservation efficiency,
- Modernize our energy infrastructure,
- Increase energy supplies,
- Accelerate the protection and improvement of the environment, and
- Increase our Nation's energy security.

The National Energy Policy includes 105 recommendations to promote dependable, affordable, and environmentally sound energy for the future; 46 of these involve fossil energy—our Nation's most abundant and affordable energy source and the focus of much of our work here at NETL. As the U.S. Department of Energy (DOE) fossil-energy research laboratory, we are charged with developing technologies to provide affordable energy without compromising the quality of life for future generations. Our portfolio of energy technologies includes coal-fired power generation; natural-gas-fired power generation, including fuel cells and combustion turbines; carbon sequestration; gas and oil production and transmission; and the production of clean liquid fuels for transportation and other end-use sectors.

To carry out our mission, we partner with industry, universities, other national and federal laboratories, private research organizations, and other federal and state agencies. We have about 1,300 active research, development, and demonstration activities at locations across the United States and in numerous other countries. We also conduct onsite research at our laboratories in Morgantown and Pittsburgh.

In addition to our fossil energy activities, NETL supports other parts of DOE. For example, we support the development and deployment of environmental technologies to reduce the cost and risk of remediating DOE's weapons complex. We support DOE's goal to use best business and management practices. We run our organization like a business and are accountable for the results.

This report describes our accomplishments during fiscal year 2001. It responds to the Government Performance and Results Act of 1993 by describing how we have spent taxpayer funds. Please take the time to look at this second annual accomplishments report. I believe the achievements speak for themselves.

Thank you,

A handwritten signature in black ink that reads "Rita A. Bajura". The script is fluid and cursive, with a large, stylized 'R' and 'B'.

Rita A. Bajura  
Director, National Energy Technology Laboratory

## **NTIS DISCLAIMER**



This document has been reproduced from the best copy furnished by the sponsoring agency.



# Contents

<b>4</b>	<b>Securing America's Energy Future</b>
<b>6</b>	<b>NETL—Who We Are</b>
<b>8</b>	<b>NETL's Contributions to America's Energy Future</b>
<b>10</b>	<b>NETL's FY 2001 Program Accomplishments</b>
<b>10</b>	Energy Resources (ER)
<b>22</b>	Science (SC)
<b>26</b>	Environmental Quality (EQ)
<b>28</b>	National Nuclear Security (NS)
<b>29</b>	Corporate Management (CM)

## Abbreviations

<b>CABE</b>	(NETL) Center for Acquisition and Business Excellence	<b>EQ</b>	environmental quality	<b>NETL</b>	National Energy Technology Laboratory
<b>CCPI</b>	Clean Coal Power Initiative	<b>ER</b>	energy resources	<b>NPTO</b>	National Petroleum Technology Office
<b>CFB</b>	circulating fluidized bed	<b>FE</b>	(DOE) Office of Fossil Energy	<b>NS</b>	national nuclear security
<b>CM</b>	corporate management	<b>FY</b>	fiscal year	<b>PJM</b>	Pennsylvania, New Jersey, Maryland Interconnection, LLC
<b>CRADA</b>	Cooperative Research and Development Agreement	<b>HEET</b>	High-Efficiency Engines and Turbines (program)	<b>R&amp;D</b>	research and development
<b>DDFA</b>	Deactivation and Decommissioning Focus Area	<b>IGCC</b>	integrated gasification combined-cycle	<b>RD&amp;D</b>	research, development, and demonstration
<b>DOE</b>	(U.S.) Department of Energy	<b>IOF</b>	Industries of the Future	<b>SC</b>	science
<b>D&amp;D</b>	deactivation and decommissioning	<b>ISM</b>	integrated safety management	<b>SCNG</b>	Strategic Center for Natural Gas
<b>E&amp;P</b>	exploration and production	<b>MMIP</b>	Minority Mentoring and Internship Program	<b>SECA</b>	Solid State Energy Conversion Alliance
<b>EIA</b>	Energy Information Administration	<b>MOU</b>	memorandum of understanding	<b>Tcf</b>	trillion cubic feet
<b>EMS</b>	Environmental Management System	<b>NASA</b>	National Aeronautics and Space Administration	<b>WIPP</b>	Waste Isolation Pilot Plant
<b>EPA</b>	Environmental Protection Agency	<b>NEP</b>	National Energy Policy		
<b>EPRI</b>	Electric Power Research Institute				

# Securing America's Energy Future

*“Our Nation must have a . . . broad, comprehensive energy strategy, that calls upon the best of the Nation’s entrepreneurs to help us develop the technologies necessary to make wise choices in the marketplace, as well as calls upon our Nation’s innovative technologies to help us find new sources of energy.”*

President George W. Bush, Remarks  
to Department of Energy employees,  
June 28, 2001

Early in 2001, the lights went out in California. Blackouts rolled through the State as electricity demand outstripped supply. Consumers were asked to conserve and they responded, switching off lights and appliances only to see their electricity bills soar. A common refrain for those sitting in the dark was, “Why is this happening, and what can be done?”

The blackouts emphasized the importance of energy to our quality of life. On January 17, 2001, the California Energy Commission provided tips on what to do in a blackout: if you use candles for light, be careful to avoid starting a fire; check on your elderly neighbors and those who may have medical conditions or use medical equipment that operates on electricity; and remember that traffic signals may be out and drive carefully.

The blackouts illustrated how critical energy is to our economic well being. The Electric Power Research Institute (EPRI), a non-profit energy research consortium, estimated that just 2 days of blackouts in January 2001 cost California businesses nearly \$2 billion in lost productivity. Federal Reserve Chairman Alan Greenspan warned at the time that prolonged energy troubles threatened not only the economic health of California, but also the economic well-being of the entire Nation.

While the reasons for California’s electricity crisis were unique, the consequences of the blackouts were not. Our lives are made richer by reliable, affordable energy. Interrupt the supply, or let the price of energy climb out of reach, and our lives are disrupted. We may not think very often about where energy comes from, but if it’s not available, we sure wonder where it went.

The knowledge that our efforts contribute to the well-being of our families, our communities, and our country drives the work we do here at the National Energy Technology Laboratory (NETL). As the U.S. Department of Energy (DOE), Office of Fossil Energy (FE) research laboratory, we develop technologies to use our abundant fossil resources more cleanly and efficiently. Our work helps to produce, transport, and use the energy you depend on, at prices you can afford, without harming our environment.

America’s economic engine is powered by fossil fuels. Coal, oil, and natural gas supply 85 percent of the Nation’s total energy, 68 percent of its electricity, and nearly all of its transportation fuels. It is estimated that fossil fuels will supply 87 percent of our Nation’s energy by 2020. America’s abundance of coal and natural gas, and the low costs of these fuels, are the main reasons why U.S. consumers benefit from some of the lowest energy costs of any free-market economy.

The technologies we have developed with our industry partners have made fossil fuels cleaner than ever before. New technologies have reduced waste, noise, and emissions; preserved water resources, habitats, and wildlife; and enhanced worker safety. Emissions that lead to smog, acid rain, and regional haze are mere fractions of what they were 30 years ago. The “footprint” for oil and gas wells—the land area required for drilling the well and producing gas and oil—is a tenth of what it was in the 1970s.

This report examines our accomplishments during fiscal year (FY) 2001 in energy supply, reliability, and affordability; our achievements in policy support and environmental issues; and our contributions to best business practices within DOE. We discuss our accomplishments in sections that match DOE performance goals and our business lines: energy resources, science, environmental quality, and national nuclear security. We also discuss corporate management goals, which support our business lines.

We are inspired by what we do, and excited to share the results with you. We want you to know what we are doing to secure America's energy future by providing reliable, affordable, clean energy.



*“Energy impacts our quality of life. Energy impacts our environment. Energy has a profound impact on our economy. Energy has a profound impact on all aspects of [our] lives.”*

Rita A. Bajura, NETL Director, Speech at 6th Natural Gas Conversion Symposium, Girdwood, Alaska, June 17-22, 2001



# NETL—Who We Are

*“In the last 20 years, . . . employees at this center [NETL] . . . have been responsible for roughly \$4 billion of clean-coal research, development, and demonstration. [This translates to] more than \$100 billion of benefits to the U.S. economy, if we project forward through the year 2020. These benefits are in terms of cleaner air, lower electric bills, and a greater energy security . . .”*

Spencer Abraham, Secretary of Energy,  
Remarks during his visit to NETL,  
March 1, 2001

NETL is the fossil energy laboratory for DOE, providing expertise in fossil energy supply, delivery, and end-use technologies. Our *mission* is to (1) resolve the environmental, supply, and reliability constraints of producing and using fossil resources; and (2) support the development and deployment of environmental technologies to clean up DOE’s weapons complex. Our *vision* is to be the preferred provider of energy technology and policy options that benefit the public.

The history of NETL dates back to 1910 when the mission was to train coal operators and miners and to develop innovative coal-mining safety equipment and practices. Then in the 1940s, the mission incorporated synthetic fuel development, and by the mid-1970s, the organization began managing contracted research work.

In the 1990s, NETL’s focus expanded to include work in environmental remediation as a constructive approach for cleaning up DOE sites that contained radioactive, chemical, and other hazardous wastes left behind after 50 years of nuclear weapons production.

In 1996, the fossil energy research centers in Pittsburgh, Pennsylvania, and Morgantown, West Virginia, merged under single management to become the Federal Energy Technology Center. In 1999, the center was elevated to national laboratory status and renamed the National Energy Technology Laboratory, becoming DOE’s 17th national laboratory. A Strategic Center for Natural Gas (SCNG) and six onsite research focus areas were created. In 2000, the National Petroleum Technology Office (NPTO) in Tulsa, Oklahoma, became part of NETL.

