

National Energy Technology Laboratory Accomplishments FY 2002



Message from the Director

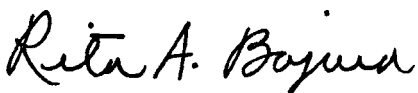
It is my pleasure to present the National Energy Technology Laboratory's (NETL's) Accomplishments Report for fiscal year 2002. As the fossil energy research laboratory for the U.S. Department of Energy, NETL conducts and implements a strong portfolio of science and technology projects, encompassing a broad range of energy and environmental topics. This report emphasizes the *results* of our activities—not our activities themselves. We believe it demonstrates that we have wisely used taxpayer funds to achieve meaningful program results that benefit the public.

Improved and innovative energy technologies are key to ensuring that the Nation has clean, affordable, and reliable energy supplies. Through its onsite research programs and its contracted activities, NETL is developing these new and improved energy technologies. Our primary focus is on the production and utilization of fossil fuels—coal, oil, and natural gas. These resources provide 85 percent of the Nation's energy supply and will continue to supply the bulk of the Nation's energy needs for the foreseeable future. The challenge is developing affordable ways to produce and utilize these resources in ways that are consistent with national environmental and energy security objectives.

This report provides examples of the progress NETL employees and contractors made during fiscal year 2002. Advances range from:

- Developing a better understanding of methane hydrate deposits, a resource that could potentially double the domestic resource base, to
- Constructing a large-scale fluidized-bed power plant at Jacksonville, Florida, in a cost-shared demonstration project. Using the fluidized-bed combustion technology, the 300-megawatt plant will demonstrate low emissions, fuel flexibility, and enhanced performance.

With funding from our parent organization, the Department of Energy's Office of Fossil Energy, other DOE offices, and other Federal agencies, NETL's work is speeding the development of comprehensive energy solutions. We remain committed to translating science and technology advances into energy systems that improve the quality of life for all people.



Rita A. Bajura

Director, National Energy Technology Laboratory



Rita A. Bajura

Director
National Energy Technology
Laboratory

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Abbreviations

CABE	(NETL) Center for Acquisition and Business Excellence	FY	fiscal year	NPTO	National Petroleum Technology Office
CCPI	Clean Coal Power Initiative	GHG	greenhouse gas	R&D	research and development
D&D	deactivation and decommissioning	GPRA	Government Performance and Results Act of 1993	RD&D	research, development, and demonstration
DOE	(U.S.) Department of Energy	IGCC	integrated gasification combined-cycle	R/V	research vessel
EIA	(DOE) Energy Information Administration	ISO	International Organization for Standardization	SCNG	(NETL) Strategic Center for Natural Gas
EM	(DOE) Office of Environmental Management	MBtu	million British thermal units	SECA	Solid State Energy Conversion Alliance
EPA	(U.S.) Environmental Protection Agency	NASA	National Aeronautics and Space Administration	SOFC	solid oxide fuel cell
FE	(DOE) Office of Fossil Energy	NETL	National Energy Technology Laboratory	Tcf	trillion cubic feet
FEMP	Federal Energy Management Program	NO_x	nitrogen oxides	USAID	U.S. Agency for International Development

Securing America's Energy Future

“The name of our agency may be the Department of Energy, but the core mission of the Department is national security. What that means is that all of the Department’s programs, initiatives, offices, and facilities have to be judged by how they advance national security.”

Secretary of Energy Spencer Abraham,
“Remarks at Lawrence Livermore National
Laboratory,” November 26, 2002.

This fiscal year (FY) marked the 25th anniversary of the U.S. Department of Energy (DOE). The National Energy Technology Laboratory (NETL), through its predecessor laboratories, has been part of DOE from its inception. We're proud to have been part of 25 years of accomplishment, leadership, and public service—and we're excited to look ahead to the next quarter century.

DOE's overarching mission can be simply stated: we enhance national security. We achieve our mission in part by increasing domestic energy production, revolutionizing our approach to energy conservation and efficiency, and promoting the development of renewable and alternative energy sources. Energy self-reliance enhances America's security in an increasingly volatile world.

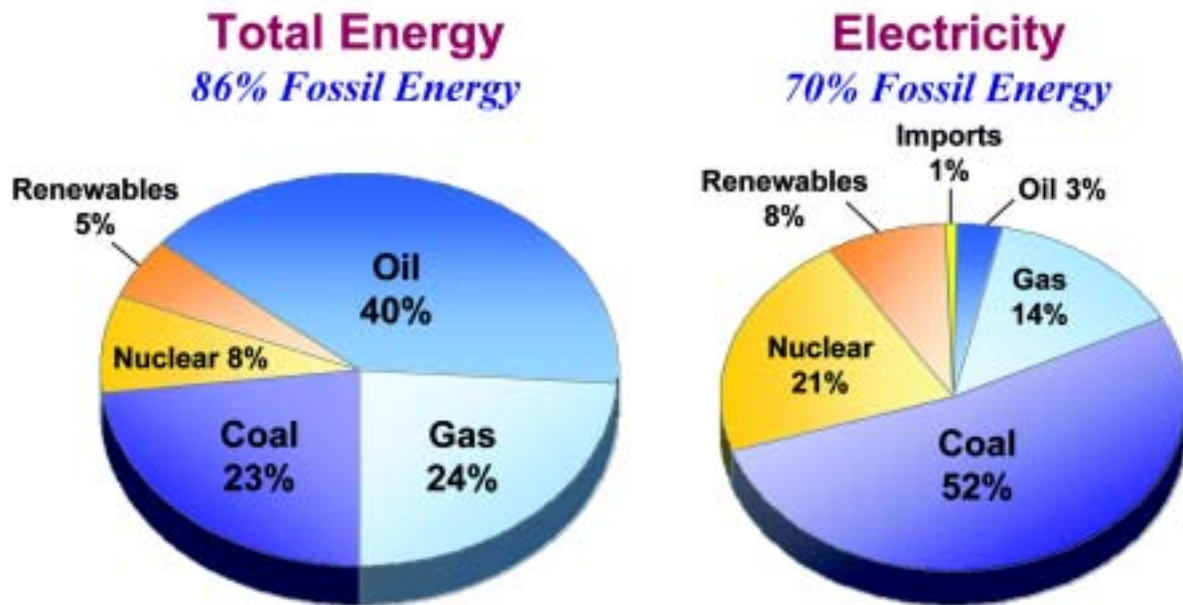
America's economic engine is powered by fossil fuels. Coal, oil, and natural gas supply 86 percent of our total energy, 70 percent of our electricity, and nearly all of our transportation fuels. It is estimated that fossil fuels will supply 88 percent of our Nation's energy by 2025. America's abundant reserves of coal and natural gas, and their affordable costs, 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, wildlife, and their habitats; and enhanced worker safety. Emissions that lead to smog, acid rain, and regional haze are a fraction of what they were 30 years ago. The “footprint” for oil and gas wells—the surface land area required for drilling the well and producing gas and oil—is a tenth of what it was in the 1970s.

As the research laboratory for DOE's Office of Fossil Energy (FE), NETL develops technologies to use our abundant fossil resources more cleanly and efficiently. Our work helps to produce, transport, and use the energy our Nation depends on, at affordable prices, without harming our environment.

This report examines our accomplishments during FY 2002 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 business lines: energy resources, science, environmental quality, national nuclear security, and corporate management.

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



Note: Totals may not equal the sum of components because of independent rounding.

Source: DOE EIA Annual Energy Outlook 2003

Fossil fuels supply most of our Nation's total energy and electricity. The chart shows U.S. energy consumption by fuel type for 2001.



“Today, fossil energy resources supply 85 percent of the energy we consume; over the next 20 years, virtually all credible energy projections agree that these fuels will supply a similar, if not larger, share of our energy needs.”

Assistant Secretary for Fossil Energy Carl Michael Smith, “Statement to the Committee on Resources, U.S. House of Representatives,” Washington, D.C., March 19, 2003.

NETL—Who We Are

“NETL is a unique entity within DOE—both our mission and approach to achieving that mission differ from those of other national laboratories. . . . While we perform important research within our laboratories, we also place great emphasis on partnering with industrial, academic, and other Governmental stakeholders to create commercially viable technical solutions to energy and environmental problems.”

NETL Director Rita A. Bajura,
“Welcome to NETL,” www.netl.doe.gov,
February 26, 2003.

NETL is a federally owned and operated national laboratory for DOE, providing expertise in energy supply, delivery, and end-use technologies. Our primary *mission* is to implement a science and technology development program to resolve the environmental, supply, and reliability constraints of producing and using fossil resources. We do this through our work for DOE’s Fossil Energy (FE) office. Our *vision* is to be the preferred provider of energy technology and policy options that benefit the public.

We also support other parts of the Department and other Federal agencies. We support DOE’s Office of Energy Efficiency and Renewable Energy (EE) by developing new energy technologies that complement work underway in the FE program. Our work for the Department of Homeland Security and DOE’s Office of Energy Assurance furthers the national goal to improve our energy infrastructure, while our work for the National Nuclear Security Administration supports nuclear non-proliferation. We also assist DOE’s Office of Environmental Management (EM) by developing technologies to reduce the cost and risk of remediating DOE’s weapons complex.

The history of NETL dates back to 1910 when the mission was to train coal operators and miners and to develop innovative coal-mine 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.

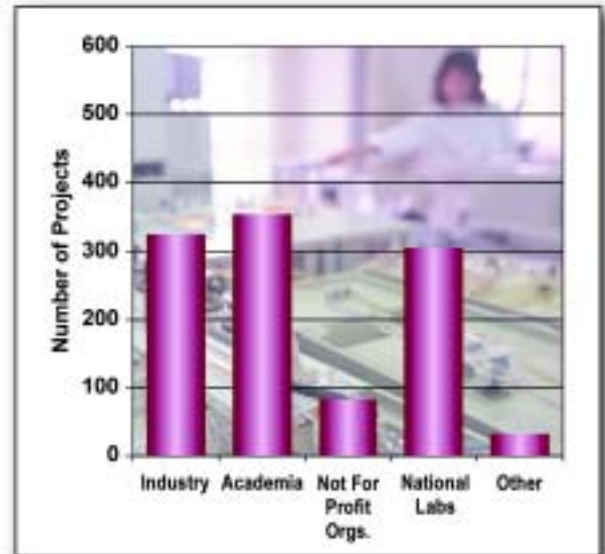
In 1996, the fossil energy research centers in Pittsburgh, PA, and Morgantown, WV, merged under single management to become the Federal Energy Technology Center. In 1999, the center was elevated to national laboratory status and renamed the National Energy Technology Laboratory, becoming the Department’s 17th national laboratory. A Strategic Center for Natural Gas (SCNG) and six onsite research Focus Areas were created. The National Petroleum Technology Office (NPTO) in Tulsa, OK, became part of NETL in 2000 and NETL’s Arctic Energy Office opened in Fairbanks, AK, in 2001.

Today, NETL’s contracted programs comprise more than 1,100 joint government-industry projects across the United States. These projects are carried out through various contracting arrangements with corporations, small businesses, universities, and other national laboratories and government agencies.

Early in the research, development, and demonstration (RD&D) process, roadmapping workshops are conducted with industry and others to gain a better understanding of end-user needs and national objectives. As a Federal organization, NETL does not compete with its partners to commercialize technologies; NETL’s partnerships help to successfully implement RD&D programs that lead to commercialized products and services for the American public. These partnerships benefit from intellectual contributions and cost-sharing with the private sector, and provide an intrinsic technology transfer mechanism to accelerate the deployment of new technologies in the marketplace.

FY 2002: Shaping, Funding, and Managing Contracted RD&D

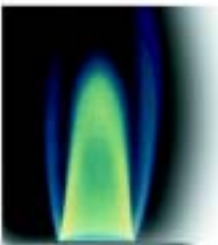
- Nearly 1,100 research activities in all 50 States and more than 40 foreign countries
- Total award value of \$8.0 billion
- Private-sector cost-sharing of almost \$4.0 billion
 - Leverages DOE funding
 - Ensures relevance of research to national objectives
 - Helps achieve commercialization by involving industry, universities, etc. in R&D
- 60 active memoranda of understanding or agreement



FY 2002 Contracted RD&D

FY 2002: Conducting Onsite Science and Technology Research

- Corporate research and development function for DOE FE
- Research laboratories in Morgantown, WV, and Pittsburgh, PA
- Involves one third of NETL's Federal and contractor staff
- Focal point for regional scientific initiatives
- 17 active cooperative research and development agreements (CRADAs)
- Technical leadership to support program development



Gas Energy Systems Dynamics

gaseous-fueled power-generation systems



Vision 21 Advanced Power Systems

pollution-free modular energy plants



Carbon Sequestration Science

stabilization of atmospheric CO₂ levels

Environmental Research

air, soil, and water characterization/treatment



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

Advanced Fuel Systems

high-efficiency transportation systems



Computational Energy Science

virtual demonstrations of energy plants of the future



NETL's Contributions to America's Energy Future

“I favor the policy of economy, not because I wish to save money, but because I wish to save people. The men and women of this country who toil are the ones who bear the cost of the Government. Every dollar that we carelessly waste means that their life will be so much the more meager. Every dollar that we prudently save means that their life will be so much the more abundant. Economy is idealism in its most practical terms.”

President Calvin Coolidge (1872–1933),
“Inaugural Address,” March 4, 1925.