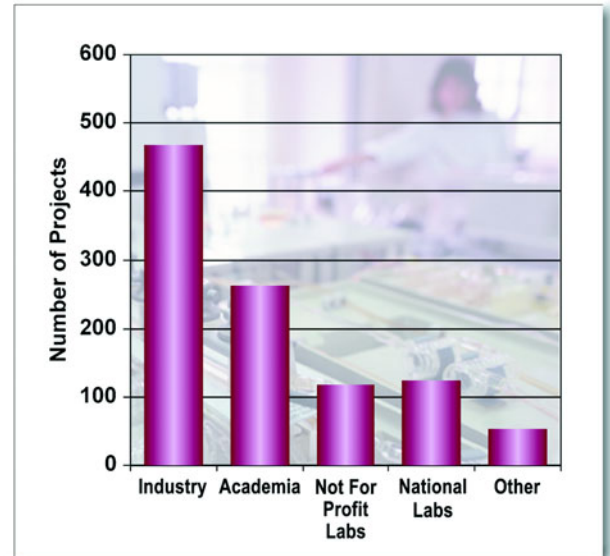
Today, NETL’s contracted programs comprise over 1,000 joint government-industry projects in all 50 states. These projects are carried out through various contracting arrangements with corporations, small businesses, universities, and other national laboratories and government agencies.

As a federal organization, NETL does not compete with its partners to commercialize technologies; our partnerships support research, development, and demonstration (RD&D) programs that lead to commercialized products and services for the American public. Early in the RD&D process, these partnerships can benefit from intellectual contributions and cost-sharing with the private sector, bringing about a better understanding of end-user needs and providing an intrinsic technology-transfer mechanism to accelerate the deployment of new technologies in the marketplace.



**FY 2001: Shaping, Funding, and Managing Contracted RD&D**

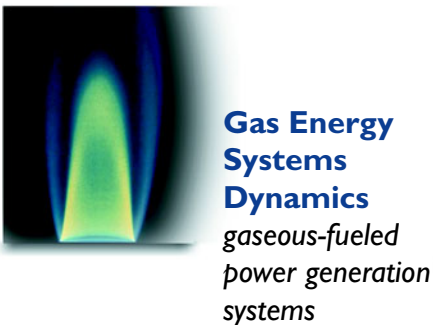
- 1,300 research activities in all 50 states and with 26 countries.
- Total award value of \$7.4 billion.
- Private-sector cost-sharing of \$3.8 billion.
  - Leverages DOE funding,
  - Ensures relevance, and
  - Helps achieve commercialization.
- 58 active memoranda of understanding or agreement.



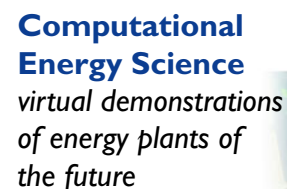
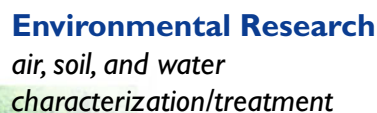
FY 2001 Contracted RD&amp;D

**FY 2001: Conducting Onsite Science and Technology Research**

- Corporate research and development (R&D) function for DOE FE.
  - Long-range exploratory research, and
  - Enabling science for energy technologies.
- Research laboratories at Morgantown and Pittsburgh.
- Involves one third of NETL's federal staff.
- Key integration facilities for university collaboration.
- Focal point for regional scientific initiatives.
- 22 active CRADAs.
- Technical leadership to support program development.



**NETL's  
Six Onsite Research  
Focus Areas**



# NETL's Contributions to America's Energy Future

*“My Administration is committed to cutting our Nation’s greenhouse gas intensity—how much we emit per unit of economic activity—by 18 percent over the next 10 years. [This] . . . will prevent over 500 million metric tons of greenhouse gases from going into the atmosphere . . . the equivalent of taking 70 million cars off the road.”*

President George W. Bush, Address at National Oceanic and Atmospheric Administration, February 14, 2002

U.S. coal-fired electric utilities have a remarkable legacy of success in reducing emissions.

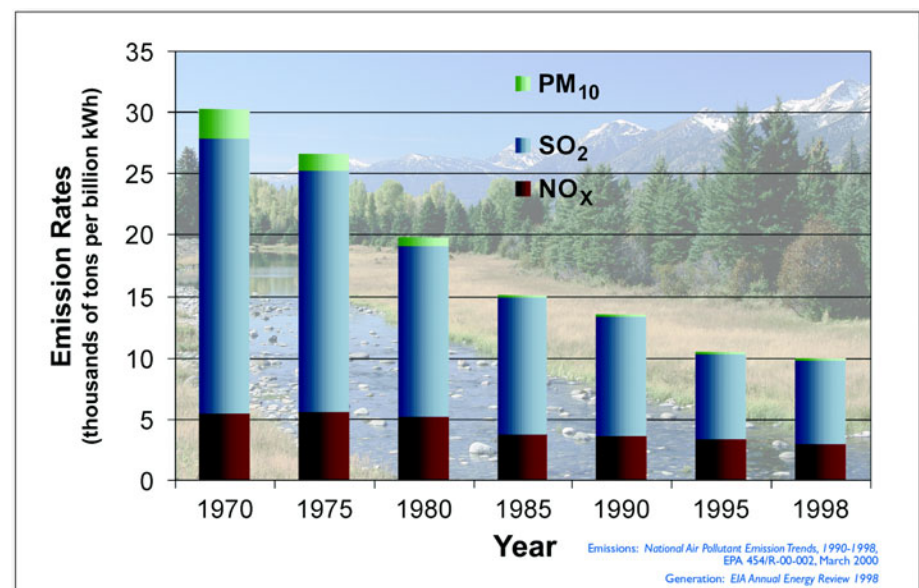
The Federal Government’s investment in fossil energy continues to pay dividends. Technological advancement, driven in large part by DOE’s partnerships with industry, is one reason why Americans continue to benefit from relatively low energy costs compared to those in the rest of the world. This is one of NETL’s major contributions to America’s energy future.

New technologies have led to remarkable progress in reducing the amount of pollutants emitted by fossil-fuel-fired power plants. For example, since 1970, emissions of sulfur and nitrogen pollutants from the average U.S. coal-fired power plant have declined by 70 percent and 45 percent, respectively. This has enabled coal use to more than double while allowing the United States to meet its clean air objectives.

NETL’s products include many diverse technologies:

- Fluidized-bed combustors that capture sulfur inside the combustion chamber—now sold by every major boiler manufacturer,
- Low-nitrogen oxides (NO<sub>x</sub>) burners—now found in 75 percent of the Nation’s coal-fired power capacity,
- Gasification combined-cycle power systems—now operating in Florida and Indiana,
- Ultrahigh efficiency gas turbines—being installed at a power plant in New York, and
- Fuel cells—being demonstrated at many sites across the country.

Technological advances have resulted in today’s “footprint” for oil and gas wells (the land area required for drilling the well and its completion if the well is successful) being one-tenth the size of wells drilled in the 1970s. Better detection and drilling tools have nearly doubled success rates in finding new oil and gas supplies, resulting in fewer dry holes and less environmental disturbance. Oil fields that would have been abandoned in Utah and Kansas continue to operate because of improved technology demonstrated in DOE’s



programs. Cooperation between DOE and the private sector in developing horizontal drilling helped to revitalize oil fields in Michigan and gas production in the Rocky Mountains. "Secondary gas recovery" development has done the same for gas fields in South Texas and the Midwest.

Many of the major accomplishments cited in this summary have translated directly into measurable energy, environmental, and economic benefits:

- **Increasing Producible Gas Resources.** DOE-industry partnerships in developing advanced technologies have added more than 100 trillion cubic feet (Tcf) of producible gas resources, resulting in increased production while adding to our proven natural gas reserve base. These gains span several types of gas resources—tight gas formations, coalbed methane, and mature producing fields; and represent a wide spectrum of geographic locations—the Rocky Mountains, the Midwest, and the Gulf of Mexico. DOE committed to R&D for coalbed methane and gas production from shale when it was too risky to attract industry support. Our program helped develop technologies so that today, coalbed methane and gas from shale provide about 7 percent of domestic gas production.
- **Oil and Gas Economic and Energy Benefits.** Projected cumulative benefits that will result from NETL's oil and natural gas technology programs between now and 2020 are
  - Over 2.4 billion barrels of incremental oil production—0.7 billion barrels or 29 percent of this from federal lands,
  - Approximately 57 Tcf of incremental gas production—23 Tcf or 40 percent of this from federal lands,
  - Savings of \$60 billion in environmental compliance costs,
  - \$26 billion in incremental federal tax revenues,
  - \$5 billion in incremental state tax revenues, and
  - \$9 billion in revenues for royalties on production from federal lands.
- **Fluidized-Bed Technology.** DOE's investment in fluidized-bed technology has resulted in every major U.S. boiler manufacturer offering this cost-effective method for burning virtually any low-grade fuel, while reducing the amount of air emissions. In Pennsylvania alone, from 1990 to 2000, fluidized-bed combustors reduced the costs of producing electricity by nearly a quarter of a billion dollars by burning waste coal cleanly.
- **Advanced Turbine Systems.** The Advanced Turbine Systems government/industry partnership produced a new generation of high-efficiency turbines, and the first commercial order has been booked. Turbines delivered through 2005 are expected to save consumers more than \$8 billion over the systems' 30-year life.
- **Selective Catalytic Reduction.** Federal investment in selective catalytic reduction, a technology for reducing NO<sub>x</sub> emissions from power plants, has reduced the costs of this technology by nearly 50 percent, translating to a savings of more than \$17 billion over the lifetime of units installed through 2005 across the United States.

## Outcomes From NETL's Programs

### Technology

Assists in providing the United States with acceptable, affordable, and available energy in the mid to longer term.

### Policy

Positively impacts the development of sound energy policies.

### Competitiveness

Helps maintain the technological competitiveness of the U.S. energy industry.

### Stability

Appropriately transfers technology to developing countries to improve geopolitical stability and reduce global climate change.

### Work Force

Provides a trained energy work force through university research programs.

### Region

Promotes regional economic development.