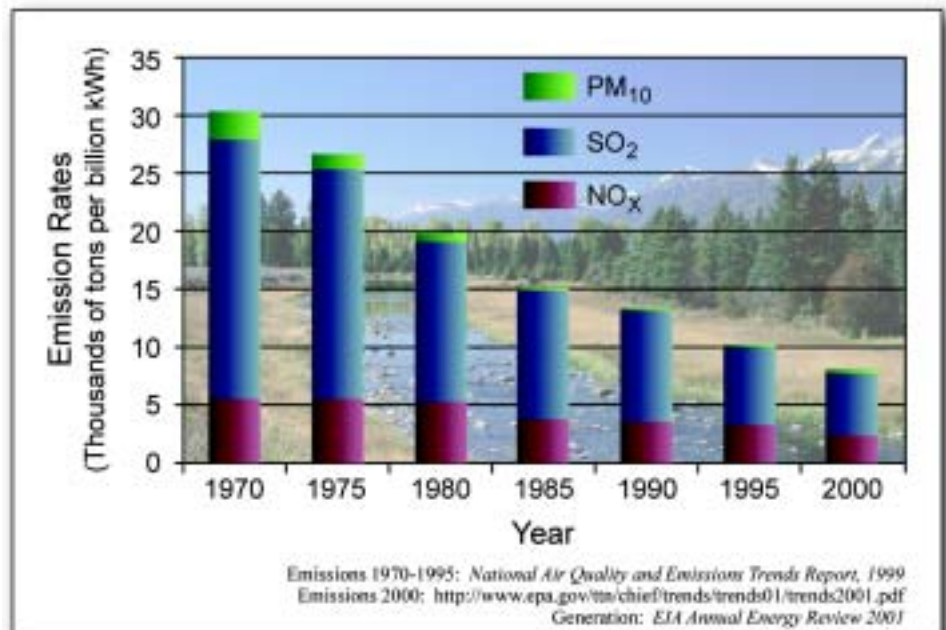
Over 50 percent of our electricity is supplied by coal-fired power plants. U.S. coal-fired electric utilities have a remarkable legacy of success in reducing emissions in the last 30+ years.

The Federal Government’s investment in fossil energy continues to pay dividends. Technological advancement, driven in 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.

Emissions Reduction. New technologies have led to remarkable progress in reducing the amount of pollutants emitted by fossil-fuel-fired power plants. For example, from 1970 to 2000, the emission rates of nitrogen, sulfur, and particulates from U.S. coal-fired power plants declined by 58, 76, and 87 percent, respectively. This has enabled coal use to more than double while allowing the United States to meet its clean air objectives.

Clean Coal Projects. NETL has implemented cost-shared clean coal demonstration projects since the inception of the Clean Coal Technology (CCT) Program in 1986. This role continues today under the Clean Coal Power Initiative (CCPI), beginning with the first successful solicitation in FY 2002. The solicitation was the first in response to the President’s pledge to invest \$2 billion in Federal funding over 10 years to advance technologies that can help meet our Nation’s growing demand for electricity while simultaneously protecting our environment.

Carbon Sequestration. NETL is uniquely positioned to contribute to an understanding of the role of technology in climate-change mitigation strategies. We are investigating the application potential of technologies to reduce greenhouse gas (GHG) emissions, primarily carbon dioxide (CO₂),



including carbon capture and sequestration. For example, NETL systems studies have shown that in some circumstances, one fossil-fuel-based power system (integrated gasification combined-cycle) combined with sequestration could produce electricity profitably in a competitive market with no government subsidy for avoided carbon emissions.

Energy Security. NETL's Energy Security Technology Program supports the DOE Office of Energy Assurance (OEA). We are helping OEA and the new Department of Homeland Security develop a seamlessly integrated national response capacity to assist facility owners in protecting their assets and ensuring that a robust national and regional response capability exists. The plan is to routinely conduct exercises, capture the lessons learned, and develop solutions to address deficiencies. We are working with State emergency management offices, State homeland security offices, and Federal Emergency Management Agency (FEMA) offices.

NETL's products are the result of research in diverse technologies, and our successes continue to provide fossil energy solutions that are reliable, affordable, and can meet ever more stringent environmental goals:

- **Gasification Technologies.** Gasification combined-cycle power systems, specifically integrated gasification combined-cycle (IGCC), can be equipped with a carbon capture and sequestration system (IGCC+S) to produce electricity at a competitive price, clean the environment of CO₂ (the most important GHG), and use the CO₂ as a valuable by-product to recover additional oil from mature reservoirs.
- **Fluidized-Bed Combustors.** These combustors, which capture sulfur inside the combustion chamber, are now sold by every major boiler manufacturer. 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 cleanly.
- **Low-Nitrogen-Oxides (NO_x) Burners.** These burners are now found in 75 percent of our Nation's coal-fired power capacity. Federal investment in selective catalytic reduction, a technology for reducing power-plant NO_x emissions, 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.
- **Fuel Cells and Gas Turbines.** Environmentally friendly and fuel-efficient fuel cells are being demonstrated at many sites across the country and worldwide. The first commercial fuel cell application for central power generation is scheduled for startup in 2003. Fuel cells are also being demonstrated in cogeneration mode, supplying heat and power. Ultrahigh-efficiency gas turbines delivered through 2005 are expected to save consumers more than \$8 billion over the systems' 30-year life spans. Current research is focusing on hybrid systems, which combine fuel cells with other power generation systems, such as gas turbines. These systems merge the best aspects of different power technologies and achieve fuel efficiency and emissions performance beyond the reach of any stand-alone system.
- **Producible Gas Resources.** DOE-industry partnerships 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. NETL is part of a large intergovernmental group that is studying methane hydrates, which could increase the worldwide known reserves of natural gas by a staggering amount: from 5,000 to 400 million Tcf.
- **Oil Resource Recovery**—Federal investment in improved oil recovery, technology transfer, and environmental technologies has resulted in many environmental-impact and cost-reduction benefits that have enabled recovery of 527 million barrels of the 175-billion-barrel technically recoverable oil resource remaining in today's reservoirs. This investment has also resulted in a technology portfolio with the potential to recover an additional 100 million barrels by 2005.

NETL's FY 2002 Program Accomplishments

“We face a 45 percent increase for electricity over the next 20 years . . . 50 percent for natural gas . . . and 33 percent for oil . . . We have to build the equivalent of as many as 1,900 new electric power plants—about one a week—over the next 20 years to meet projected energy demand.”

Secretary of Energy Spencer Abraham, “Remarks to the Detroit Economic Club,” May 13, 2002.

DOE is committed to improving accountability to American taxpayers through implementation of the Government Performance and Results Act of 1993 (GPRA). This law requires agencies to develop long-range strategic plans, annual performance plans, and annual performance reports. DOE’s mission is accomplished through five Department goals, one for each of the five mission areas: National Nuclear Security, Energy Resources, Science, Environmental Quality, and Corporate Management. Each goal is supported by strategic objectives.

The goals are long-term outcome-oriented statements, and the strategic objectives are major accomplishments that significantly contribute to each DOE goal. NETL actively supports and responds to all five DOE goals and has program accomplishments that meet strategic objectives within these goals.

Most of our accomplishments fall under the Energy Resources goal. Thus, we first describe our Energy Resources accomplishments by objective and follow with other DOE goals and objectives.

Energy Resources (ER)—Increase global energy security, maintain energy affordability, and reduce adverse environmental impacts associated with energy production, distribution, and use by developing and promoting advanced energy supply, diversity, productivity, and reliability.

The United States spends over \$0.5 trillion annually for energy, and our economic well-being depends on reliable, affordable supplies of energy. For the past 90 years, NETL has been at the forefront of research to advance fossil energy exploration, supply, and end-use technologies. We are developing new technologies and approaches to ensure the safe, clean, and affordable use of U.S. fossil energy resources throughout the 21st century.

Our primary goal is to ensure that the United States can meet its increasing demand for affordable energy without compromising the quality of life for future generations of Americans. Our vision is to be a recognized national leader in fossil energy technologies by 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 conducting information collection, analysis, and research.

ERI—Use public-private partnerships to promote energy efficiency and productivity technologies in order to enhance the energy choices and quality of life of Americans in 2020 relative to 2000 by: reducing the oil intensity of the U.S. economy by 25 percent, reducing energy intensity in the U.S. economy by 32 percent, and reducing the need for additional electricity generating capacity by 10 percent.

Aiding the Federal Energy Management Program (FEMP)—NETL awarded biomass and alternative methane fuels (BAMF) super energy savings performance contracts (ESPCs) in FY 2002 to provide a mechanism for Federal facilities to acquire energy management services. The purpose of the DOE FEMP is to reduce the cost and environmental impact of the Federal Government through energy efficiency measures. Through these ESPCs, NETL is helping reduce Federal-sector energy use by 35 percent by 2010 and GHG emissions to 30 percent below 1990 levels by 2010. In addition, an NETL assessment identified BAMF resources (e.g., landfills, wastewater treatment plants, wood waste sources) located near large Federal facilities. More than 1,200 large Federal facilities are within 15 miles of a candidate landfill and 500 of these are within 5 miles, a proximity that would be economical for piping the methane gas to the facilities for use in generating electricity.

Exterior and Home Improvements Conserve Energy—Solid-state lighting was installed in 18 signs at NETL and at public parks in West Virginia. Nine of these signs are solar powered. Compact fluorescent lamp technology that meets Energy Star requirements for efficiency was improved to better resemble natural lighting. In another energy conservation project, an optical flame monitor for oil-fired heating boilers was demonstrated in 85 homes. The monitor triggers a service call if operating efficiency degrades. To date, 45 patent disclosures have been filed in connection with this program.

Environmentally Clean Shuttle Bus—A first-of-a-kind shuttle bus operating on an environmentally clean, alternative transportation fuel was dedicated in a ceremony at Pennsylvania State University, where it was developed. The shuttle will operate on a mix of conventional diesel fuel blended with dimethyl ether (DME), which contains no sulfur and produces no smoke or particulate emissions upon combustion. Researchers will determine the optimum blend of DME with diesel fuel. DME can be produced from coal, natural gas, or biomass. Vehicles fueled by DME-diesel blends could facilitate transition to ultraclean transportation fuels.



The NETL sign at the Morgantown site uses solid-state lighting technology.



Nighttime Airborne Thermal Imagery

Using Remote Sensing to Characterize Watersheds—Nighttime airborne thermal imagery has been successfully used to identify surface discharge locations of groundwater at a spatial resolution of 1 meter and a thermal resolution of 0.1 °C. NETL is filing a patent disclosure on the post-collection data-processing approach. Airborne electromagnetic conductivity has been used to locate underground water pools within 50 meters of the surface, groundwater infiltration or recharge zones, and surface areas that contain acid-generating material, such as refuse piles and reclaimed surface mines. This means that remote sensing can be used to accurately locate the boundaries of flooded abandoned mines. To date, thermal scanner data from over 300 square miles have been processed from sites in Pennsylvania, West Virginia, Maryland, and California. NETL plans to cooperate with the Office of Surface Mining and the State of Virginia to extend the potential utility of this approach to deeper mines.

State Energy Program Award—The DOE State Energy Program presented a National Recognition Award to NETL employee Judith Dyer for outstanding contributions to the program. Ms. Dyer helped West Virginia become the first State to launch an Industries of the Future project, a program that improves the energy efficiency of energy-intensive industries such as steel, chemicals, glass, aluminum, and forest products. She also led an initiative that launched a program of energy-efficiency improvements in historic structures, and took part in the State Energy Office's advocacy effort to get a statewide building code in place.



DOE 2002 Energy Management Achievement Award Recipients

Energy Management Achievement Award—NETL employees Joseph P. Kanosky and Bernard M. Avon were presented the DOE 2002 Energy Management Achievement Award. Their award was one of eight presented to individuals from five national laboratories. The employees have been instrumental in implementing strategies to reduce energy consumption through designs for new construction, maintenance and relamping programs, outreach programs, and communication with NETL employees through the Intranet and NETL employee newsletter. They developed energy efficiency leadership goals, energy and fuel usage goals for certification by the International Organization for Standardization (ISO), and a new energy management performance agreement with FEMP.

Energy Management Retrofit Project Award—NETL received the DOE Energy Management Retrofit Project Award in FY 2002. The cash award of \$220,000 was given in recognition of five energy conservation measures associated with one of NETL's buildings. The retrofit project was reviewed and approved by FEMP, and was funded by FEMP as a cost-shared project with NETL. Upon completion, the five energy conservation measures will save over \$80,000 and 8,200 million British thermal units (MBtu) per year. The project will also help the building meet ISO 14001 requirements.

ER2—Use public-private partnerships to bring cleaner, more reliable, and more affordable energy technologies to the marketplace, enhancing the energy choices and quality of life of Americans in 2020 relative to 2000 by: increasing the share of renewable energy to 10 percent, increasing the share of renewable-generated electricity to 12 percent, and doubling the share of capacity additions accounted for by distributed power, which increases distributed generation to 11 percent of all electricity generation.

Fuel Cell Simulator—To aid parties interested in installing onsite distributed power generation, NETL developed a fuel cell simulation device that can be installed at the power load center of a building or facility. This device will monitor power demand and calculate fuel cell energy cost versus other dispatch options, thereby providing economic data for fuel cell-system investment decisions. Favorable decisionmaking for advanced technologies like fuel cells will dramatically benefit our environment and energy infrastructure.

Second-Generation Sorbent Becomes Commercial—The fixed-bed sorbent RVS-1, invented by NETL researchers Dr. Ranjani V. Siriwardane and Daniel C. Cicero, is showing promise in black liquor and biomass applications. The sorbent was originally developed to remove sulfur from high-temperature coal gasification streams. In collaboration with Research Triangle Institute (RTI), NETL has found that RVS-1 can remove sulfur from black liquor-generated syngas to less than 20 parts per million, and the sorbent becomes mechanically stronger and remains chemically active when subjected to multiple cycles. Initial bench-scale desulfurization reactor tests at RTI show the newly developed fluidized-bed/transport-reactor desulfurization sorbent operates at elevated temperatures. The test conditions, similar to those in the Chevron-Texaco Inc. gasification process, are very challenging, since the sorbent must be operational at 316 °C (600 °F). Sud Chemie is manufacturing and selling the second-generation sorbent, which is currently being tested on the M.W. Kellogg transport reactor unit and will be demonstrated on a Chevron-Texaco Inc. gasifier.

Industrial Partner Selected for R&D 100 Award—Acrion Technologies, Inc., a small business partner from Cleveland, OH, received an R&D 100 award for NETL-funded work on developing technology for recovery and use of GHG from landfills. The technology provides an approach for avoiding large quantities of methane and CO₂ emissions as landfill materials decompose. The approach developed by Acrion captures and separates landfill gas into commercially valuable products: clean-burning methane gas and liquid CO₂. The technology was featured in the September issue of *R&D 100 Magazine* and is being demonstrated at the New Jersey EcoComplex in Columbus, NJ.

“As a people, we have the problem of making our forests outlast this generation, our iron outlast this century, and our coal the next; not merely as a matter of convenience or comfort, but as a matter of stern necessity.”

President William Howard Taft (1857–1930).



NETL's Fixed-Bed Sorbent RVS-1

“As we peer into society’s future, we—you and I, and our Government—must avoid the impulse to live only for today, plundering, for our own ease and convenience, the precious resources of tomorrow. We cannot mortgage the material assets of our grandchildren without asking the loss also of their political and spiritual heritage. We want democracy to survive for all generations to come, not to become the insolvent phantom of tomorrow.”

President Dwight D. Eisenhower (1890-1969),
“Farewell Address,” January 17, 1961.

ER3—Reduce the burden of energy prices on low-income families by working with State and local agencies to weatherize at least 123,000 homes per year from 2003 through 2005.

NETL Supports Rebuild America—NETL manages marketing, communications, and customer service support for the DOE Rebuild America Program. The program is helping DOE lead the Nation in research, development, and deployment of advanced energy efficiency and clean power technologies and practices. Rebuild America has 497 community partnerships that are dramatically improving the energy efficiency in commercial buildings. Efficiency improvements were installed in 528 million square feet of commercial space, an increase of 25 percent over 2001. The result was a realized annual energy cost savings of \$298 million, a 12-percent increase from 2001.

Energy Star Participation Increases—NETL recruited more manufacturers and retailers to Energy Star products in FY 2002. Energy Star is an Environmental Protection Agency (EPA)-DOE partnership to promote voluntary labeling that is designed to identify and promote energy-efficient products in order to reduce CO₂ emissions. Energy Star offers businesses and consumers assurance about the cost effectiveness of these energy-efficient solutions, thereby saving money while protecting the environment for future generations. Manufacturer participation during FY 2002 increased by 85 percent in three areas: lighting, appliances, and windows. Utilities, government, retail, and storefront participation also increased. The market share of Energy Star labeling in three product areas increased dramatically during the year: room air conditioners—from 16 to 43 percent, clothes washers—from 10 to 18 percent, and dishwashers—from 21 to 39 percent.



Weatherization Efforts Reduce Household Heating Costs—Program analyses, training, and technical assistance managed by NETL aided State office implementation of the DOE Weatherization Assistance Program, which provides services to over 70,000 low-income households. On average, these homes received \$2,500 in energy efficiency improvements that resulted in heating cost savings of \$218 per household, a 34-percent reduction in heating costs.

ER4—Create public-private partnerships to provide technology to ensure continued electricity production from the extensive U.S. fossil fuel resource, including control technologies to permit reasonable cost compliance with emerging regulations, and ultimately, by 2015, zero-emission plants (including carbon) that are fuel-flexible and capable of multi-product output, and have efficiencies of over 60 percent with coal and 75 percent with natural gas.

Advances in Combustion Technology—NETL has been involved in research on combustion technology for decades. The research has focused on identifying and defining the needed technological developments to continue using domestic coal supplies for power generation, and on developing and commercializing new combustion technologies that can enter the global market arena. Examples of FY 2002 activities are given below.

- **Sensor Developed for Turbine Combustion**—To meet the emissions reduction requirement for nitrogen oxides (NO_x) proposed by the President's Clear Skies Initiative, low-emissions combustion technologies must have narrower operating limits and tighter controls. The Combustion Control and Diagnostics Sensor technology, developed and patented by NETL, was successfully demonstrated in the laboratory and is rapidly moving toward commercial deployment. The technique measures and monitors combustion stability and flashback of fuel flames in gas engines, and can perform both diagnostics and control of a combustor using a single sensor. NETL recently signed licensing agreements with an industrial partner (Woodward Industrial Controls) through a CRADA.
- **Zero-Emissions Combustor**—NETL is assisting an industry partner, Clean Energy Systems, Inc., in developing a zero-emissions combustor that can potentially produce energy from fossil fuels with negligible production of CO₂ or other pollutants. Design and fabrication of the combustor were completed and a demonstration test was conducted at the Plum Brook Facility of the National Aeronautics and Space Administration (NASA) Glenn Research Center. The combustor uses oxy-fuel combustion diluted by steam to produce an exhaust of CO₂ and water vapor. The CO₂ is easily separated from the steam, leaving a highly concentrated CO₂ by-product that can be marketed or sequestered.

New Pollution-Control Device—A cooperative agreement between NETL and the Otter Tail Power Company has paved the way for installation of a new type of pollution control device on the 450-megawatt Big Stone Power Plant in Milbank, SD. This first-of-a-kind device is expected to remove more than 99.99 percent of the microscopic particulate matter (PM_{2.5}) released when coal burns, virtually eliminating a pollutant that contributes to haze and that can cause respiratory problems. This \$13.4-million project is one of eight projects selected under the DOE Power Plant Improvement Initiative, which is implemented by NETL.

“Coal is a portable climate. It carries the heat of the tropics to Labrador and the polar circle; and it is the means of transporting itself whithersoever it is wanted. Watt and Stephenson whispered in the ear of mankind their secret, that a half-ounce of coal will draw two tons a mile, and coal carries coal, by rail and by boat, to make Canada as warm as Calcutta, and with its comfort brings its industrial power.”

Ralph Waldo Emerson (1803–1882), U.S. essayist, poet, philosopher; “Wealth, The Conduct of Life,” 1860.

“Just a few years ago, the idea that a coal plant could be pollution free, including even carbon emissions, seemed farfetched. Today that view has changed. It now appears likely that if the current pace of R&D can be sustained, a new type of fossil fueled energy plant can be introduced by 2015 that would have virtually no negative environmental effects.”

Assistant Secretary for Fossil Energy Carl Michael Smith, “Statement Before the House Committee on Appropriations, Subcommittee on Interior and Related Agencies, Concerning the FY 2003 DOE Fossil Energy Budget Request,” Washington, D.C., February 28, 2002.



NETL scientist Evan Granite explains that ultraviolet light drives a reaction that removes mercury from power-plant flue gas.

Assessing Ambient PM_{2.5} Data—NETL has compiled ambient air quality data collected over a 3-year period from six DOE-funded regional air-sampling stations into a common database. An Internet web-based tool is being developed to access this database, which will assist both researchers and regulators in improving their understanding of air quality. The information was incorporated into a comprehensive report of results from the PM_{2.5} research program, including results on the concentration and composition of ambient PM_{2.5} in coal-burning regions and conclusions on implications for coal-fired power plants. The report was provided to the EPA for use in reviewing the PM_{2.5} National Ambient Air Quality Standard.

Mercury Control—Several NETL projects involve control or removal of mercury from coal combustion effluents or by-products:

- **Advanced Mercury Control Technologies**—NETL managed the first-of-a-kind field testing of advanced mercury control technologies. The goal is to develop performance and cost data and information for regulatory decisionmaking on potential future mercury regulations. Leaching tests on coal utilization by-products indicate that mercury would be retained in the solid products rather than being mobilized and released into the environment.
- **Removing Mercury From Power-Plant Flue Gas**—A key component of the President’s Clear Skies Initiative is removal of mercury from flue gas. NETL researchers have developed and filed patents for two technologies that may greatly lower the cost of mercury effluent reductions. One method involves removing partially combusted coal and reinjecting it further downstream, instead of using activated carbon to scrub out the mercury. The other approach involves irradiating the flue gas with ultraviolet light, which photochemically oxidizes the mercury, allowing it to be easily removed.

Clean, Efficient Energy From Coal—NETL has been the principal DOE manager of cost-shared clean coal projects since the inception of the Clean Coal Technology (CCT) Program in 1986. This role continues today under the Clean Coal Power Initiative (CCPI).

- **Successful First-Round Solicitation**—NETL implemented a successful first-round solicitation in response to the President’s CCPI, which resulted in 36 proposals for projects valued at more than \$5 billion. This solicitation was the first in response to the President’s pledge to invest \$2 billion in Federal funding over 10 years to advance technologies that can help meet our Nation’s growing demand for electricity while simultaneously protecting the environment.

- **2002 Power Plant/Project of the Year**—*Power* magazine presented the 2002 Power Plant of the Year Award to JEA (formerly Jacksonville Electric Authority) for their large-scale circulating fluidized-bed (CFB) combustion demonstration project in Jacksonville, FL. The project also earned the Project of the Year Award from *Power Engineering* magazine. *Power* chronicled the progress of power-generation technologies and specifically examined the promise of low emissions, fuel flexibility, and enhanced performance possible through CFB technology, such as the project supported by NETL at JEA. The JEA repowering project increased plant efficiency while reducing both emissions and the cost of electricity. The project resulted in one of the cleanest coal-fueled facilities, with ultralow emissions of sulfur dioxide (SO₂) at 0.15 lb/MBtu, NO_x at 0.09 lb/MBtu, and particulates of all sizes (0.011 lb/MBtu).



The JEA repowering project converted an existing oil/gas-fired steam plant to coal-fuel blends, and resulted in the largest circulating fluidized-bed unit in the world.

- **Transport Gasifier Reduces Costs/Increases Efficiencies**—The feasibility of using high-rank coals in an integrated gasification combined-cycle (IGCC) transport gasifier was demonstrated by completing a 180-hour test with Sufco bituminous coal at the Power Systems Development Facility in Wilsonville, AL. Steady operations were achieved in both the gasifier and particulate collection equipment. Southern Company Services, the facility operator, estimates that total capital costs for using a transport gasifier in an IGCC system would be reduced by 5 to 18 percent from the costs for using conventional gasifiers, and that plant efficiencies would be increased to 46 percent from a level of 38 to 43 percent. In addition, the transport gasifier was successfully operated with oxygen feed, which would further improve IGCC efficiency and provide a simpler, more reliable, and less expensive gasification system. The use of oxygen would also avoid the extensive nitrogen dilution created in air-blown gasifiers, thus enhancing the potential for low-cost carbon capture and sequestration.
- **Intelligent Sootblowers**—NETL has signed an agreement with Tampa Electric Power Company to demonstrate how advances in 21st-century computer technology can make a vintage 1970s coal-fired power plant run cleaner and more efficiently. This \$2.4 million project calls for engineers to install a new “neural network-driven” computer system in one of the boiler units at the Big Bend Station near Apollo Beach, FL. Designed to prevent soot from building up in coal boilers, this computerized system will replace conventional, manually operated sootblowers. Sootblowers use high-velocity jets of steam or air to blow carbon residue off the inside surfaces of coal-fired boilers.

Ultralow-NO_x Combustion System—NETL-sponsored research on oxygen injection technology has resulted in a new approach to coal combustion that can reduce NO_x emissions to levels below the regulatory target of 0.15 lb/MBtu. The new oxygen injection technology can be retrofitted to most existing coal burners and could reduce regulatory compliance costs by up to 50 percent, compared to the cost of the best currently available technology. In addition, improved combustion efficiencies result from oxygen injection, which reduces the amount of unburned carbon in the combustion process fly ash, thus producing a more usable by-product.

Improved Sulfur Recovery Process—NETL-sponsored research at Research Triangle Institute has resulted in a patent application for a low-cost, less-complex process to remove and recover sulfur from gas streams produced from coal-gasification systems. This single-step process could recover 99 percent of the sulfur in the gas stream. Conventional scrubbing technology typically requires a more-expensive, more-complex scrubbing operation.



NETL's Virtual Environment Facility

“To clean the air, and to address climate change, we need to recognize that economic growth and environmental protection go hand in hand. Prosperity is what allows us to commit more and more resources to environmental protection. And in the coming decades, the world needs to develop and deploy billions of dollars of technologies that generate electricity in cleaner ways. And we need strong economic growth to make that possible.”