# NETL's FY 2001 Program Accomplishments

*“Societies will, of course, wish to exercise prudence in deciding which technologies . . . are to be pursued and which not. But without funding basic research, without supporting the acquisition of knowledge for its own sake, our options become dangerously limited.”*

Astronomer Dr. Carl Sagan  
(1934-1996)

## Fossil Fuels Today

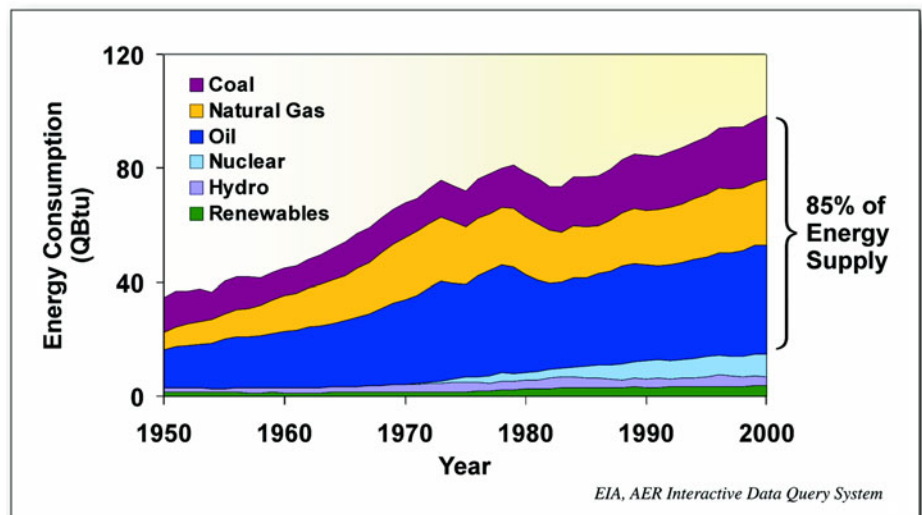
- Provide 85% of U.S. energy,
- Are projected to provide 87% of U.S. energy in 2020,
- Should last throughout this century, and
- Have an infrastructure for low-cost delivery.

The goals of DOE are to advance the Nation's energy, environmental, economic, and national security. According to DOE's *Annual Performance Plan for FY 2002*, goals are accomplished within DOE's four-business-line framework: Energy Resources, Science, Environmental Quality, and National Nuclear Security. The business lines are supported by Corporate Management, which comprises environmental, safety, and health issues; good business practices; and communication and trust.

The objectives used to determine NETL's FY 2001 accomplishments are based on objectives contained in DOE's *Annual Performance Plan for FY 2002*. More specifically, within each of the four business lines, there are specific objectives, measurements, and strategies for achieving DOE's goals. NETL plays an important role in ensuring that DOE meets those objectives.

**Energy Resources (ER)—Promote the development and deployment of energy systems and practices that will provide current and future generations with energy that is clean, reasonably priced, and reliable.**

NETL's vision is to be a recognized national leader in fossil energy technologies, providing technology and policy options to ensure that the United States has a reliable, affordable, and environmentally sound energy supply. This means reducing the vulnerability of the U.S. economy to energy-supply disruptions; ensuring that competitively priced electricity is available; increasing the efficiency and productivity of energy use; supporting U.S. environmental, energy, and economic interests in a global market; and carrying out information collection, analysis, and research.



**ERI—Promote reliable, affordable, clean, and diverse domestic fuel supplies.**

**Reservoir Class Revisit Program**—The Reservoir Class Revisit program, which began in 1998, was designed to revisit the first three oil reservoir classes that address new technology applications in different regions of the country. The purpose was to exploit the knowledge and developments already made by the program; the original projects are now mature enough to permit such evaluation. These projects show near-term benefits, but the benefits are compounded with time and often occur after the projects expire. The success is the technology transfer and the applications of these technologies across the resource base.

During FY 2001, DOE FE awarded 10 projects from 27 submitted proposals under the Revisit program. DOE funding was \$23 million, and the industry cost share was \$46 million. The following demonstrations, when applied to other oil fields, could mean economical recovery of up to 4 billion barrels of oil.

- The Pru Lease project turned an abandoned lease into a million-barrel producer. This California oil field was brought back to life using advanced seismic and steam-flooding technologies.
- Continuous carbon dioxide (CO<sub>2</sub>) injection and gravity drainage in the naturally fractured Spraberry Trend was effectively demonstrated. Improved waterflood techniques were used.
- The Lost Hills Field, California, project shows a tenfold increase in oil production using CO<sub>2</sub> injection. Core/fluid analysis, borehole imaging, nuclear-magnetic-resonance logging, numerical simulation, and cross-well seismic techniques were used to characterize the reservoir.
- In the West Texas East Ford field, the CO<sub>2</sub> flooding project showed that good reservoir characterization can lead to successful applications. Results so far show that oil production has increased sixfold using these technologies.
- Good results were achieved in a new horizontal drilling program in a New Mexico underdeveloped Delaware formation.

**Stripper Well Consortium Technologies**—NETL established an industry-driven, national stripper well consortium focusing on technology issues related to low-producing oil and gas wells (called stripper wells) that are predominantly owned and operated by small independent producers. Over 190,000 stripper gas wells and 419,000 stripper oil wells exist, contributing roughly 8 percent and 27 percent of the total conterminous U.S. gas and oil production, respectively. The purpose of the selected projects is to develop technologies to improve the production performance of stripper oil and gas wells. The projects have ties to ten states covering the Appalachian, Southwest, and Rocky Mountain regions of the United States.



A horsehead pump is used to extract crude oil from a well. This type of pump can lift oil 10,000 feet or more.



NETL provides cooperative support to smaller independent companies to develop new or improved technologies.



Research has reduced the costs of drilling by reducing the size of the footprint required.

*“We need to focus on programs that help America increase its supply of energy by increased domestic production; that help us identify a wider array of not only the types of sources of energy, but also the geographic sources of energy.”*

Spencer Abraham, Secretary of Energy,  
Remarks at Quarterly Leadership Meeting,  
DOE, October 2001

**Natural Gas Exploration and Production R&D**—Exploration and production (E&P) R&D is lowering the cost of gas that is being produced from increasingly more difficult and complex geological formations. NETL selected two projects in August 2001:

- The first project will develop a high-speed method of transmitting data from the bottom of a wellbore through the drill string to operators at the surface.
- The second project will resolve one of the primary impediments to obtaining high-resolution, three-dimensional images of deep and complex gas reservoirs.

NETL selected two other firms in August 2001 to develop advanced methods for locating and producing low-permeability gas reservoirs:

- One project will develop a three-dimensional model that will give gas producers valuable information on where gas “sweet spots” are located.
- The second project will improve the performance and lower the cost of hydraulic fracturing—where water is injected under high pressure to open fractures in dense sandstone rocks, which frees trapped gas.

**Diagnostics and Imaging Needs Identified**—NETL hosted a collaborative Diagnostics and Imaging Workshop in Houston, Texas, on February 27 and 28, 2001. The purpose was to gather government and industry input on diagnostics and imaging needs for oil and gas R&D. NETL analyzed the workshop results and formulated a solicitation for collaborative resolution of critical R&D needs.

**Natural Gas Infrastructure**—A secure and reliable U.S. natural gas distribution, storage, and transmission infrastructure is essential to continued availability of clean, affordable energy. Demand growth means that the existing infrastructure must be significantly expanded at considerable capital investment. NETL-sponsored vision and road-map workshops with industry during the summer of 2000 brought new focus to advanced technology needs.

In May 2001, the first set of 11 industry infrastructure projects was selected to develop high-tech ways to improve the safety and performance of the Nation’s gas delivery system. Included in the array of innovations are new types of miniature robots and other sophisticated detection devices that can pinpoint leaks or corrosion in both the large gas transmission lines that crisscross the country and the smaller distribution lines that deliver gas to homes and businesses. As examples, one project will develop an automated warning system to prevent nearby digging from damaging buried pipelines, and another will study how a natural pepper extract might prevent a pipeline from corroding.



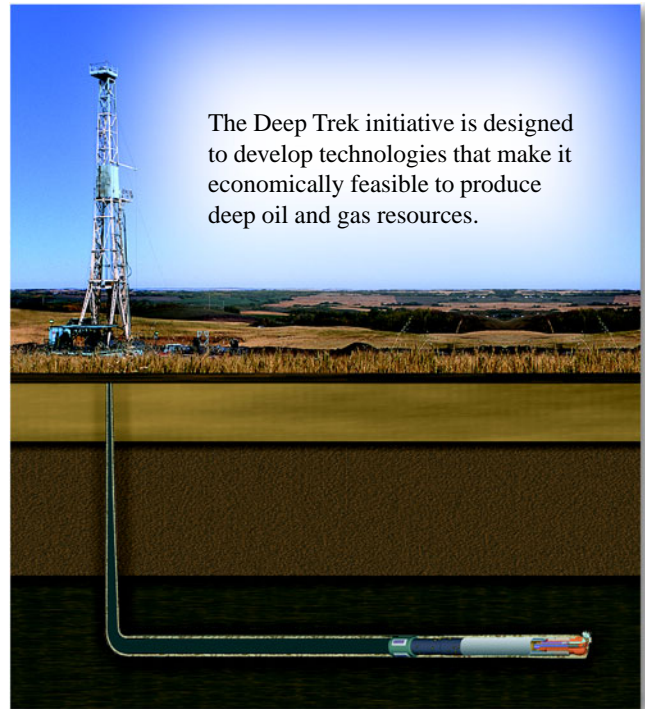
**Deep Drilling**—A Deep Trek Workshop held in March 2001 in Houston, Texas, was cosponsored by Sandia National Laboratories. Industry presenters detailed their needs for an R&D program. The workshop produced an R&D road map for advanced smart drilling systems, drilling and completion fluids, completion-based well design, and drilling diagnostics and sensor systems. NETL formulated a solicitation that will likely result in collaborative efforts to develop the technologies necessary to reduce drilling costs and enhance the economics of deep hydrocarbon resources.

**Clean Fuels**—NETL completed a long-duration synthesis gas conversion test at the DOE-owned LaPorte, Texas, Alternative Fuels Development Unit for production of advanced ultraclean fuels to be used in engine testing. This joint government-industry effort represents the first step and a significant milestone in opening the facility to technology developers who wish to fund 100 percent of the operation costs.

The Ion Transport Membrane Syngas project will develop and demonstrate a ceramic membrane reactor from laboratory- to pre-commercial-scale. The novel syngas reactor separates oxygen from air and then delivers the oxygen for use in partially oxidizing methane to a synthesis gas (carbon monoxide and hydrogen) in a single step.