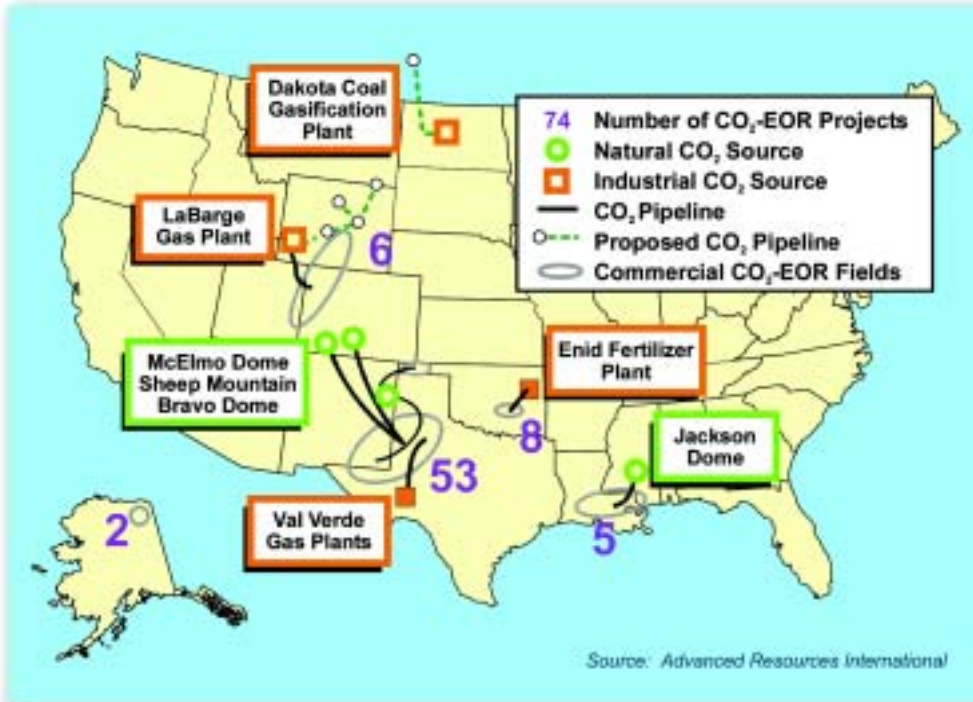
President George W. Bush, “President Announces Clear Skies & Global Climate Change Initiatives,” Silver Spring, MD, February 14, 2002.

New Class of Sensors—A university research program that focuses on developing sensors capable of operating in high-temperature combustion environments has been initiated. Properties of sensor devices, including chemical stability, hardness, high-temperature conductivity, and electronic characteristics, are being studied in harsh operating environments to determine stability and survivability. These improved sensors could be capable of rapid and real-time measurement and control of pollutants in advanced high-efficiency energy technologies.

Virtual Environment Center—Researchers at NETL have devised a four-surface, virtual-environment technology that immerses users in a synthetic environment generated from digital science and engineering data. NETL is collaborating with Ames National Laboratory to develop the cave-like automatic virtual environment facility into a science laboratory and engineering design center for the fossil-fueled energy plants of the future. The center will be capable of predicting dynamic responses of entire energy systems, and will be used to find science, engineering, and design solutions to Vision 21 plant development.

Carbon Sequestration—NETL seeks to define carbon sequestration’s role in stabilizing atmospheric CO₂ levels by developing scientific understanding and environmentally acceptable technologies. Many power plants and other large point sources of CO₂ emissions are located near geologic formations that are amenable to CO₂ storage. Injection of CO₂ into a geologic formation can often enhance the recovery of oil and gas, which can offset the cost of CO₂ capture. Sequestration of carbon in terrestrial ecosystems offers a low-cost means of reducing net carbon emissions with significant collateral benefits: restored natural environments for plants and wildlife, reduced runoff, and increased domestic production of agriculture and forest products. Terrestrial carbon sequestration could also serve a strategic role in offsetting carbon emissions from vehicles and other dispersed energy systems, such as residential heating and small industrial processes.

- **Geologic Sequestration**—Geologic formations, such as oil fields, coalbeds, and saline formations may provide large-scale opportunities for sequestering CO₂, and NETL has initiated studies to determine the potential of such formations to hold CO₂. Agreements have been established to examine the technical feasibility and environmental consequences of injecting CO₂ into underground formations. Working with the U.S. Geologic Survey, NETL researchers developed a comprehensive saline-formation database containing information on over 65,000 such formations from all 50 States.
- **CO₂ Injection in Enhanced Oil Recovery**—NETL and Canada’s Department of Natural Resources have implemented an agreement to monitor the storage capacity, movement, and fate of CO₂ injected into a geologic formation for enhanced oil recovery. While CO₂ injection has historically been used for enhanced oil recovery, this Weyburn CO₂



Commercial CO₂ Projects and Sources in the United States

sequestration project in southeastern Saskatchewan, which was organized by the International Energy Agency, will provide the first large-scale test to determine if oil reservoirs offer sufficient storage integrity to provide long-term carbon sequestration. CO₂ for the project will be provided from the Great Plains Synfuels plant in Beulah, ND. In addition, agreements with Battelle Laboratories, American Electric Power, CONSOL Energy, and the University of Texas-Austin will examine injection of CO₂, including CO₂ recovered from coal-fired power plant emissions, into underlying geologic formations, including coalbeds and saline aquifers.

- **Terrestrial Sequestration**—The Nature Conservancy, through a grant from NETL, initiated a project to explore the compatibility of carbon sequestration and biodiversity. The Conservancy will study how CO₂ can be stored more effectively by changing land-use practices and undertaking forestry projects. Using newly developed aerial and satellite-based technology, researchers will study forestry projects in South America to determine their carbon sequestration potential. A Technical Advisory Panel was convened to critique progress in developing tools to measure and verify the quantity of carbon stored in terrestrial sequestration projects in Brazil, Bolivia, and Belize. The projects are designed to offset GHG emissions. New software models will also be tested to predict the quantity of carbon uptake by soil and vegetation in the United States and internationally, thus supporting development of accurate, cost-effective, and accepted tools that can account for the amount of carbon stored using terrestrial-sequestration technologies.

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

President George W. Bush, “President Bush Discusses Global Climate Change,” The White House, June 11, 2001.

Commercial Success for Fuel Cells—Largely because of DOE leadership in technology development and the communication of results, commercial interest in environmentally friendly and fuel-efficient fuel cells is rapidly emerging. This is demonstrated by the 20-percent increase in attendance and the 92 exhibitors at the June 2002 Fuel Cell Seminar in Palm Springs, CA, in November 2002. The seminar has now become an annual conference. Examples of the rise in commercial viability of fuel cells follow.



A 200-kilowatt phosphoric-acid fuel cell sits on the roof of the North Central Bronx Hospital.

- **Fuel Cell Operation at Bronx Hospital**—Under an agreement with NETL, New York Power Authority successfully demonstrated a 200-kilowatt (kW) phosphoric acid fuel cell at the North Central Bronx Hospital that is connected to the grid, but can also automatically switch to a backup generation mode in the event of grid failure. The unit manufactured by United Technology Fuel Cells generated 707,695 kilowatt hours (kWh) of electricity at a capacity factor of 97.5 percent with only three shutdowns for a period of 1 year. Based on this experience, other public hospitals in the city are considering adoption of fuel cells and other clean, highly efficient distributed generation technologies.
- **Largest Ever Fuel Cell Demonstration**—A first-of-a-kind fuel cell operation on coal gas was resited from its original project to the IGCC plant in Wabash, IN. By doing so, DOE accelerated the FuelCell Energy (FCE) 3-megawatt electric (MWe) demonstration by several years, which is now expected to start up in 2003. This will be the first commercial fuel cell application for central power generation.
- **FuelCell Energy Torrington Facility**—Beginning as a Small Business Innovation Research award, NETL-nurtured technology development resulted in FCE designs and manufacturing processes that reduced molten carbonate fuel cell (MCFC) product costs by 40 percent. The technology advances led to a recently constructed, privately financed, facility in Torrington, CT, that is capable of manufacturing 50 megawatts (MW) per year of fuel cell units. These fuel cell power systems will generate electricity from natural gas at about 50 percent efficiency and with near-zero pollutant emissions. The high efficiency also greatly reduces CO₂ emissions.
- **Clean Electricity from Sewage**—FCE's MCFC systems are being applied in unique ways. For example, FCE has partnered with EPA and King County, WA, to deliver a 1-MW fuel cell-based power plant that will be fueled by digester gas from a municipal wastewater treatment plant. The plant will supply electricity to the municipality. In another application, an FCE MCFC system will operate in a cogeneration mode, supplying 90 percent of the backup power and 20 percent of the building heat for Ocean City College in Toms River, NJ. Emissions from these operations will be near zero.



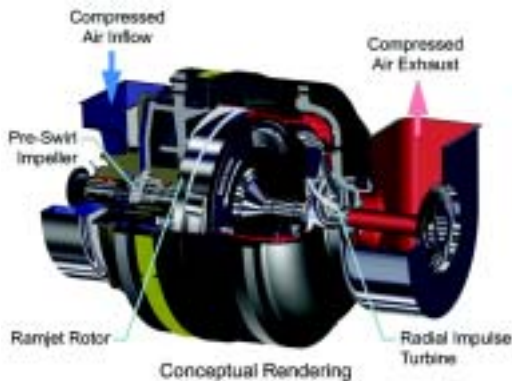
Testing of a 1-MW FuelCell Energy MCFC Plant

Hybrid Systems for Efficient Power Generation—Hybrid systems combine two or more power-generating technologies into an integrated power generation system. These systems can merge the best aspects of different power technologies into one system that achieves fuel efficiency and emissions performance beyond the reach of any single stand-alone system. Examples of hybrid system advances in the past year follow.

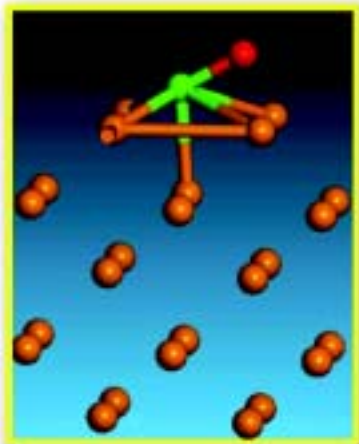
- **National Fuel Research Center**—The successful outcome of an NETL-managed fuel cell R&D project resulted in completion of the world's first acceptance test of a 220-kW hybrid power plant. The hybrid plant is a combination of a fuel cell and a microturbine, the most advanced fuel cell system ever developed. Linked together in a mini-power plant the size of a small house trailer, this system was tested for 1,300 hours at the National Fuel Cell Research Center at the University of California-Irvine.
- **Advanced Hybrid Fuel Cell Attracts Investors**—NETL-sponsored R&D has attracted the commercialization expertise of Caterpillar, Inc. FCE and Caterpillar, Inc., recently announced an agreement to distribute and develop ultralow-emission power generation products for industrial and commercial use. The companies plan to jointly develop Caterpillar-branded power plants in the 250-kW to 3-MW size range, incorporating FCE's fuel cell module. They also plan to explore the development of a hybrid power system utilizing Caterpillar's turbine engine technology and FCE products. FCE has developed MCFC technology and indirect fuel cell/turbine hybrid power systems under separate contracts with NETL.
- **Hybrid Control Strategies**—NETL researchers are modeling system dynamics and controls for both MCFC and solid oxide fuel cell (SOFC) systems. A dynamic model of a SOFC integrated with a gas turbine was run for the first time in FY 2002. The fuel cell/gas-turbine integration could generate electricity at efficiencies greater than 75 percent. The model evaluates load conditions and can thus identify potential inlet over-temperature and turbine over-speed conditions. Model results help define and support research strategies, such as mitigation for loss of load to the fuel cell or gas turbine.
- **Zero-Emissions Power**—Under NETL sponsorship, Siemens Westinghouse validated a concept for zero emissions from a SOFC power plant. A ceramic oxygen-transport membrane is incorporated, which separates oxygen that combusts depleted fuel from the fuel cell. The result is a pure CO₂ stream that can be sequestered. Approximately 2,500 hours of membrane operation were completed. Such designs will be demonstrated as part of the Vision 21 power plant initiative.

Improving Fuel Cell Performance and Reducing Costs—Fuel cells offer a clean, quiet, and adaptable power source for electricity generation, but they need to be made cost-competitive with other power sources. NETL is involved in improving fuel cell performance and making them even cleaner as well as reducing their costs:

- **Solid State Energy Conversion Alliance (SECA)**—The NETL plan for bringing fuel cell energy benefits to American citizens achieved a major milestone with the selection and announcement of 19 research projects that are expected to provide the scientific breakthroughs allowing a tenfold cost reduction in fuel cell systems. Researchers will extend the frontier of high-temperature materials science, devise models to reduce manufacturing cost, and develop innovative sensors and state-of-the-art simulation methods. As of 2002, SECA has four industry teams that include Delphi, General Electric, Cummins, and Siemens Westinghouse working on designs for target markets for high-power-density SOFC systems that can be mass produced.
- **Reducing Fuel Cell Costs**—Under NETL sponsorship, General Electric (previously Honeywell, Inc.) demonstrated a 33-percent performance improvement in power generation at 800 °C for planar solid-oxide fuel cells. Very high fuel utilization rates (up to 80 percent) were attained, leading to high fuel-efficiency and low cost. This project is part of NETL's SECA program, which is targeting a tenfold reduction in fuel cell system costs.



Schematic of the 400-kilowatt
Ramgen Turbine



This computer simulation of the Fischer-Tropsch process shows carbon monoxide (green and red) adsorbing on iron (orange) surfaces.

- **Novel Device for Improved Fuel Cell Performance**—Fuel cell life and performance have been improved through research at NETL. Researchers have invented a novel concept that uses micro-valves to control cell-to-cell flow of air and fuel. These valves use micro-electro-mechanical systems. In collaboration with the University of Pittsburgh, a prototype design has been completed and fabrication has been initiated. The expected fuel cell life extension and reliability could dramatically reduce fuel cell system operating costs.

Prototype Ramgen Engine—A radical new power generating technology called Ramgen was shown to be ready for prototype fabrication under a project cosponsored by NETL. Ramjet engines are mounted at the tips of turbine blades to spin a generator at supersonic speed. Design review by DOE revealed no insurmountable technical barriers. Prototype testing is expected to occur in 2004 by Ramgen Power Systems, headquartered in Bellevue, WA. If tests prove successful, Ramgen could become a key component in DOE's Vision 21 program to develop high-efficiency, virtually pollution-free power plants.

Understanding Carbon Monoxide Adsorption—Iron can be used as the Fischer-Tropsch (FT) catalyst to produce coal-derived syngas. In the FT process, synthesis gas, a mixture of hydrogen and carbon monoxide (CO), is reacted in the presence of an iron catalyst to produce such products as methane, synthetic gasoline and waxes, and alcohols. Knowledge of the chemisorption properties of CO on the iron surface is important in properly describing the mechanism associated with FT catalysis and in developing more optimal processes. NETL researchers used mechanical calculations to determine the most stable adsorption configuration for CO modules on the iron surface. The results can assist in modifying the FT process for producing fuels and chemicals from coal.

Hydrogen: Clean Fuel of the Future—Hydrogen produced from fossil fuels can provide the transition to sustainable, renewable resources for energy production in the long term, yielding solutions to America's energy security needs and minimizing the environmental impacts of energy use. NETL is working with industrial and academic partners on advanced technologies and processes to convert coal to hydrogen. In addition, NETL researchers are examining novel hydrogen-separation membranes, as well as an enhanced water-gas shift reaction using membrane reactors, to improve the separation and yield of hydrogen under the high-temperature, high-pressure conditions that are typical of gasification processes. Our Nation can rely on its abundant coal reserves and use these technologies and processes to produce hydrogen, while capturing CO₂ emissions and producing electric power. These activities can provide our Nation with a new hydrogen way of life—a hydrogen economy.

Oxygen Membrane Technology—Two projects on oxygen membrane technology could make advanced coal combustion technologies cleaner and more efficient:

- ***Ion-Transport Membrane Syngas***—High-purity oxygen is a key requirement for many industrial processes and advanced energy technologies, but extracting oxygen from air is both capital- and energy-intensive. DOE and Air Products and Chemicals, Inc., of Allentown, PA, are jointly funding development of a novel ion-transport membrane that can separate oxygen at potentially much lower costs and with much better energy efficiency than current technology. Tests to determine ceramic membrane performance in a laboratory-scale apparatus are complete, and five candidate membranes have operated for more than 6 months at high pressure, producing data for performance models. Additional laboratory-scale testing of catalysts and membrane stability will continue in support of pilot-scale operations and future commercialization.
- ***Oxygen-Transport Membrane Technology***—In a cooperative agreement with NETL, Praxair, Inc., of Tonawanda, NY, has made remarkable progress in developing a ceramic membrane that will economically separate oxygen from air for improved coal gasifier performance. By using oxygen instead of air, the synthesis gas produced from coal is undiluted with nitrogen, resulting in higher downstream processing efficiency, lower NO_x production, and easier carbon capture and sequestration if combusted. Separation by a ceramic membrane is expected to overcome the thermal inefficiency and capital intensity of current technologies, which could favorably impact the cost of IGCC systems.

Ash for Aggregate Manufacturing—Construction has begun on a demonstration plant to transform 115,000 tons/year of ash from the Mirant-Birchwood Power Facility in King George County, VA, into aggregate for manufacture of lightweight masonry block and concrete. Nationally, the use of combustion-related ash for material production could significantly reduce the landfill costs and environmental impacts of ash disposal. Universal Aggregates, LLC, of Bridgeville, PA, will demonstrate its aggregate manufacturing technology in this demonstration project. The project, managed by NETL, is a result of the DOE Power Plant Improvement Initiative.



Mirant-Birchwood Power Facility
in King George County, VA

“We all believe technology offers great promise to significantly reduce emissions—especially carbon capture, storage and sequestration technologies. . . . So we’re creating the National Climate Change Technology Initiative to strengthen research at universities and national labs, to enhance partnerships in applied research, to develop improved technology for measuring and monitoring gross and net greenhouse gas emissions, and to fund demonstration projects for cutting-edge technologies, such as bioreactors and fuel cells.”

President George W. Bush, “President Bush Discusses Global Climate Change,” The White House, June 11, 2001.

Enhancing Economics and Efficiency of IGCC—Several operational successes were achieved in the Liquid-Phase Methanol Process Demonstration Unit at Eastman Chemical Company’s chemicals-from-coal complex in Kingsport, TN. The catalyst needed to synthesize methanol from coal-derived gas was successfully activated using in-situ techniques in two separate operation cycles. Activation within reactor vessels at the plant avoids the external batch activation approach previously used and could result in an estimated 10-percent reduction in capital costs for a new plant. The plant has experienced additional periods of uninterrupted operation, which has increased the overall level of availability of the plant to 97.7 percent since the initial startup in early 1997. This technology demonstration was established through a cooperative agreement between NETL and Air Products and Chemicals, Inc., to enhance the economics and efficiency of IGCC power generation by producing a clean-burning, storable liquid (methanol) from synthesis gas, particularly during periods of low power demand.

Improved Materials for Higher Efficiency Processes—NETL-supported research on materials improvements for enhancing fossil energy processes has uncovered an approach that increases the durability of molybdenum-silicon materials. These materials are lighter and less expensive and possess greater stability at higher temperatures than materials currently envisioned for use in advanced fossil energy plants, such as nickel-based super alloys. Molybdenum-silicon materials could enable advanced fossil energy systems to achieve ultrahigh thermal efficiencies.

- **Laboratory Research**—Research work sponsored by NETL at the Pacific Northwest National Laboratory (PNNL) has resulted in development of new methods for improved sealing of ceramic-to-metal joints that are exposed to high-temperature environments. Effective seals are vital for the high-temperature ceramic-to-metal components that are needed to separate hydrogen, oxygen, or CO₂ from process gas streams for efficient downstream processing.
- **Ceramic Material Formulations**—Ceramic material formulations have been identified that increase hydrogen permeability, by a factor of three, above the permeability of previously studied materials, while achieving greater stability and easier processing. These formulations could reduce the cost of producing hydrogen from gasified coal. Effective and regenerable sorbents have also been identified that could reduce solid waste and improve the overall economics of power generation from gasified coal.

Awards—NETL and NETL researchers continue to earn awards for outstanding achievements in research on advanced fossil energy technologies:

- **American Chemical Society Names Outstanding Paper**—A paper on coal swelling theory by NETL scientists Badie Morsi, Ekrem Ozdemir, and Karl Schroeder received the R.A. Glenn Award at the Spring 2002 meeting of the American Chemical Society. The paper was recognized as outstanding in the

fuel division. CO₂ sequestration in deep unmineable coal seams with recovery of methane is one of the most appealing forms of long-term CO₂ storage, and may also be a cost-effective way for coal and power industries to mitigate GHG emissions. The NETL scientists investigated physical, chemical, and environmental effects on the ability of coal to adsorb CO₂. Their research led to alteration of the equation describing CO₂ adsorption to account for coal swelling.

- **Project of the Year Award**—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 was the first time DOE has won this award for one of its R&D activities. The award cites a joint government-industry development effort that began in 1992 and culminated recently with the commercial introduction of advanced turbine system products.
- **Financial Times 2001 Global Energy Award**—The NETL High-Efficiency Engines and Turbines (HEET) program was nominated for a *Financial Times* 2001 Global Energy Award, which recognizes outstanding accomplishments in the global energy industry. A Clean Energy Systems (CES) project was one of seven nominated finalists in the category of Pre-Commercial Technology Development of the Year, which focused on commercially inspired innovation. The CES HEET project is based on a zero-emission rocket engine design used in NASA space shuttles.
- **Achievement and Innovation Awards**—NETL Director Rita A. Bajura was awarded the Washington Coal Club's Annual Achievement Award in December 2001. This award honors an individual who has recently made a meaningful contribution to the coal community. Ms. Bajura was cited as an effective champion of advanced approaches for cost effectively using coal for electric power generation with near-zero emissions of CO₂ and air pollutants. Rita Bajura also received the University of Pittsburgh's Annual Award for Innovation in Coal Conversion in September 2002, which honors an individual who has provided recent and significant contributions to new technologies, new procedures, or new policies for coal utilization.

ER5—By 2020, add over 1 million barrels per day in domestic oil production and almost 2 trillion cubic feet (Tcf) per year in additional gas production as a result of technologies and practices from DOE-supported research and development.

Diagnostics and Imaging—Newly developed imaging and modeling technologies will enable production from tight, inaccessible, and fractured reservoirs, which contain major portions of our Nation's future oil and gas resources. Such reservoirs include fractured shale, fractured tight gas reservoirs in the Rocky Mountain region, deeper parts of producing basins, and reservoirs in deep water or below salt in the Gulf of Mexico. In FY 2002, NETL demonstrated numerous seismic and geophysical tools and techniques for use in characterizing hydrocarbon reservoirs, and the results were transferred to industry for implementation through the Petroleum Technology Transfer Council.



- **Advanced Visualization Software**—Researchers at Michigan Technological University have combined existing reservoir information from core samples and well logs with advanced software visualization techniques to model fracture systems that control reservoir fluid flow. Eleven new faults have been mapped on three horizons (Dundee, Salina, and Stray) in the Central Michigan Basin. The data are now available on the Internet, permitting visualization and interpretation of reservoir conditions in the Dundee formation throughout the Michigan Basin. Improved models will aid geoscientists in predicting reservoir characteristics from seismic data. This will decrease risks associated with exploration and development operations, thus reducing costs and increasing profits.

“The President’s National Energy Policy emphasizes that 21st century technology is the key to environmental protection and new energy production. The American oil and gas industry has made great strides in technology development and is one of the global leaders in the successful use of advanced technologies and best operational practices.”

Assistant Secretary for Fossil Energy Carl Michael Smith, “Statement to the Committee on Resources, U.S. House of Representatives,” Washington, D.C., March 19, 2003.



- **Advanced Imaging Method**—A Southwest Research Institute project resulted in a method that integrates nuclear magnetic resonance techniques and acoustic measurements to improve predictability of the productive rock layers in hydrocarbon reservoirs. This is particularly important in understanding extremely complex carbonate rocks. Carbonates are often fractured because of their brittle nature, and drilling through fractured carbonates can cause large volumes of drilling fluids to be lost in the rock formation. Carbonates constitute about 13 percent of sedimentary rocks.
- **Vertical Seismic Profiling**—Vecta Exploration’s seismic technology uses a conventional, unidirectional compression sound wave, plus three other major types of shock waves, to paint a richer and much more revealing portrait of underground rock formations. Expectations are that the combination of all four wave types will permit petroleum geologists to locate the elusive stratigraphic traps where oil can accumulate because of changes in the rock’s character, such as porosity. This new imaging technology is considerably more expensive than conventional methods, but is expected to reduce drilling costs, increase oil discovery rates, and improve the recovery of bypassed oil. Use of vertical seismic profiling could result in recovery of billions of additional barrels of oil across the United States.
- **Improved Ways to Find Gas Reservoirs**—NETL and Paulsson Geophysical Inc. achieved a fivefold improvement in wellbore vertical seismic imaging. The development enhances the capability of gas well operators to find hidden reservoirs between existing wellbores in a natural gas field. Gas field production can thereby be greatly increased or extended without developing new drill sites.
- **Seismic Technology Helps Native Americans**—Use of seismic technology has also helped a Native American Tribe. An estimated 890 million barrels of oil and natural gas liquids and six trillion cubic feet (Tcf) of natural gas are thought to exist beneath Native American lands in the lower 48 States and Alaska. NETL’s Native American Initiative program is designed to help Tribes develop and manage their energy resources in an environmentally sound manner by participating in joint exploration and production efforts with the oil industry. By providing Tribes access to the latest technological innovations, NETL hopes to enable them to develop and manage their mineral resources. The effort is expected to return economic dividends to the Tribes at the same time it helps to strengthen our country’s energy security. The Uintah and Ouray reservation in Utah is the location of two discoveries by independent Wind River Resources Corporation and the Ute Indian Tribe. Combined, the two wells produce in excess of 2 million cubic feet of gas and 50 barrels of oil per day. These exploration wells were drilled as a result of 3-D seismic survey funded by NETL.