- This technology can then be coupled with a Fischer-Tropsch reactor for subsequent conversion to environmentally friendly, liquid, transportation fuels.
- Successful development of this technology could result in a 25- to 30-percent reduction in liquid production costs over conventional technologies.
- This technology can be used for economic recovery of more than 30 Tcf of stranded Alaska North Slope gas.

Laboratory-scale tests of thin film membranes demonstrated oxygen fluxes that could achieve greater than 30 percent in capital cost savings with the syngas system compared to a conventional oxygen-blown auto-thermal reformer. To further develop and verify the performance capabilities of the processing system, construction of a 24,000 standard-cubic-feet-per-day process development unit was completed and commissioning was initiated.



*We must ensure “. . . our energy security by strengthening our ability to identify and protect the critical infrastructure that supports the production and delivery of energy in America.”*

Spencer Abraham, Secretary of Energy,  
Remarks at Quarterly Leadership Meeting,  
DOE, October 2001



Methane Burning From Hydrates

Estimates are that in-place gas hydrate resources in the United States are two to three orders of magnitude greater than conventional natural gas resources.

*“In the United States, at least, increasing amounts of unconventional resources will be needed to meet demand growth. Where will we get this gas, and at what cost? Will there be enough affordable natural gas to meet demand? If we in the research community are successful in developing cost-effective technology to produce methane hydrates, they will become conventional. Post 2020, we believe they could start to make an important contribution to [our] gas supply.”*

Rita A. Bajura, NETL Director, Speech at First Meeting of the International Committee on Methane Hydrates, Honolulu, Hawaii, March 7, 2001

**Methane Hydrates**—Methane hydrate R&D program activities were expanded. Estimates are that in-place gas hydrate resources in the United States are two to three orders of magnitude greater than conventional natural gas resources.

- A panel of experts from industry, academia, and the Federal Government now advises DOE on potential applications of methane hydrates, assists in developing recommendations and priorities for the national methane hydrate program, and assists in reporting results and progress of the program to Congress.
- As part of the effort to foster communication among the partner organizations and others involved in methane hydrate R&D, NETL launched a national methane hydrate R&D website, and distributed the inaugural issue of a methane hydrate newsletter.
- NETL selected six new projects in October 2001 valued at almost \$48 million to determine whether hydrates are tomorrow's new gas frontier, or a dangerous foe for future drillers. Drilling and producing hydrates may well pose enormous challenges: as hydrates dissociate into water or ice and methane, instabilities can be created within the sea floor or the wellbore. These projects are exploring technologies to locate and either avoid or deal with potential problem areas associated with hydrate production.
- NETL scientists made engineering calculations to address sea-floor stability issues related to gas hydrate recovery. Laboratory measurements were made for the first time on equilibrium properties of gas hydrate rock. These measurements are critical to improving the accuracy of field-test simulations. This NETL research group is interacting with more than 50 government, university, and private sector firms.
- NETL cosponsored a methane hydrates exploration-sampling cruise from July 2 to 19, 2001, in the Gulf of Mexico. Texas A&M University used a new drill unit, the “hydrate microdrill,” on a submersible vehicle called the Johnson Sea Link to collect hydrate samples from the sea floor.

## **ER2—Promote reliable, affordable, and clean transformation of fuel supplies into electricity and related products.**

**Gasification Technologies**—NETL and DOE FE, in partnership with the Environmental Protection Agency (EPA), the Gasification Technologies Council, and the Southern States Energy Board, conducted technical workshops to improve the understanding of state and federal regulations, the environmental attributes of gasification technology, and critical technical and environmental performance data. The purpose was to facilitate the permitting process for gasification-based plants. In addition, NETL held 22 meetings with key stakeholders. These meetings provided significant input to the direction of the Gasification Technologies R&D program, and helped to stimulate future commercial interest in the technologies.

**Advanced Materials for the Repowering Market**—NETL, working with U.S. utility boiler makers, EPRI, and the State of Ohio coal program, successfully formed a team of government and industrial corporations to develop materials for supercritical power systems. The goal is to develop advanced materials to extend the supercritical boiler operating range to as much as 1,600 °F, and to have 50- to 55-percent efficient supercritical systems available for repowering by 2008 to 2010. Since virtually pollution-free Vision 21 energy plants are not scheduled to be on-line until after 2015, plants that use advanced materials are needed during this interim period.

**Circulating Fluidized-Bed (CFB) Combustion**—DOE's investment in fluidized-bed technology has resulted in the successful completion of the design phase of Jacksonville Electric's 300-megawatt electric, CFB combustion plant. Construction is essentially complete and commercial operation using coal is expected by mid to late FY 2002. This plant will be the largest CFB unit in the United States and one of the world's cleanest coal-fired plants with ultralow NO<sub>x</sub> emissions at 0.09 lb/million Btu.

**Computer Modeling**—NETL researchers predicted non-isothermal flow patterns in the filter vessel at the Power Systems Development Facility in Wilsonville, Alabama, and conducted cold-flow tests of several configurations, which assisted in successful operations at the facility. Researchers used a computational fluid dynamics code to simulate coal-biomass combustion and validated the code with onsite data.

**Power Plant Improvement Initiative**—As a follow-on to the Clean Coal Technology Demonstration program, eight projects were selected under the Power Plant Improvement Initiative. Of the projects selected, five were technologies aimed at reducing power plant emissions, two were chosen to improve advanced process controls, and the final project will examine the problems of waste handling and disposal. These projects have a total value in excess of \$110 million, including the DOE share of about \$55 million.

**Clean Coal Power Initiative**—NETL planned for a government-industry partnership to implement the National Energy Policy (NEP) goal of producing increased electric power from coal. This partnership, called the Clean Coal Power Initiative (CCPI), will fund commercial-scale demonstrations of technologies to ensure the reliability of the Nation's energy supply from existing and new electric generating facilities. The CCPI will complement core R&D, carbon sequestration, and other programs to ensure that the United States can continue to enjoy the economic benefits that derive from coal remaining as a viable energy resource well into the 21st century. Two billion dollars is expected to be applied to the Initiative over the next 10 years. The ultimate goal is reduction of emissions, increased efficiencies, lower costs, and improved reliability of our Nation's electricity supply system.

The CCPI will fund commercial-scale demonstrations of technologies to ensure the reliability of the Nation's energy supply.

*“Public opinion is increasingly linking mining with end-use in power plants. [But] for coal-fired power plants, since 1970, SO<sub>2</sub> emissions are down by more than two-thirds, NO<sub>x</sub> emissions are down by almost half, and particulate emissions are less than one-tenth of 1970 levels. This technological progress will enable coal use [for electricity] generation to triple between 1970 and 2005.”*

Rita A. Bajura, NETL Director, Speech at Mineral Economics and Management Society Tenth Annual Conference, Pittsburgh, Pennsylvania, April 4-6, 2001





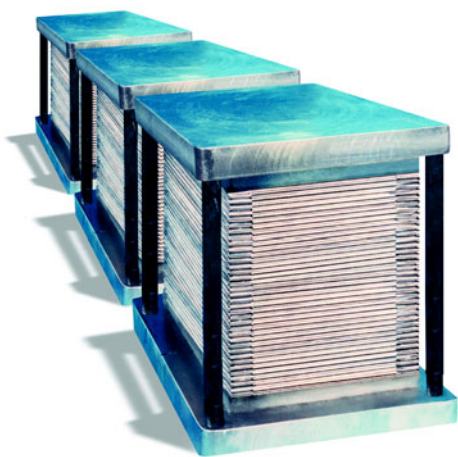
**High-Efficiency Engines and Turbines Program**—NETL completed a report to Congress for the High Efficiency Engines and Turbines (HEET) program. This program is key to achieving the NEP goal of a secure, reliable, and affordable source of electricity. The HEET program uses science and technology to advance four fundamental technology elements: advanced systems analysis, and simple/combined-cycle, hybrid-cycle, and technology-base development. To accomplish these goals, R&D will be performed in five major areas: materials, combustion, aero-thermal technology, instrumentation/condition monitoring, and design tools. The program will infuse technology into advanced power systems such as Vision 21 and fuel-cell/turbine hybrids.

Numerous advanced turbine R&D projects supportive of the HEET program and Vision 21 objectives were selected over the past year. Four R&D projects were selected in August 2001 to extend the life and improve the operations of advanced gas-fired turbine systems:

- Two projects will focus on protecting turbine components from erosion at the high temperatures at which modern-day gas turbines operate.
- Two projects will study ways to improve the stability and performance of turbines, also with a goal of lengthening their useful operating life.

**Power Engineering “Project of the Year”**—NETL received the “Project of the Year” award from *Power Engineering* magazine at the Power-Gen conference in December 2001 for the Advanced Turbine Systems program. This is the first time DOE has won this award for one of its R&D activities. The award cites the joint government-industry development effort that began in 1992 and culminated recently in the commercial introduction of a new generation of advanced utility-scale turbine systems.

**Fuel-Cell/Turbine Hybrids for Distributed Generation**—Two of the best technologies for distributed generation are the fuel cell and the microturbine—but an even better approach may be a hybrid of both technologies. Two types of fuel-cell/turbine hybrid were being tested in spring 2001. A third hybrid system was added to the R&D program, which contains a Honeywell flat planar design that may offer greater power density—that is, more kilowatts of power per cubic inch of material. In December 2000, two advanced technology R&D projects were selected to develop a new gas-turbine combustion system and a Smart Power Turbine sensor-and-control system.



Fuel cells are one of the most promising new distributed generation technologies for meeting the Nation's energy needs.

**Fuel Cells**—Fuel cells are one of the most promising new distributed generation technologies for meeting the Nation's energy needs well into the 21st century. NETL and FE are sponsoring the development and demonstration of several advanced fuel cells. Because fuel cells don't rely on combustion and operate much more efficiently than traditional power plants, they release 25 to 50 percent less heat-trapping CO<sub>2</sub> than today's natural-gas- or coal-fired power generators. The NETL-managed portfolio of currently active or recently completed fuel cell installations consists of 68 phosphoric acid units, 48 proton exchange membrane units, 4 molten carbonate units, and 3 solid oxide units. These demonstrations are effectively stimulating a major expansion in the U.S. fuel-cell manufacturing capability.