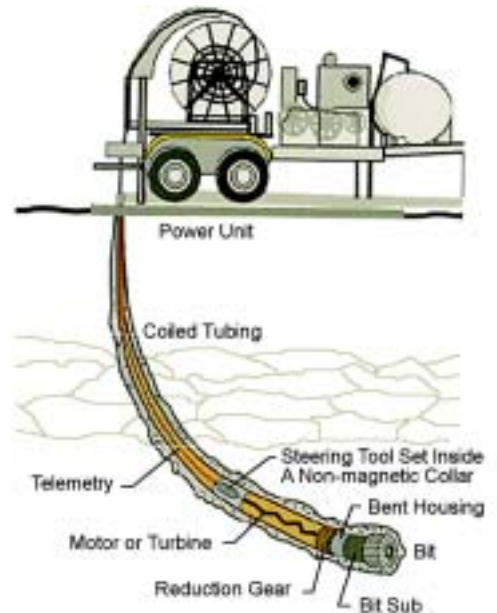
Drilling—Drilling technologies under development permit high-efficiency directional drilling, faster rock penetration rates, reduced environmental risks, and lower costs. Significant NETL accomplishments in FY 2002 include the following:

- **High-Fracture Technology for Low-Permeability Gas Reservoirs**—Multiple projects are proving that production from low-permeability natural gas reservoirs can be doubled, thereby transforming uneconomic reservoirs into economically recoverable gas reserves. These technology solutions are favorably impacting the availability of low-cost natural gas. For example, drilling in New York confirmed that new seismic, gravity, and magnetic techniques can locate gas-containing fractures; and drilling in the San Juan Basin, NM, proved that a borehole tool—high-resolution cross-well seismic survey—is effective in fracture density evaluation.

- **Sonic Tool to Unclog Wells**—A low-cost sonic cleaning tool may do a better job than conventional means of unclogging wells that are used to withdraw gas from underground storage reservoirs. A DOE-sponsored team of companies led by Furness-Newburge Inc. of Versailles, KY, has produced a prototype system that uses sound waves to remove inorganic matter and other debris that clog the perforations of gas wells. The technology could significantly increase the efficiency at which natural gas is withdrawn from storage reservoirs, making a larger amount of gas available to consumers during the winter heating season.

- **Deep Trek**—The technology needs for Deep Trek have been defined, and five responsive research projects have been selected. The Deep Trek initiative is designed to develop technologies that make it economically feasible to produce deep oil and gas resources. If these projects are successful, drillers will be provided with new tools to unlock natural gas supplies that lie 20,000 feet or more beneath the Earth's surface. The projects, totaling almost \$8 million, will assist industry in developing high-tech smart drilling systems—tough enough to withstand the extreme conditions of deep reservoirs, yet economical enough to make the gas affordable to produce.

- **Composite Drill Pipe Readied for Demonstration**—Composite drill pipe may provide a low-cost natural-gas-well drilling option that is cheaper and easier to use than steel drill pipe. Such options are needed to contain cost as greater depths, deeper water, and longer horizontal drill paths are needed to satisfy our appetite for energy. NETL has worked with Advanced Products and Technology Inc. to develop standard-diameter pipe designs that are ready for production and initial drilling demonstrations.



An Example of DOE's Microdrilling Technology: Attaching the drill bit to a thin steel coil could be a major advancement in underground oil and gas exploration.



Engineers demonstrate the flexibility of the advanced composite drill pipe.

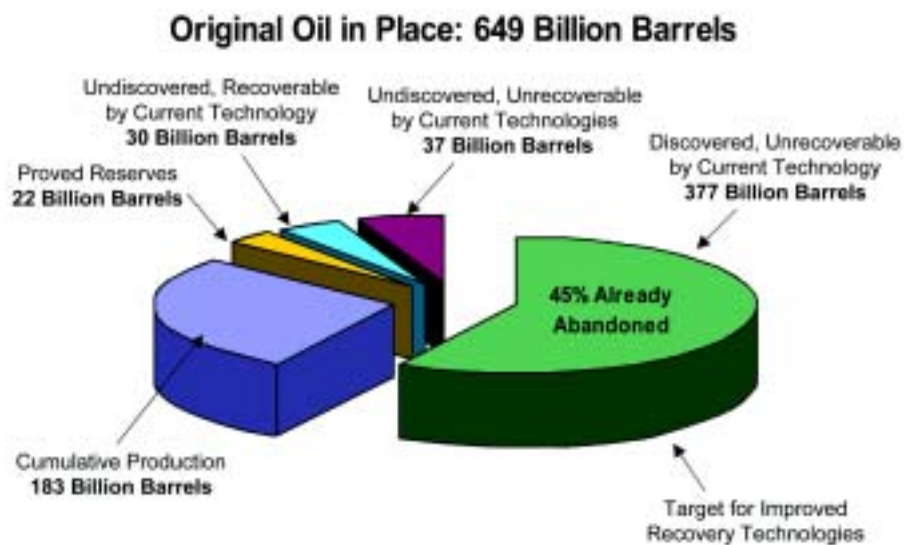


Laying Pipeline in Alaska

“As Presidents Bush and Putin said almost a year ago, ‘An open market economy, the freedom of economic choice and an open democratic society are the most effective means to provide for the welfare of the citizens of our countries.’ . . . we see additional opportunities for technology exchange in the areas of arctic production technologies, gas flaring and gas hydrates; opportunities for expanded exchange programs to enhance data collection and analysis; and opportunities to exchange ideas and technology on increased energy efficiency.”

Secretary of Energy Spencer Abraham, Remarks at the U.S.-Russia Commercial Energy Summit, Houston, TX, October 1, 2002.

- **Novel Drill Bit for Gas Wells**—The search for natural gas requires drilling deeper and doing so economically. Pennsylvania State University and NETL have developed a new approach for manufacturing tungsten-carbide bit cutters that is expected to reduce costs and extend bit life. A powder-metallurgy microwave-sintering process produces a material grain boundary that results in a bit with much better wear and less erosion and corrosion. A prototype production system has been designed, built, and transferred to Dennis Tool Company for manufacturing.
- **Slimhole Drilling in Arctic Environment**—In collaboration with NETL, the Alaskan Tribal-owned NANA Development Corporation, Cominco Alaska Inc., and Advanced Resources International produced improved arctic drilling tools and systems that are more cost efficient, and reduce the size of the footprint to one-third that of a typical drilling operation. The new tools drill holes that are 3-inches in diameter compared to conventional 8-inch holes, and require substantially reduced volumes of drilling muds/fluids and casing cement. By reducing by-product accumulation and disposal, slimhole technology reduces costs and environmental risks. The smaller, mobile drilling rig is designed to protect workers from exposure to harsh environments and because it’s so light, can be transported to remote locations by helicopter, thus avoiding road construction and surface disturbance to the tundra. Drilling fluids designed to prevent freezeup in the permafrost zone are effective, safe, and biodegradable. Using this slimhole technology, Cominco and NANA discovered and are developing a large (>2 Tcf) gas shale deposit. This unconventional energy resource will be used to fuel nearby mining operations, avoiding the expense of diesel fuel and its transportation. The technology can be used to provide electrical power for remote villages and communities. The technology is applicable to unconventional gas deposits not only in Alaska, but also other arctic settings such as Canada and Russia.



Enhanced Reservoir Efficiency—For every barrel of crude oil produced in the United States, two barrels are left in the ground. Average oil recovery from U.S. reservoirs is only about 32 percent. Although it is physically impossible to recover all of the oil that is discovered, the potential for improvement with the use of advanced technologies is very large indeed. These advanced technologies can slow down, even stabilize the declining oil production rate, and increase the gas production rate. They can also reduce the rate at which domestic oil and gas fields are being abandoned—an extremely important result because once shut down, restoring oil and gas reservoirs to production is usually uneconomic. NETL had significant accomplishments in this area in FY 2002:

- **Stripper Well Technology**—Stripper wells (low-producing oil and gas wells) are a recognized source of U.S. energy from oil and gas, now providing 8 percent of our gas annually. A new research consortium helped find technology solutions that allowed members to continue production from this existing infrastructure that otherwise would have been prematurely abandoned. The NETL-managed Stripper Well Consortium, consisting of over 60 members in 14 States, completed over 13 highly relevant and quick-turnaround research projects with timely web-based dissemination of results to members.
- **Produced Water Disposal Technique**—As part of an NETL project, researchers at the Environmental Energy Research Center of the University of North Dakota successfully completed a commercial-scale demonstration of the Freeze-Thaw/Evaporation (FTE[®]) process that treats and disposes of water produced from oil and gas operations. The process was shown to be field-worthy and effective in removing salts, dissolved heavy metals, and organics from produced water, making the water safe for wildlife and livestock and suitable for beneficial uses, such as irrigation, dust abatement, and drilling mix. The process is based on the principle that as ambient temperature falls below 32 °F, pure water freezes sooner than brine. This provides a mechanism for separating the heavier brine fraction from the relatively high-quality water fraction. By relying on seasonal changes to produce the freezing and thawing, the cost for disposing of the treated water from the demonstration site in the Jonah Gas Field, WY, was reduced by 80 percent over the commercial disposal option. Comparable savings in other climatically suitable areas will depend on local disposal fees and transportation costs.
- **Oilfield Waste Injection Disposal Techniques**—Terralog Technologies and NETL have partnered to develop and test improved fracture-injection disposal techniques and diagnostic tools. One such process is slurry fracture injection (SFI), a means to dispose of accumulated oilfield wastes by deep well injection. This process yields considerable advantages to the operator over conventional disposal methods. SFI provides an environmentally attractive and permanent disposal solution for considerable volumes of nonhazardous oilfield waste, and has minimal impact on surface land use. In addition, it affords a significant reduction in long-term liability to the operator while reducing transportation and disposal costs.

“ When President Bush took office he was handed a number of energy challenges: electricity shortages, and high prices for gasoline and natural gas. . . . he addressed them not in piecemeal fashion, but by designing comprehensive plans to ensure our energy security for this century. The quiet diplomacy in international oil markets and creative solutions to our natural gas supply challenges were part of the plan.”

Secretary of Energy Spencer Abraham,
“Remarks to the National Petroleum Council,”
May 16, 2003.



During the FTE[®] separation process, ice piles separate into produced water and brine.

- **Risk-Based Data Management System (RBDMS)**—The RBDMS is a PC-based program that allows States to easily manage their production and underground injection data and to make risk-based regulatory and operational decisions, such as where to assign inspectors for maximum effectiveness. The system enables States to generate reports quickly for EPA and the public. Originally developed for six States, RBDMS has proven so successful that 25 States have formed a users group to help each other implement the system. At least 17 States have adopted the system and more are in the planning stage.

Synthetic Fuels—Several NETL accomplishments in improving the production of synthetic gas and liquid fuels can be reported for FY 2002:

- **Novel Reactor for Synthesis Gas Production**—Synthesis gas production technologies available today require large reactors and significant amounts of steam, and the resulting ratio of hydrogen to carbon monoxide still must be adjusted for conversion to liquid. These disadvantages make the technologies capital-intensive and difficult to implement, particularly in remote locations or in limited space (e.g., oil platforms). Praxair, Inc., designed and fabricated a prototype high-pressure reactor to produce synthesis gas from natural gas by partial oxidation reforming. The reactor has a residence time on the order of milliseconds, steam is not needed, and hydrogen and carbon monoxide are produced at a ratio ideal for gas-to-liquid production. Reactors using the technology cost 25 to 50 percent less than more traditional methods.
- **High-Efficiency Syngas Generation**—Reforming natural gas into carbon monoxide and hydrogen is the highest cost step in producing methanol and Fisher-Tropsch liquids. Steam reforming requires expensive high-nickel-alloy reforming tubes. Conventional auto-thermal or partial oxidation reforming minimizes the size and cost of the reformers and provides a near optimum mixture of carbon monoxide and hydrogen, but incurs the added expense of pure oxygen. With funding from NETL, TDA Research, Inc., is developing a process that has the advantages of the pure oxygen process (smaller reactors and nitrogen-free product) at a reduced cost by using a nickel catalyst for both oxygen extraction and steam reforming. During FY 2002, four sorbents were prepared; characterized for strength, oxygen loading, and catalytic activity; and subjected to multiple-cycle tests. One sorbent gave promising results in the multiple-cycle tests, and will be subjected to extended-cycle testing. An economic analysis showed approximately 15-percent cost savings on producing gas-to-liquids utilizing the TDA process, compared to oxygen-blown auto-thermal reforming.
- **Syntroleum Clean Fuels Plant**—Syntroleum Corporation and Marathon Oil Corporation broke ground for a synthetic fuels plant in the Port of Catoosa near Tulsa, OK, in August 2002. The demonstration plant, being constructed at an approximate cost of \$36 million, will produce 70 barrels of ultraclean diesel fuel per day by mid-2003. Initial testing of the synthetic fuels will involve bus transit vehicles in Washington, D.C., and Government vehicles in Denali National Park, AK. Daimler-Chrysler and Volkswagen are also demonstrating the use of these fuels in vehicles having prototype diesel engines and emission control systems. The U.S. Army and U.S. Air Force will test these fuels in ground, aviation, and rocket systems. This NETL project is expected to be a key in meeting the demanding quality specifications of tomorrow's fuels.
- **Nickel-Based-Catalyst Development**—NETL researchers have developed a robust catalyst that is superior to those commercially available on the market for producing syngas from natural gas and CO₂. A series of nickel-based catalysts containing alkali-earth metals such as magnesium and calcium, promoted with sodium and potassium, has been prepared and tested for more than 360 hours, producing a mixture of hydrogen and carbon monoxide from natural gas without forming significant amounts of carbon in the catalyst bed. Since carbon is a major cause of catalyst deactivation and shutdown in processes that produce hydrogen, the catalyst could significantly reduce the cost of hydrogen production. The information obtained from this study has been presented at national meetings and published in peer-reviewed journals.

Methane Hydrates—Methane hydrates are cage-like lattices of ice, inside of which are trapped molecules of methane (the chief constituent of natural gas). Around the United States, large deposits have been identified and studied in Alaska, the west coast from California to Washington, the east coast, including the Blake Ridge offshore of the Carolinas, and in the Gulf of Mexico. Worldwide estimates of the natural gas potential of methane hydrates approach 400 million Tcf—a staggering figure compared to the 5,000 Tcf that make up the world's currently known gas reserves. This huge potential, alone, warrants a new look at advanced technologies that might one day reliably and cost-effectively detect and produce natural gas from methane hydrates. If only 1 percent of the methane hydrate resource could be made technically and economically recoverable, the United States could more than double its domestic natural gas resource base. In FY 2002, researchers collected naturally occurring gas hydrate samples during research cruises off the coast of Oregon and in the Gulf of Mexico, and from a deep well in the Northwest Territory of Canada:

- **Oregon**—The research vessel (R/V) *JOIDES Resolution* docked at Victoria, BC, in September 2002. The largest amount of marine methane hydrate core samples ever recovered for scientific study was unloaded. The samples were collected from 50 miles offshore of Oregon in an area known as Hydrate Ridge. The samples were shipped in pressure vessels to Texas A&M University for study by scientists from around the globe. Their detailed analyses of the icy substance could reveal new clues about this potential resource that many believe could hold the key to a virtually inexhaustible supply of natural gas. NETL provided over \$1 million in cofunding along with the specially designed pressure vessels used to preserve core samples.
 - **Gulf of Mexico**—Research cosponsored by NETL provided valuable new gas hydrate scientific data during 14 successful dives conducted in May and June 2002 by the cruise ship R/V *Seward Johnson* and the submersible *Johnson Sea-Link*. The cruise was dedicated to studying the near-seafloor hydrocarbon system within the hydrate stability zone of the northern Gulf of Mexico, and specifically at locations in the Green, Mississippi, and Desoto canyons. Researchers are also analyzing the results from the seafloor probe recovered at this hydrate site.
- Partially funded by DOE, gas hydrate samples were obtained from the seafloor by the R/V *Marion Dufresne* in July 2002. U.S. scientists obtained 17 40- to 70-foot-deep core samples. Ongoing sample analysis will aid in the predictive capability of the nature and location of the resource, a critical research need for preserving seafloor stability during drilling operations.



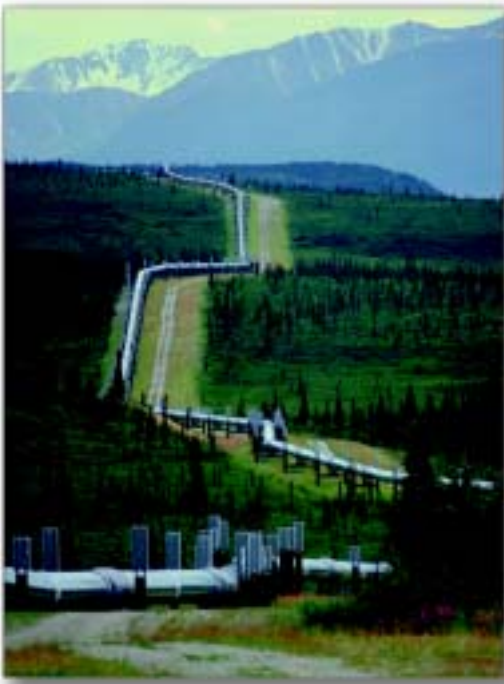
Researchers use gloves to handle methane hydrates.



The R/V *JOIDES Resolution* is the world's largest scientific drill ship.

- **Northwest Territory**—Cofunded by DOE, researchers drilled a 1,200-meter-deep well in the Mackenzie Delta of the upper Northwest Territory of Canada and obtained samples of methane hydrates for resource characterization. NETL research personnel present during the drilling are working with the U.S. Geological Survey and other team members to expand the scientific knowledge of this gas resource, which is believed to be more than seven times the U.S. original gas-in-place estimates for all non-hydrate methane.
- **The Arctic**—NETL and industry partners finalized plans for the first dedicated gas hydrate well in Alaska to test the concentrations of hydrates in the North Slope. In preparation for the 3,500-foot well, scheduled for groundbreaking in March 2003, the partners developed a unique arctic drilling platform and a specialized onsite core characterization system. Recoverable gas locked in arctic hydrates is estimated at 11,000 to 24,000 Tcf.

Pipeline Infrastructure—Natural gas is distributed to virtually every region of the country through an extensive system made up of more than 1.3 million miles of pipelines, meters, compressor stations, and more than 400 storage reservoirs. The gas industry currently has the capability to deliver approximately 75 billion cubic feet per day during peak periods. NETL is working with private industry to reduce consumer costs through increased deliverability, decreased deliverability revitalization costs, and increased operating efficiency.



Natural Gas Pipeline

- **Conformable Array Measures Pipeline Corrosion**—Initial tests confirm the feasibility of using a conformable array as a low-cost way for field engineers to quickly map corrosion of natural gas pipelines. This device, a flexible pad of eddy-current sensors, measures depth and pattern of corrosion when wrapped around the pipe. The analyzed field data produces a two-dimensional color-contour map that can be used to update maintenance records or trigger repair. New technology such as the conformable-array device will provide greater reliability and security for our Nation's gas pipeline infrastructure.
- **Unique Flow-Loop Facility**—As a member of the Joint Industry Partnership focused on hydrate research, DOE funded relocation of a \$1.5-million "flow loop" donated by Marathon Oil Company from their facility in Littleton, CO, to the north campus of the University of Tulsa, OK. The orientation of the flow loop is variable. Temperature and pressure controls allow researchers to determine the conditions leading to the formation of hydrate accumulations that can obstruct flow within the simulated pipeline. Ensuring the proper flow of oil and gas in many different, sometimes extreme, operating environments is a key challenge facing the industry. DOE's effort to stem the continuing decline of industry involvement in domestic R&D activities was rewarded when British Petroleum recently announced their intention to use the facility to help plan a \$15-billion deep-water Gulf of Mexico exploration and production effort.



This unique flow-loop facility can simulate the flow of oil, water, and gas in a pipeline at different slopes on the ocean floor.

ER8—Provide national and international energy data, analysis, information, and forecasts to meet the needs of the energy decision-makers and the public in order to promote sound policy making, efficient energy markets, and public understanding.

Forecasting Tool Updated—NETL provided the Energy Information Administration (EIA) with alkylation and iso-octane technology information and cost data to be entered into their national energy modeling system (NEMS). Alkylation is the principal technology used to convert gaseous hydrocarbons produced during refinery cracking operations into a salable liquid product. Iso-octane is a biodegradable gasoline component that has low vapor pressure and superior octane value, making it very clean burning. The updated technology and cost information mean that NEMS can now be used to estimate the short- and mid-term effects of pending legislation on these specific petroleum refining techniques. NEMS can also be used for sensitivity studies to establish the consequences of a range of responses by refiners to any regulatory changes that result from the legislation.

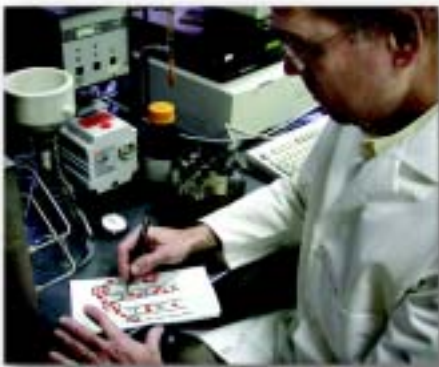
Oil in the Sea—A report, sponsored in part by NETL, presented the most up-to-date estimates of the various sources of petroleum and petroleum products found in the world's oceans. Of the oil found in the oceans, approximately 60 percent is from natural sources, such as seeps. Oil exploration and extraction are responsible for only 3 percent of the petroleum that enters the oceans. The report was published by the National Research Council. Committee members included the U.S. Geological Survey, U.S. Coast Guard, Chevron Texaco Corporation, several universities across the country, Environment Canada, and Woods Hole Oceanographic Institution. Recommendations from this report are intended to help policy makers prioritize next steps for pollution prevention and response.

“Energy technologies have become extremely complex. For the most part, they are no longer invented by the brilliant individual working in isolation: the Thomas Edison, the George Westinghouse. They are developed by teams of individuals, with diverse skills, working in collaboration.”

NETL Director Rita A. Bajura, speech at Relaunch of JEA's Northside Generating Station, Jacksonville, FL, October 14, 2002.

“Anyone who is practically acquainted with scientific work is aware that those who refuse to go beyond fact rarely get as far as fact; and anyone who has studied the history of science knows that almost every great step therein has been made by the ‘anticipation of Nature.’”

Thomas Henry Huxley (1825–95),
British biologist and educator.



An NETL scientist describes storage opportunities in the channels of disordered arrays of nanotubes.

Science (SC)—*Deliver the scientific knowledge and discoveries for DOE’s applied missions; advance the frontiers of the physical sciences and areas of the biological, environmental, and computational sciences; and provide world-class research facilities and essential scientific human capital to the Nation’s overall science enterprise.*

NETL’s world-class onsite research facilities in Pittsburgh, PA, and Morgantown, WV, support the DOE Science goal and the U.S. position as the world leader in science. NETL scientists are making important contributions in separation of hydrogen from carbon dioxide, computational energy science, and gas energy system dynamics. NETL recruits top scientists through various programs to support U.S. leadership in science and ensure the success of DOE’s Science mission.

SC4—**Provide leading scientific research programs in materials sciences and engineering, chemical sciences, biosciences, and geosciences that underpin DOE missions and spur major advances in national security, environmental quality, and the production of safe, secure, efficient, and environmentally responsible systems of energy supply; as part of these programs, by 2010, establish a suite of Nanoscale Science Research Centers and a robust nanoscience research program, allowing the atom-by-atom design of revolutionary new materials for DOE mission applications; and restore U.S. preeminence in neutron scattering research and facilities.**

Nanotubes for Hydrogen Storage—Researchers at NETL and the University of Pittsburgh have suggested that a chemically and physically disordered array of activated carbon nanotubes may provide a solution to hydrogen storage problems. They have discovered that the best material for hydrogen storage may not be the ideal nanotube structures frequently assembled in theoretical studies. Disordered arrays of nanotubes can be activated and engineered to provide molecular nooks and crannies with improved chances of approaching the density target of 6 weight-percent required to make the onboard storage of hydrogen using carbon nanotube technology economical.

Presidential Green Chemistry Challenge Award—Dr. Eric Beckman of the University of Pittsburgh received the Presidential Green Chemistry Challenge Award for his work on designing non-fluorous, highly CO₂-soluble materials. Collaborating with researchers at Yale University on an NETL project in enhanced oil recovery, Dr. Beckman is applying these less expensive and environmentally friendly materials to enhance CO₂ viscosity, which increases the amount of oil that can be recovered from a reservoir. The awards program provides national recognition of outstanding chemical technologies that incorporate the principles of green chemistry into chemical design, manufacture, and use, and can be or have been utilized by industry in achieving their pollution-prevention goals.

John Franklin Carll Award—The Society of Petroleum Engineers awarded Dr. Gary A. Pope, University of Texas-Austin, the John Franklin Carll award for achievements that advance petroleum engineering technology. Dr. Pope is the principal investigator for the NETL enhanced oil recovery project, “A New-Generation Chemical Flooding Simulator.”

Distinguished Achievement Award—The Society of Petroleum Engineers presented Dr. William R. Rossen, University of Texas-Austin, the Distinguished Achievement Award for Petroleum Engineering Faculty for his superior teaching, excellence in research, and significant contributions to the petroleum engineering profession. Dr. Rossen is the principal investigator for the NETL project, “Mechanistic Studies of Improved Foam-Enhanced Oil Recovery Processes.”

SC5—Enable advances and discoveries in DOE science through world-class research in the distributed operation of high-performance scientific computing and network facilities; and deliver, in 2006, a suite of specialized software tools for DOE scientific simulations that take full advantage of terascale computers and high-speed networks.

Advanced Gasifier Model—NETL scientists completed the first version of an advanced gasifier model that incorporates gasification chemistry into a multiphase fluid dynamics code to simulate the transport gasifier at Wilsonville, AL. The code was run on the new terascale computer at the Pittsburgh Supercomputer Center. Such advanced models will be instrumental in economically attaining the goals of the Vision 21 initiative. Vision 21 plants will be virtually pollution-free, will process a wide variety of fuels (such as coal, natural gas, biomass), and will produce multiple products (electricity, liquid fuels and chemicals, hydrogen, and industrial process heat).

“Progress in energy technology development is not linear. It occurs in fits and starts as forms of energy that have dominated for decades, if not centuries, give way to new energy technologies. Just as direct forms of energy—wood, wind, water, and animals—gave way to steam engines, electricity, and the internal combustion engine, so too will today’s energy technologies give way to a future we can only imagine.”

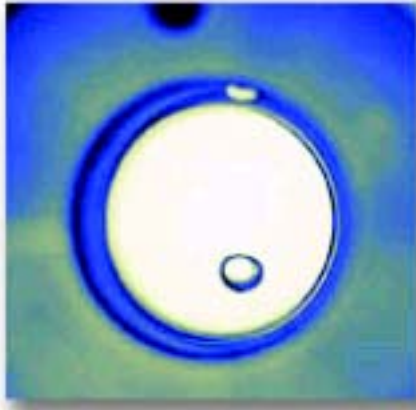
NETL Director Rita A. Bajura, speech at International Energy Policy Conference, Oklahoma City, OK, October 24-25, 2002.