FuelCell Energy, Inc., completed over 11,000 hours in validation and endurance testing of a 250-kilowatt (kW) Direct FuelCell®. In November 2001, the company announced a 50-MW-per-year production capability in fuel cells at the company's new manufacturing facility in Torrington, Connecticut.

***Solid State Energy Conversion Alliance (SECA)***—SECA comprises commercial developers, universities, national laboratories, and government agencies. The purpose is to develop the all-solid-state fuel cell concept. NETL and the Pacific Northwest National Laboratory in Richland, Washington, are the driving forces behind SECA. The goal is to cut the costs of fuel cells to as low as a tenth of the cost of currently marketed systems and to only a third of the cost of the more advanced concepts now beginning to reach commercial readiness. At \$400/kW or less, these future fuel cells could find widespread market acceptance well beyond the niche applications of today's systems. In FY 2001, efforts began under SECA to develop the 5-kW solid-state fuel cell. Four industry teams were selected in August 2001 to initiate SECA efforts, which should lead to the wide deployment of fuel cell technology into every energy sector.

***Ambient Air Sampling for Particulates***—Scientists collected and analyzed a year's worth of tiny particulate (PM<sub>2.5</sub>) ambient air samples in the Pittsburgh, Pennsylvania, area. They developed methods for identifying the sources of fine particles based on specialized analytical chemistry techniques. NETL researchers correlated release of metals by coal combustion byproducts to mineral content, and developed a batch-leaching test for these byproducts. As part of the Upper Ohio River Valley Project, NETL delivered 2 years of high-quality PM<sub>2.5</sub> ambient monitoring data to the EPA Office of Air Quality Planning and Standards. This research project responds to the 1997 PM<sub>2.5</sub> National Ambient Air Quality Standards. The purpose is to better understand the relationship between emissions from coal-based power systems and air quality.

***Carbon Sequestration Science***—NETL held national and regional workshops on carbon sequestration technology and started a one-of-a-kind high-pressure water tunnel for studies of CO<sub>2</sub> sequestration in deep ocean environments, including gas hydrate phenomena. NETL conducted experimental and theoretical estimates of the parameters needed to stabilize drops of CO<sub>2</sub> in sea water. New discoveries of monoethanolamine degradation pathways will improve CO<sub>2</sub> capture by reducing losses of expensive makeup chemicals. New fundamental insights and physics-based models of carbon sequestration flows in porous rock were developed that will improve reservoir simulations. Basic laboratory information was developed on interactions of CO<sub>2</sub> with coals that will be used in models to support field-testing of coalbed sequestration.

- NETL funded three multi-national projects to study (1) CO<sub>2</sub> capture and storage, (2) terrestrial sequestration, and (3) storage of CO<sub>2</sub> in oil reservoirs. The projects will provide much needed data for development of full-scale demonstrations as well as models to adequately address the safety, monitoring, and verification of sequestration approaches.
- Initial results in NETL onsite R&D sequestration activities were showcased at the First National Conference on Carbon Sequestration, sponsored by NETL and held in Washington, D.C., in May 2001. This conference provided a forum for technical exchanges on the new, groundbreaking approaches to capturing and sequestering greenhouse gases associated with energy production and utilization that are being conducted at NETL and throughout the world.

***Multi-Pollutant Control Strategies***—NETL developed a portfolio of advanced affordable emissions control technologies in response to emerging multi-pollutant control strategies. The technologies being developed include systems to reduce mercury and NO<sub>x</sub> emissions from coal-based power systems. NO<sub>x</sub> technologies are focused on achieving emission levels of 0.15 lb NO<sub>x</sub> per million Btu at three-fourths of the cost of selective catalytic reduction. NETL researchers are conducting first-of-a-kind field testing of mercury controls capable of 50- to 70-percent mercury capture at half the cost of current technology. In addition, NETL is developing six new mercury control concepts that potentially can reduce mercury by 90 percent and that would be available for commercial-scale testing around 2010.



*“As a country, we have demanded more and more energy. But we have not brought on line the supplies needed to meet that demand. . . . We can explore for energy, we can produce energy and use it, and we can do so with a decent regard for the natural environment.”*

Vice President Richard B. Cheney, *National Energy Policy*, Report of the National Energy Policy Development Group, May 2001, page xiii

**ER3—Increase the efficiency and productivity of energy use, while limiting environmental impacts.**

***Industries of the Future (IOF) Program***—NETL completed the timely negotiation and award of 16 new Mining IOF crosscutting technology projects with a federal cost share of \$8 million in DOE funding over 3 years. The Mining IOF, a collaboration between the U.S. mining industry and the DOE Office of Industrial Technologies, is working to make the U.S. mining industry the most efficient and advanced in the world. These new 50-50 federal-industry cost-shared cooperative agreements bring the number of active projects in the program to 26. NETL completed and issued the third solicitation in the Mineral Processing Technologies IOF, and coordinated and completed the industry proposal evaluation process.

***Building Technologies***—Homes and commercial buildings consume more than 36 percent of the Nation’s energy, as well as two-thirds of all electricity generated. Over the past 2 years, NETL substantially expanded partnerships with utilities, retailers, manufacturers, building contractors, and communities on behalf of the DOE Office of Building Technology, State and Community Programs. These programs support development and deployment of innovative technologies that could offer significant energy savings in residential and commercial buildings. In FY 2001, our government procurement program resulted in a 33-percent increase in the portfolio of retailers promoting the use of Energy Star-labeled products. The fiscal year increase of 2,200 retailers exceeded DOE’s Annual Performance Plan target of 500 new partners by 340 percent.

**ER4—Inform public policy makers, energy industries, and the general public by providing reliable energy information.**

***Electricity Supply and Demand Characterization***—Characterizing demand helps understand and define the market for new technologies. Characterization of the Pennsylvania, New Jersey, Maryland (PJM) Interconnection was completed. PJM is the largest centrally dispatched electric control area in North America, and the third largest in the world. The characterization describes the competitive electric market in PJM’s territory, including how PJM operates now and PJM’s conjecture about how load might grow and be met by planned construction.

NETL also characterized the California Power Exchange, including the duties of the State’s independent system operator, CAISO, which is responsible for the electricity integrity of and unit dispatch in California. The characterization describes electricity-generation supply and demand and price implications as the competitive market for electricity in California adjusts itself to various factors while transitioning from regulation to competition.

***Fuel-Price Modeling***—Fuel-price modeling helps set targets for R&D on new technologies. The historical price of fuel in different regions of the United States, including an estimate of future prices, was evaluated. Each of the nine regions reported on Federal Energy Regulatory Commission Form 423 was



evaluated. The historical delivered prices of the principal fossil fuels—natural gas, coal, and oil—to generating companies are documented for each region. Other fuel resources are also modeled, for example, nuclear, hydroelectric, municipal, and solid waste. Prices are available on a current-year dollar basis, or on a fixed-year 2001-dollar basis. Charts show the expected regional price for each fuel in each region for the period from 1990 to 2020.

**Strategic Center for Natural Gas (SCNG) Strategic Plan**—Guided by national strategic planning and policy analysis, the SCNG pursued a big-picture perspective of natural gas supply, infrastructure, and utilization. The SCNG worked closely with various DOE organizations (FE; the DOE offices of Energy Efficiency and Renewable Energy, Policy, and Science; and the Energy Information Administration [EIA]) to prepare a national Natural Gas Strategic Plan.

**Natural Gas Policy Studies**—SCNG policy analysis experts achieved significant progress in framing natural gas technology within an overall policy context through effective cooperation with other key DOE policy stakeholders, industry, and regulatory agencies. The first two policy studies listed below were completed and are posted on the SCNG website. Five other studies—all critically important to natural gas production, distribution, and use—are in progress.

- Understanding How Gas Price Volatility Impacts the Economics of Gas Turbines
- Hydraulic Fracturing of Coals for Methane Production
- Fuel Diversity and the Impact on Natural Gas Price
- The Value of R&D to Meet Future U.S. Energy Needs
- Supplying Natural Gas for Peaking in a 30+ Tcf Market
- Significance of Hydraulic Fracturing in Meeting U.S. Natural Gas Supply Requirements
- Identification of Barriers and Valuation of Public Benefits for Gas Turbines

The economics of natural-gas-fueled turbines and combined-cycle systems in the PJM Interconnection were evaluated. Gas-turbine, combined-cycle, and pulverized-coal plants of different sizes were evaluated to find the threshold in fuel price where one or the other made sense. The study showed that as long as natural gas prices are below about \$4.00/million Btu, investors will continue to find it profitable to invest in new gas-turbine and combined-cycle electric generation projects.

**Ultralow-Sulfur Diesel Fuels**—NETL collaborated with EIA on a congressionally mandated study of ultralow-sulfur diesel-fuel production. NETL developed models of refinery operations and the needed changes in equipment and operations to significantly reduce the amount of sulfur in diesel fuel. These models were for widely different types of starting materials (petroleum feedstock). The information generated by these models allowed EIA to accurately estimate the cost of proposed regulations that would reduce the amount of sulfur allowed in diesel fuel.

**NETL Website**—A highly successful campaign was initiated to improve Internet access for information about NETL programs and accomplishments. Over 50 criteria covering appearance, functionality, and content were measured. Compliance with these website criteria increased from 70 to about 90 percent in FY 2001. Usage also increased dramatically during this period and is trending toward a twofold increase in FY 2002.

**Publications**—Onsite research publications and professional activities in FY 2001 include two books, more than 50 peer-reviewed journal articles, and four patents.

*“Every American uses  
1,875 tons of minerals,  
metals, and fuels in  
a lifetime—150 pounds  
a day.”*

Rita A. Bajura, NETL Director, Speech at  
Mineral Economics and Management  
Society Tenth Annual Conference,  
Pittsburgh, Pennsylvania, April 4-6, 2001



*“In the transaction of . . . foreign affairs we have endeavored to cultivate the friendship of all nations . . . We have . . . cherished mutual interests and intercourse on fair and equal terms. We are firmly convinced, and we act on that conviction, that with nations as with individuals our interests soundly calculated will ever be found inseparable from our moral duties . . .”*

President Thomas Jefferson (1743-1826),  
Second Inaugural Address, March 4, 1805

## **ER5—Cooperate globally on international energy issues.**

**Cooperation With China on Clean Energy Technologies**—Two major conferences were held in China under the recently signed United States-China Protocol for Cooperation in the Field of Fossil Energy Technology Development and Utilization between DOE FE and China's Ministry of Science and Technology. The conferences focused on clean energy and CO<sub>2</sub> emission control. NETL employees helped organize both events, organized technical sessions, and presented papers on fossil-energy-related technologies.

NETL also participated on the Permanent Coordinating Committee and helped develop four Fossil Energy Annexes to the protocol agreement. NETL is leading activities under Annex I (Advanced Power Systems) and Annex IV (Energy and Environmental Control Technologies) by organizing

- A 2-week training course on design and procurement, and operations and maintenance, of flue gas desulfurization systems for coal-fired power plants;
- A 2 to 3 day workshop on U.S. technologies to reduce emissions of sulfur dioxide and NO<sub>x</sub> from coal-fired power plants; and
- A joint study on ammonia scrubbing of flue gases to remove CO<sub>2</sub> and produce a saleable fertilizer.

**Assistance to Egypt on Fuel Cells**—DOE signed a fuel-cell cooperative agreement with Egypt on February 23, 2000. NETL is supporting this effort by managing a \$250,000 project, funded by USAID-Cairo, to design a fuel-cell test facility for the Egyptian Electrical Holding Company. Company officials visited the United States in late 2001 and met with fuel cell developers to learn more about U.S. fuel cell technologies.

In a separate \$50,000 project funded by the U.S.-Egypt Science and Technology Fund, NETL is supporting Cairo University in conducting a market study for fuel cells in Egypt. Both of these efforts are aimed at encouraging fuel cell deployment in a variety of end-use applications in Egypt.

**Deploying Oil Solidification Technology**—The Nochar PetroBond® product was deployed internationally in May 2001 at the Whiteshell Laboratory, Atomic Energy of Canada, Ltd. Twenty-eight samples were successfully solidified. Before the successful deployment, the Atomic Energy of Canada had “no path forward” for the treatment of contaminated oils. The entire waste stream, about 5,000 gallons, can now be solidified for approximately \$100,000. Discussions are currently under way to deploy Nochar PetroBond® oil solidification technology outside North America in Russia and Romania, and potentially in other newly independent states.

***Assistance to Mexico on Clean Fossil Fuel Technologies***—NETL conducted a workshop on clean fossil-fuel technologies related to gasification, fuel cells, heavy oils, ultraclean fuels, and gas hydrates in March 2001 in Mexico City, Mexico. Attendees represented the Mexican Institute of Petroleum, the Institute of Electric Research, the National Commission for Energy Savings, universities, and the Energy Secretariat. This activity was conducted under Annex IV of the U.S.-Mexico Agreement of Cooperation on Energy.

***Assistance to India on Coal Technologies***—NETL is continuing its lead role in managing technical activities under the Climate Change Supplement of the USAID-India Greenhouse Gas Pollution Prevention project. NETL is receiving \$5.9 million over 5 years from USAID-India in New Delhi to continue

- Supporting the introduction of high-efficiency coal power generation technologies into the Indian power sector,
- Improving the thermal and environmental performance of existing coal-fired Indian power plants,
- Increasing large-volume fly-ash utilization, and
- Increasing capacity development at the Centre for Power Efficiency and Environmental Protection at the National Thermal Power Corporation and at three regional training facilities.

A solicitation to support a detailed engineering study for deployment of U.S. integrated gasification combined-cycle (IGCC) technology was issued, and the winning proposal is expected to be announced in early 2002.



*“The issue of climate change respects no border. Its effects cannot be reined in by an army nor advanced by any ideology. Climate change, with its potential to impact every corner of the world, is an issue that must be addressed by the world.”*



NETL continues to work with USAID-India to improve performance of coal-fired Indian power plants.

President George W. Bush, Address at the White House, June 11, 2001



*“During the centuries since the dawn of modern science, the frontiers of discovery have been defined by the limits of technology. This is one of the imperatives of science—that exploration at the frontier entails advances in technology—and it is also a powerful and pragmatic argument for supporting basic science.”*

John H. Marburger, Director, Office of Science and Technology Policy, Speech at the Meeting of the American Association for the Advancement of Science, Boston, Massachusetts, February 15, 2002

**Science (SC)—***Advance the basic research and instruments of science that are the foundations for DOE’s applied missions, a base for U.S. technology innovation, and a source of remarkable insights into our physical and biological world and the nature of matter and energy.*

NETL scientists are making important contributions in separation of hydrogen from carbon dioxide, computational energy science, and gas energy system dynamics. NETL is also recruiting top scientists through various programs to support U.S. leadership in science and ensure the success of DOE’s science mission.

**SCI—***Provide the leadership, foundations, and breakthroughs in the physical sciences that will sustain advancements in our Nation’s quest for clean, affordable, and abundant energy.*

**Separation of Hydrogen From Carbon Dioxide**—NETL is demonstrating how hydrogen and CO<sub>2</sub> separation from syngas can be successfully performed to meet the long-term goals of providing (1) low-cost hydrogen for high-efficiency fuel cells, and (2) concentrated CO<sub>2</sub> streams for sequestration. The process, being developed jointly by Bechtel, Simtech, and Los Alamos National Laboratory, could

- Reduce the parasitic energy requirement for CO<sub>2</sub> capture by 50 to 65 percent and capital costs by 50 percent compared to current technologies, and
- Capture greater than 75 percent of the CO<sub>2</sub> for sequestration.

The success of this technology will provide an economically viable approach for sequestering carbon. It could also enable the transition to a hydrogen economy in the long term. During FY 2001, flow-reactor experiments with pure CO<sub>2</sub> validated the concept of producing CO<sub>2</sub> hydrate. The next step will be to demonstrate hydrate formation using mixtures of CO<sub>2</sub> with other gases.

NETL completed an in-house research investigation on an initial set of hydrogen separation membranes to advance the Nation’s capability of producing pure hydrogen for use in future vehicles and distributed generation applications. Through collaborations with Argonne National Laboratory, the University of Massachusetts, REB Consulting, and Worcester Polytechnic Institute, tests were performed on 20 different membranes, encompassing 7 different membrane types. Composite membranes, containing thin hydrogen-permeable films placed over or within porous or non-porous substrates, were particularly successful in separating hydrogen from mixed gas streams, such as those produced in natural gas reforming or coal gasification processes.

**Computational Energy Science**—A high-speed communications line was completed between NETL's Morgantown and Pittsburgh sites and the Pittsburgh Supercomputer Center. Operations were initiated to allow interactive supercomputing among the sites.

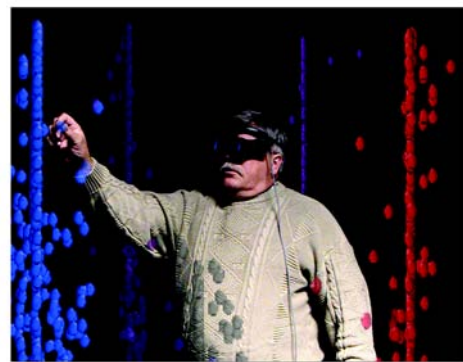
- Nine computational projects were initiated using these supercomputers.
- Two regional training courses on use of supercomputers were held in collaboration with the Pittsburgh Center.
- NETL co-hosted a Vision 21 simulation workshop to hear industry priorities in computational sciences.
- NETL hosted a workshop for a public/private consortium on multiphase fluid dynamics.

NETL researchers upgraded the well-known MFI multi-phase code (originally developed at NETL) as a major tool for simulating circulating fluidized-bed (CFB) plants, and established an MFI website to distribute the code. NETL developed a method to predict transitions between dilute- and dense-phase transport regimes and developed a black-liquor gasification model to support the goals of the paper industry in the Industries of the Future (IOF) program.

**Gas Energy System Dynamics**—NETL has a national leadership position in gas energy system dynamics, collaborating with U.S. Department of Defense and National Aeronautics and Space Administration (NASA) laboratories to develop the trapped vortex combustor as an advanced low-emission gas-turbine combustion concept. A simulation-validation combustor was designed to provide key information for gas turbine models in conjunction with Sandia National Laboratories and private organizations. Onsite researchers developed sensors for ultralow-emissions combustion systems to detect flashback and in-situ combustion conditions.

A computational fluid dynamics code was modified to include fuel cell electrochemistry for the first time, which led to new insights into the operating complexities of high-efficiency electric power production using fuel cells. Dynamic models were developed of fuel-cell/turbine hybrids that are capable of ultrahigh efficiencies in electric power production. Fundamental laboratory studies led to new insights and concepts for laser ignition in engines, which have been tested for the first time at laboratory scale.

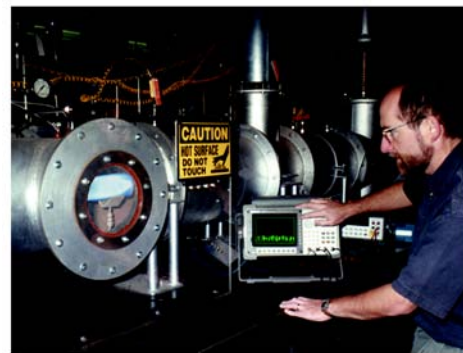
**Energy @23 Awards**—Two of NETL's long-standing technology research areas—CFB and low-NO<sub>x</sub> burner technologies—received Energy @23 Awards. These awards were given to the 23 highest-ranked DOE innovations between 1977 and 2000 chosen from a list of 100 scientific and technological innovations. The winners successfully demonstrated benefits to the American public, a contribution to U.S. competitiveness in the global marketplace, and the potential for future growth. Specifically, CFB sales in the United States have exceeded more than \$6.2 billion while creating more than 75,000 new jobs. Both are the technologies of choice for new and retrofit electric power generation using coal because of their low cost and outstanding environmental performance.



An NETL researcher examines simulation results in a virtual environment.

*“A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty.”*

Sir Winston Churchill (1874-1965)



An NETL employee monitors flame stability in the pressurized pulse combustor.



Research conducted by NETL staff members has resulted in many awards. Staff developed a regenerable hot/warm gas desulfurization sorbent to remove hydrogen sulfide from fuel gas streams.

### *We must direct*

*“ . . . our research and development budgets at ideas and innovations that are relatively immature in their development, and [ensure] the greater application of mature technologies.”*

Spencer Abraham, Secretary of Energy,  
Remarks at Quarterly Leadership Meeting,  
DOE, October 2001

**Individual Awards**—NETL researchers continue to receive recognition for their world-class expertise and research activities. Some highlights are noted below.

- The Society of Petroleum Engineers John Franklin Carll award. This award honors distinguished achievements that advance either petroleum engineering technology or professionalism.
- The Society of Petroleum Engineers Anthony F. Lucas Gold Medal. This award was established in 1936 as the major annual technical award. It recognizes distinguished achievements in improving the technique and practice of finding and producing petroleum.
- Bronze awards for Research Scientist of the Year and Rookie of the Year, both from the Pittsburgh Federal Executive Board.
- The Technician of the Year award from the local section of the American Chemical Society.
- The University of Pittsburgh's Aristech Foundation Fellowship. The fellowship recognizes outstanding scholastic achievement and significant contributions to the welfare of the graduate student body.

**SC2—Develop the scientific foundations to understand and protect our living planet from the adverse impacts of energy supply and use, support long-term environmental cleanup and management at DOE sites, and contribute core competencies to interagency research and national challenges in the biological and environmental sciences.**

**Mercury Emission Control**—NETL scientists investigated how the performance of mercury removal processes is affected by operational parameters in a small-scale coal-combustion research facility. They developed the critical data needed to improve models for coal/biomass co-firing. Airborne remote sensing was used to acquire water quality information to help EPA, state regulators, and watershed associations. Researchers determined that coal-combustion byproducts can stabilize phosphate waste slurries. NETL completed comparative testing of three mercury emission monitors developed by external contractors.

**Air-Sparging/Bioremediation Technology**—Pilot-scale demonstration of air-sparging/bioremediation technology was completed at the underground oil shale retort remediation site at Rock Springs, Wyoming, thus initiating full-scale remediation. This technology is in its second year of full operation at the underground coal-gasification remediation site at Hoe Creek, Wyoming.



**SC4—Provide the extraordinary tools, scientific work force, and multidisciplinary research infrastructure that ensure success of DOE's science mission and support our Nation's leadership in the physical, biological, environmental, and computational sciences.**

**Cooperative Research**—NETL researchers continued an active program of cooperative research and development agreements (CRADAs) and funds-in agreements with 16 continuing CRADAs, 4 new CRADAs, 2 extended CRADAs, and 16 CRADAs currently in development. Partnerships with other federal agencies or laboratories include the U.S. Army on ultraclean fuels, fuel cells, and reciprocating engines research; U.S. Air Force on ultraclean fuels and gas turbines, U.S. Navy on gas hydrates, gas turbines, and engines; and NASA on gas turbines. Relationships with other DOE national laboratories include Los Alamos on carbon sequestration and simulation, Sandia on combustion and simulation, Oak Ridge and Albany on materials research, and Argonne on hydrogen separation.

**Recruiting Scientists and Engineers**—Recruiting efforts resulted in hiring 10 highly qualified Ph.D.-level scientists as full-time federal employees this year. Ten promising students have been hired as part-time federal employees, providing an influx of new ideas. One of NETL's strategies for recruiting women and minorities into science and engineering positions uses research associate programs to build a pool of qualified candidates. NETL has increased the numbers of research associates this year to about 80. Approximately 40 percent of these associates are minorities and women.

More than 35 people participated in the Oak Ridge Institute for Science and Education programs at NETL during FY 2001. These participants included undergraduate and graduate students, post-doctoral participants, and faculty participants. There were also several participants in the Oak Ridge Research Travel program.

**University Partnership Program**—NETL continued to build regional partnerships to solve national energy problems by meeting with high-level university officials (for example, academic deans, provosts for research, and department chairs) at five regional universities and encouraging research-level interactions. This has been very successful and is a primary thrust of NETL's regional development initiative. Numerous new research-level interactions occurred in FY 2001, including at least 45 university-faculty/onsite-researcher collaborations, using a variety of administrative mechanisms. This has led to joint workshops and seminars and employee assistance in graduate-level instruction. The university partnership program has more than 25 graduate student participants from the five universities working with NETL scientists.

**Peer Reviews**—The second round of comprehensive peer reviews was conducted, covering all onsite R&D focus areas. Reviews were performed for more than 70 projects, and more than 40 external and DOE reviewers participated. These comprehensive reviews, which were held for the first time in FY 2000, are a landmark in NETL's short history as a national laboratory.



A goal of the ultraclean fuels program is to provide clean and affordable aviation fuel from petroleum, natural gas, coal, and other energy sources.



NETL has a highly trained work force that includes many Ph.D.-level scientists.



**Environmental Quality (EQ)—***Aggressively clean up the environmental legacy of nuclear weapons and civilian nuclear research and development programs at the Department's remaining sites, safely manage nuclear materials and spent nuclear fuel, and permanently dispose of the Nation's radioactive wastes.*

NETL is a vital contributor to the development of innovative environmental technologies and their subsequent deployment at DOE's former weapons complex sites, reducing remediation costs and risks. NETL scientists and contractors are developing technologies to clean up DOE's 42 remaining contaminated nuclear sites. Scientists aim to safely and expeditiously dispose of waste generated by nuclear weapons and civilian nuclear R&D programs. Demonstrations are conducted to reduce the life-cycle cost of environmental cleanup and to maximize the beneficial reuse of land following cleanup of residual contamination.

**EQI—**Safely and expeditiously clean up sites across the country that supported nuclear weapons research, production, and testing and [that] conducted DOE-funded nuclear energy and basic science research in the United States. After completion of cleanup, continue stewardship activities to ensure that human health and the environment are protected.



Solidified Mixed Waste Oil  
After Nochar Treatment

**Oil Solidification Polymer Used for Nuclear Waste**—The Nochar PetroBond® solidification polymer was demonstrated in August 1999 to cost-effectively solidify tritium-contaminated vacuum pump oils at the Mound site in Ohio. Since then, the Nochar product has been deployed at DOE locations across the country, most recently at the Rocky Flats Environmental Technology Site, to solidify transuranic oils in preparation for shipment to the Waste Isolation Pilot Plant (WIPP). Savannah River is currently evaluating Nochar PetroBond® as a means to efficiently treat 37,000 gallons of PUREX waste. Preliminary estimates show that this treatment approach could save the site \$91 million.

**Communications Systems Aid in Nuclear Cleanup**—The Deactivation and Decommissioning Focus Area (DDFA), managed by NETL, demonstrated the RaceScan Communications System in FY 2001. The system is used by the automobile racing industry for drivers and pit crews. The system was demonstrated (1) by Los Alamos National Laboratory workers wearing full-face respirators while they were excavating fiberglass-reinforced crates containing plutonium-contaminated gloveboxes, and (2) among workers who were installing vents in waste drums. In the former case, the improved communication accelerated the excavation work by 16 percent. In the latter case, the system accelerated the drum-vent-installation work by 50 percent. Based on results of the demonstration, many other DOE sites have contacted NETL for information on purchasing the units.

**Waste Inspection Tomography**—NETL contracted with Bio-Imaging Research, Inc. of Lincolnshire, Illinois, for the development of waste inspection tomography, which was deployed this year at the WIPP in Carlsbad, New Mexico. Waste inspection tomography characterizes the contents of a radioactive waste drum without the high costs and risks associated with opening the drum and analyzing the contents. Bio-Imaging Research is currently under contract with Westinghouse TRU Solutions, the WIPP management and operating contractor, to provide mobile drum inspection before the drums are shipped to the plant. The life-cycle cost saving for this deployment is \$14 million.



Waste inspection tomography identifies the characteristics of the contents of a waste drum without the risk of opening the container for analysis.

**Remediation Technology Removes Soil Contaminants**—The deployment of the Well Injection Depth Extraction system, commercialized by Informatics, was initiated in late FY 2001 at the Columbus Environmental Management Project, West Jefferson Facility. The system is an innovative in-situ remediation technology that utilizes an applied vacuum in prefabricated vertical wells to extract ground water, soil vapor, or both. The system will be deployed in conjunction with the selective separation cartridges developed by 3M to remove cesium (Ce-137) from the soil. The 3M selective separation cartridge is a cost-effective alternative to present methods of chemical separation, most specifically resin-based ion-exchange columns and reverse osmosis.

**DDFA Strengthened**—NETL's DDFA has strengthened its role of providing technical assistance by participating in value engineering studies, pollution prevention assessments, and resolution of site-specific issues related to deactivation and decommissioning (D&D) of nuclear-contaminated facilities at DOE sites. In the past year, NETL's DDFA participated on expert panels performing pollution-prevention assessments at the Brookhaven Graphite Research Reactor Decommissioning Project, and the Idaho Nuclear Technology and Engineering Center's Liquid Waste Reduction Project. The Brookhaven project team has already implemented some of the approaches recommended by the assessment panel, particularly those focusing on alternative waste disposal options.

**DDFA Technologies Deployed**—DDFA technologies have been successfully deployed at several DOE facilities, as well as in New York City and Washington, D.C.:

- The NETL DDFA has supported projects at Rocky Flats focused on the use of improved characterization, decontamination, and size reduction techniques. The primary objective is safety and reduced amounts of transuranic waste shipped to the WIPP in Carlsbad, New Mexico, for disposal. Significant savings are being achieved through innovative technologies and alternative approaches. Recent estimates by Rocky Flats indicate \$256 million in life-cycle cost savings attributed to projects supported by NETL's DDFA.
- Recommendations resulting from a value engineering effort in FY 2000 led to the implementation of a project for intrusive and non-intrusive characterization through concrete walls and floors at Mound's Old Cave facility. The Old Cave, a hot cell used to process radium (Ra-226) and actinium (Ac-227), underwent partial D&D, and was eventually



entombed in 1959. Before the city of Miamisburg will accept ownership of the site, the Old Cave must be removed. The recommendation was for immediate characterization of the entombed contents—radiological and physical. The project deployed several enhanced characterization technologies that helped to accelerate the decommissioning schedule, providing an estimated life-cycle cost savings of \$13 million.

- NETL's DDFA supported the implementation of the universal demolition processor at the Fernald facility in Ohio. Essentially three technologies in one, the processor utilizes interchanging jaw sets to pulverize or crack concrete and to shear thick plate steel. The processor is deployed from a track-mounted carrier and is being used at Fernald for structural steel segmentation and other demolition operations. The tool provides significant worker safety benefits and an estimated life-cycle cost savings to Fernald of \$2.8 million.



New York City's Tribute in Light honored those lost on September 11 and celebrated the spirit of New Yorkers.

- Like Americans everywhere, NETL employees were shocked and saddened by the events of September 11, 2001, and found ways to respond to the recovery and cleanup effort. NETL's DDFA was able to support cleanup at the World Trade Center and the Pentagon by identifying D&D technologies that could be useful in the cleanup, and by contacting prospective vendors to encourage support. Much of the equipment sent was developed for environmental cleanup programs funded by DOE's Office of Environmental Management:
  - A universal demolition processor;
  - Multiple oxy-gasoline torches;
  - Personal ice-cooling-system suits;
  - Nochar PetroBond® for cleanup of oils and fuels;
  - Hydraulic cutting tools for metals;
  - Large-scale vacuum system for collecting asbestos, dust, and other loose particles; and
  - A laser mapping system for evaluating the integrity of buildings near ground zero.

## **National Nuclear Security (NS)—*Enhance national security through the military application of nuclear technology and reduce global danger from weapons of mass destruction.***

DOE is required by law to enhance U.S. national security through the military application of nuclear technology and to reduce the global danger from the proliferation of weapons of mass destruction. NETL is committed to strengthening our national security, and has been involved for several years in helping DOE meet this goal.

**NSI—Maintain and refurbish nuclear weapons in accordance with directed schedules to sustain confidence in their safety, security, and reliability, indefinitely, under the nuclear testing moratorium and arms reduction treaties.**

**Tritium Production Support**—NETL continued in FY 2001 to provide technical, engineering, quality assurance, environmental, and safety support to the DOE Office of Tritium Production. The strategic objective of this work is to further strengthen U.S. national security by developing a replacement source of tritium by FY 2005, based on selection of the commercial light-water-reactor technology required for the nuclear weapons stockpile.

## **Corporate Management (CM)—*Demonstrate excellence in the Department's environment, safety, and health practices and management systems to support our world-class programs.***

NETL provides a safe and rewarding work place, and we are recognized for both our business excellence and our ability to deliver results. NETL contributes to best business and management practices throughout DOE. Our mentoring initiatives offer employment opportunities to talented students. Our state-of-the-art information technology systems are improving efficiency and effectiveness across DOE. NETL performs as a customer-oriented public servant, working for our internal DOE customers, but ultimately for American taxpayers.

### **CM1—Ensure the safety and health of the DOE work force and members of the public and the protection of the environment in all Departmental activities.**

***Environmental Management System (EMS)***—NETL's formal EMS was initiated in FY 2001. NETL conducted an external EMS gap analysis in January 2001 to determine the actions required to attain EMS certification (i.e., ISO 14001). An action plan was generated in February 2001. Over 40 percent of the corrective actions associated with the EMS gap analysis have been performed.

***Integrated Safety Management***—A series of rigorous integrated safety management (ISM) improvement/maintenance actions associated with an FY 2000 review were completed in FY 2001, leading to certification by a DOE team that ISM has been implemented at NETL. The benefits include full compliance with directives, resulting in an enhanced safety culture and overall lower risk levels for the NETL sites.

***Safety and Health Protection Program***—In April 2001, a gap analysis was conducted for NETL's Occupational Safety and Health Administration, Voluntary Protection Program. An action plan was generated based on this analysis, and corrective actions are being implemented. Anticipated benefits include a robust safety and health program, leading to lower occupationally related injuries and illnesses.

***Emergency Preparedness Program***—The Emergency Preparedness Program was used extensively in FY 2001 as a means of reassuring the communities surrounding NETL's three sites that NETL's operations and programs guarantee and promote public safety and environmental stewardship. NETL received extensive and positive television, newspaper, and radio coverage when conducting its emergency response drills. This increases public interest, stakeholder involvement, and worker involvement in the program.



NETL employees and community emergency personnel participate in an emergency preparedness response drill.



NETL interns conduct hands-on research.

*“I am pleased to send to the Congress a bold strategy for improving the management and performance of the Federal Government. What matters in the end is completion.*

*Performance. Results. Not just making promises, but making good on promises. This Administration is dedicated to ensuring that the resources entrusted to the Federal Government are well managed and wisely used. We owe that to the American people.”*

President George W. Bush, *The President's Management Agenda*, Fiscal Year 2002, page 1.

*The Agenda includes five government-wide goals to improve federal management and deliver results that matter to the American people: strategic management of human capital, competitive sourcing, improved financial performance, expanded electronic government, and budget and performance integration.*

## **CM2—Manage human resources and diversity initiatives and implement practices to improve the delivery of products and services.**

***Mentoring Programs***—NETL has several active mentoring and training programs targeted at recruiting the science and technology leaders of the future.

- The Minority Mentoring and Internship Program (MMIP) is designed to offer employment opportunities for talented minority youth aspiring to careers in the fields of science, engineering, and mathematics. Interns work with their mentors and conduct hands-on research directly related to their educational programs and career goals. NETL is a state-of-the-art national laboratory with a broad range of technical fields, including computer science, engineering, life sciences, mathematics, and physical sciences. The MMIP successfully paired four talented students with NETL mentors during FY 2001.
- Eighteen students participated in the Student Career Experience Program at NETL during FY 2001. NETL converted two of these participants to career-conditional appointments at the completion of their degree programs.

***Daycare Center***—In order to enhance NETL's ability to attract and retain high-quality federal employees, NETL is planning to construct a new child care center at the Pittsburgh facility and to build a larger child care center in Morgantown. Preliminary data from an employee survey will assist NETL in determining the location, size, staffing, and enrollment for the facilities.

***Labor-Management Partnership Council***—The primary function of the Council is to provide a forum for the constructive exchange of ideas and concerns between management and labor. An equal number of managers and union officials meet bi-weekly and come to consensus on workplace issues. The Council also sponsors other teams of employees and managers to perform specific studies.

***MOUs With Hispanic and African-American Chambers of Commerce***—NETL successfully established public-private partnerships through memoranda of understanding (MOUs) with the African American Chamber of Commerce of western Pennsylvania, and the Hispanic Chamber of Commerce in western Pennsylvania. These MOUs will promote minority- and women-owned businesses in the gas commodity trading business. The partnerships will first work with regional banks, gas suppliers, and end-users in western Pennsylvania. If successful, subsequent phases in eastern Pennsylvania and West Virginia will be initiated. Eventually, the partnerships are expected to have a national scope.



### **CM3—Manage financial resources and physical assets to ensure public confidence.**

**Land Transfer**—On April 6, 2001, the final transfer of the Bartlesville National Institute for Petroleum and Energy Research site was completed. The 17-acre site, originally donated to the government by Bartlesville in 1917, reverted back to the city with the signing of this document.

**External Independent Reviews**—As requested by multiple DOE customers, the NETL Center for Acquisition and Business Excellence (CABE) performed more than 20 program and project reviews. These reviews ranged from baseline validation reviews at another national laboratory to independent project reviews at five sites. Results from these unbiased, independent reviews have enabled DOE Headquarters and onsite personnel to make more informed decisions about their programs and projects.

**Industry Interactive Procurement System**—This web-based electronic procurement system allows synopses, solicitations, negotiations, and awards to be accomplished within the “expanded electronic government,” which is one of the President’s five government-wide management goals. During FY 2001, NETL established a pilot program in which electronic proposals were received for four competitive solicitations. NETL began using the system on October 1, 2001, for all competitive actions encompassing complicated acquisition procedures, including awards made under multiple award solicitations and competitive financial assistance.

### **CM4—Manage information technology systems and infrastructure to improve the Department’s efficiency and effectiveness.**

**Enterprise Architecture**—NETL’s enterprise architecture team achieved several significant milestones in FY 2001. The team adopted the industry-recognized “Zachman Framework” as the structure to relate all architectural entities. The Zachman Framework was combined with NETL’s strategic structural model to provide high-level entry points into all information contained in the architecture. Modeling work was initiated with a pilot effort to model project management activities and information.

**Environmental Cost Analysis System**—CABE completed development of the first phase of a web-based, environmental, cost-analysis system. This system collects, stores, maintains, analyzes, and reports actual cost data for completed environmental-management site-cleanup projects. The system fulfills the need to capture detailed cost data and understand those parameters that impact DOE environmental management project costs. The first phase of the system is now available for use by DOE field sites to enter their project information.

**Remedial Action Cost Engineering and Requirements System**—CABE is also providing technical oversight for the development and installation of a web-based version of the Remedial Action Cost Engineering and Requirements System. During FY 2001, a new task order was put in place to add five new cost models to the system. The estimated completion date is June 2002. The purpose of these new models is to estimate specific D&D activity so DOE can prepare appropriate budgets and independent cost estimates for planned DDFA work.

**Interagency Agreement**—An interagency agreement between the U.S. National Institute of Standards and Technology and NETL was developed in FY 2001. The purpose is to develop a standardized guide to computing and reporting of life-cycle costs of environmental management projects as well as accompanying software to implement the guide. Completion of these contracts should provide useful tools for DOE Headquarters and field offices.

**Network Intrusion Detection System**—NETL acquired a new network intrusion-detection system and began to deploy the software to protect NETL’s public networks. The network sensors monitor all Internet traffic on NETL public network segments to check for signatures commonly associated with network probes and break-in attempts. Deployment of the system has improved NETL’s cyber security posture.





**For more information,  
contact:**

**National Energy Technology  
Laboratory**

626 Cochrans Mill Road  
P.O. Box 10940  
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road  
P.O. Box 880  
Morgantown, WV 26507-0880

National Petroleum Technology Office  
One West Third Street, Suite 1400  
Tulsa, OK 74103-3519

**Or visit our website at:**

[www.netl.doe.gov](http://www.netl.doe.gov)

Customer Service  
800-553-7681



**U.S. Department of Energy  
Office of Fossil Energy**

Printed in the  
United States on recycled paper



May 2002