Operation of high-performance scientific computing and networking facilities will be instrumental in attaining Vision 21 goals.

“Science is the knowledge of consequences, and dependence of one fact upon another.”

Thomas Hobbes (1588–1679),
British philosopher.



By manipulating seawater flow, NETL's high-pressure water tunnel facility can hold a buoyant drop of CO₂ stable for extended observation through its viewing port.

SC7—Provide major advanced scientific user facilities where scientific excellence is validated by external review; average operational downtime does not exceed 10 percent of schedule; construction and upgrades are within 10 percent of schedule and budget; and facility technology research and development programs meet their goals.

Facilities Improvement Program—NETL initiated a 7-year facilities improvement program in FY 2002 that included the construction of two new buildings, the renovation of several existing buildings, and the disposal of obsolete buildings. The improvement program will provide an excellent return on investment: (1) the total life-cycle cost savings for the improvement program is almost \$11 million over 30 years; (2) operational costs are projected to be reduced by about \$3.00 per square foot for operation, maintenance, and utilities; and (3) 22,500 square feet of billable space will be eliminated. A design contract was initiated for one of the new buildings and design contracts were awarded for renovation of several buildings. Several projects were completed to repair critical building systems, renovate mission-sensitive research facilities, and upgrade high-priority infrastructure.

New Facility Used to Study Ocean Sequestration—NETL has designed and constructed a high-pressure water tunnel facility that allows laboratory duplication of deep-ocean conditions. The facility is being used to investigate the chemical, physical, and thermodynamic behavior of CO₂ when it is injected into the ocean. The rig is helping scientists understand the formation mechanism of ice-like CO₂ hydrates and the ultimate fate of sequestered CO₂ in deep-ocean conditions. Recent results on the rate of CO₂ dissolution in seawater compare favorably with those obtained from actual investigations by the Monterey Bay Aquarium Institute.

Peer Review Process—Consistent with NETL's performance metrics, our onsite research projects are subject to periodic merit reviews. Each project is typically reviewed by a team of technical experts representing industry, academia, other research institutions, and the Government. In FY 2002, merit reviews were conducted for 60 projects in various research areas, including carbon sequestration, advanced fuel processing, advanced power systems, gas hydrates, combustion processes, fuel cell and hybrid systems, computational energy science, and environmental research. The merit reviews have contributed significantly to improving the quality of research at NETL.

Environmental Quality (EQ)—*Aggressively clean up the environmental legacy of nuclear weapons and civilian nuclear research and development programs at 114 of the Department's sites; permanently dispose of the Nation's radioactive wastes; minimize the social and economic impacts to individual workers and their communities resulting from Departmental activities; and ensure the health and safety of DOE workers and the public and the protection of the environment.*

During the Cold War, the nuclear weapons complex generated large amounts of waste, which pose unique problems. DOE is committed to remediating sites across the country that supported the Nation's production and testing of nuclear weapons. The DOE Office of Environmental Management (EM) manages some of the most technically challenging and complex work of any environmental program in the world.

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 is committed to perfecting techniques that will protect the health and safety of its workers, the public, and the environment while removing the contamination.

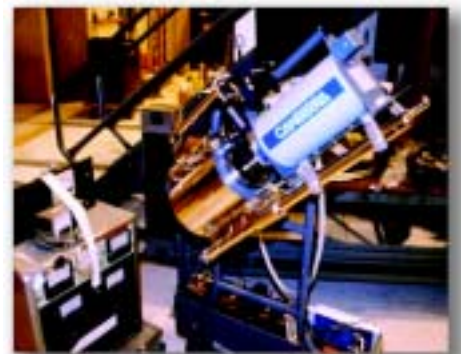
EQI—*Safely and expeditiously manage waste; clean up facilities and the environment; and stabilize and store nuclear material and spent nuclear fuel, with the intent to complete cleanup of 16 additional sites by the end of 2006, bringing the total number of sites cleaned to 92 out of the total 114.*

New System Saves Money/Time and Reduces High Radiation Exposure—

The in-situ object counting system (ISOCS), manufactured by Canberra Industries, Inc., has been deployed at the Nevada Test Site and at Brookhaven National Laboratory. The gamma-ray spectroscopy system, demonstrated by NETL, identifies isotopes and characterizes structures, facilities, and soil as well as waste packages. ISOCS is being deployed with the Multi-Agency

“In this century, the greatest environmental progress will come about not through endless lawsuits or command-and-control regulations, but through technology and innovation.”

President George W. Bush, “State of the Union,” The U.S. Capitol, January 28, 2003.



The In-Situ Object Counting System

“In the end, the fate of children depends on our ability to use technology constructively and carefully. . . . Technological decisions made today will determine, perhaps irrevocably, the kind of physical and social world we bequeath them and the kind of people they become.”

Kenneth Keniston, U.S. professor of human development, *All Our Children*, chapter 3, The Carnegie Council on Children, 1977.



Furnace Packaged With Spray-On Polyurea Coating for Shipment to the Nevada Test Site

Radiation Survey and Site Investigation Manual. The methodology verifies that the exterior of a structure can be released for disposal prior to demolition. The combined system is lowering disposal costs and time by reducing the need to send smears, physical samples, and cores for analysis onsite and offsite, and by reducing information compilation and quality assurance reviews. A big bonus is that the combined system reduces personnel exposures to high radiation.

Three-Dimensional Model of Soil Contaminant Concentrations—During operation and following shutdown of a reactor pile at Brookhaven National Laboratory, two very large below-grade air ducts used to provide cooling to the reactor experienced water intrusion. Using the ISOCS instrument verified in the earlier project as well as other innovative technologies, NETL partnered with Brookhaven to produce a three-dimensional representation of soil contaminant concentrations under the ducts. Results indicated that contamination was located in several discrete areas, but most of the soil beneath and surrounding the ducts was clean. The cost savings that resulted from the reduced number of needed samples, the accelerated schedule, and the costs for sample analysis are estimated to be \$3.4 million. An additional \$7.1 to \$8.1 million in potential savings resulted from leaving the ducts in place and only removing the contaminated soil.

Bioremediation Technology—ARCADIS of Durham, NC, is developing biotechnology that can significantly reduce remediation costs under a contract with NETL. Bioremediation could achieve the required effluent standards in about 5 years, whereas comparable baseline pump-and-treat technology could take up to 100 years. Using this new technology means that a number of contaminated DOE sites should meet the 2006 closure schedule.

Cheaper Treatments for Metal Contaminated Soils—Nuclear Fuel Services, Inc., is partnering with IT Corporation of Knoxville, TN, to develop a treatment for mercury-contaminated soil. The treatment is an amalgamation process that stabilizes mercury and other Resource Conservation and Recovery Act metals; remediates contaminated soils, sludge, and waste; and meets land disposal requirements. Preliminary cost-benefit analyses show a potential 50-percent reduction in costs compared to the current baseline technology.

Encapsulation Technology for Radioactive Waste—Kaiser Hill Company has successfully demonstrated the use of a polyurea spray as an industrial encapsulation package for low-level radioactive and hazardous equipment at the Rocky Flats Closure Project. Under the accelerated deployment contract managed by NETL, two 20-ton Lindberg furnaces were removed, packaged using the encapsulation spray, and shipped to the Nevada Test Site for disposal. The estimated cost savings for disposal of the two furnaces exceeded \$30,000. The process is now being considered for a large contaminated waste compactor at Rocky Flats at an estimated cost savings of over \$100,000.

Russian-Developed Device Demonstrated and Deployed—NETL was successful, through its participation on the U.S.-Russian Joint Coordinating Committee on Environmental Restoration, in bringing a Russian-developed gamma-locator/isotope-identification device to the United States for demonstration. The technology was initially demonstrated at Idaho National Engineering and Environmental Laboratory (INEEL), and INEEL has since deployed it. The device is a unique arrangement that combines a gamma camera with a gamma spectrometer. It was designed and developed by the Research and Development Institute of Construction Technology (NIKIMT) in Moscow, Russia, based on a machine originally used at Chernobyl. NIKIMT and RedZone Robotics of Homestead, PA, are exploring the possibility of U.S. commercialization of the device. The device can eliminate the need to send samples offsite for analysis, reduce worker exposure to radiation, and can reduce both time and cost over similar conventional devices.

Hemispheric Center for Environmental Technology (HCET) Activities—Under DOE funding, Florida International University has been evaluating baseline and innovative technologies for deactivation and decommissioning (D&D) applications since 1995. As a result of these assessments, directly comparable performance data related to operations and maintenance, primary and secondary waste generation, and health and safety have been compiled. Two successful HCET projects are described below.

- **Jet Edge Ultrahigh-Pressure Water-Jet Cutting System**—Using 55,000-psi water pressure combined with an abrasive for controlled cutting of metal, Jet Edge technology was demonstrated in early June at the HCET by sectioning a glove box and annular tank. The demonstration was part of an evaluation of innovative technologies performed under the DOE Office of Science and Technology (OST) University Program managed by NETL.
- **Remote Harsh Environment Surveyor**—HCET's harsh-environment surveyor is a remotely controlled, mobile unit equipped with a radiation sensor that enables workers to safely assess radioactive contamination. The surveyor is an example of the technologies emerging from the DOE OST University Program that could drastically improve the D&D process at radiologically contaminated facilities while reducing decommissioning time schedules. The surveyor can also be fitted with additional tools and sensors for use in long-term monitoring and surveillance.

NETL Technology Receives Engineering Achievement Award—A diamond wire-cutting process, developed under NETL's D&D Focus Area, has received prestigious recognition. The Princeton Plasma Physics Laboratory received the 2002 Outstanding Engineering Achievement Award from the New Jersey Society of Professional Engineers. The process was used to safely dismantle the tritium-contaminated vacuum vessel of the TOKAMAK Fusion Test Reactor. Only the diamond saw comes in contact with the radioactive material, and it can cut dissimilar materials in one operation through remote control. Compared to conventional methods, the process reduces worker exposure to radiation, and produces fewer airborne emissions and radioactive waste.

“Thanks to increased international cooperation, the turn to market-based economies, and the great promise of today’s and tomorrow’s technologies, we are entering a world of almost limitless potential.”

Secretary of Energy Spencer Abraham,
“Remarks at the Announcement of the
FutureGen Power Plant of the Future Project
and the Carbon Sequestration Leadership
Forum,” Washington, D.C., February 27, 2003.



Remote Harsh Environment Surveyor

“Since September 11, 2001, our Nation has taken great strides to improve homeland security. Citizens, industry, and Government leaders from across the political spectrum have cooperated to a degree rarely seen in American history.”

President George W. Bush, *National Strategy for Homeland Security*, July 2002.



A Fuel Cell Power Plant

National Nuclear Security (NS)— *Strengthen United States security through the military application of nuclear energy and by reducing the global threat from terrorism and weapons of mass destruction.*

Nuclear weapons remain a key component of the Nation's security posture. A critical challenge is the proliferation of weapons of mass destruction: nuclear, chemical, or biological weapons or nuclear materials that could fall into the wrong hands and be used against U.S. interests, both domestically and internationally. In addition, international events and crises continue to arise to which the United States must project a proactive presence. NETL is involved in looking at ways of reducing the production of weapons of mass destruction by foreign countries, and in finding safe and economical ways to store radioactive waste.

NS2—Detect, prevent, and reverse the proliferation of weapons of mass destruction while promoting nuclear safety worldwide.

Creating a Fuel Cell Industry in Russia—NETL is helping create a new industry and partnership among DOE, the Russian Federation (RF) Minatom, and U.S. and Russian private industry with funding from the Nuclear Cities Initiative (NCI). The goal of the NCI program is to engage Russian nuclear-weapons scientists in alternative economic pursuits other than the production of weapons of mass destruction, and the objective of the partnership is to use the resources of former RF weapons manufacturing facilities to launch a fuel cell industry in Russia. NETL is helping the partnership develop a business plan, form a U.S.-RF joint venture, and obtain capital funds. The joint venture will commercialize several types of fuel cells. Goals include cost reduction, market and infrastructure development, and job creation. The ultimate vision is a self-sustaining, worldwide, competitive, RF fuel cell power plant industry by 2010.

International Nuclear Safety and Cooperation—NETL initiated work on the National Nuclear Security Administration's Seversk and Zheleznogorsk plutonium production elimination projects. These two projects and the nuclear safety upgrades project, which is supported by Pacific Northwest National Laboratory, constitute the Office of Defense Nuclear Nonproliferation's Elimination of Weapons Grade Plutonium Production Program. NETL's efforts in support of the program are to provide sufficient coal-based replacement energy to permit the RF to shut down its three remaining plutonium-production reactors. These RF reactors, two located at Seversk (Tomsk region) and one located at Zheleznogorsk (Krasnoyarsk region), provide essential heat and electricity to these two Siberian cities and surrounding regions.

Corporate Management (CM)—
Demonstrate excellence in the management of the Department's human, financial, physical, and information assets. Successfully implement each of DOE's requirements in the President's Management Agenda; demonstrate measured progress in resolving DOE's management challenges; and resolve all management recommendations from DOE's Inspector General and General Accounting Office within 3 years of issuance.

The corporate management goal is the focus for improving management and accountability while ensuring the safety, security, and health of the workforce and members of the public. NETL contributes to best business and management practices by using corporate systems that integrate a diverse portfolio of program missions with our program support structure. We provide a safe and rewarding workplace, and we are recognized for our business excellence and our ability to deliver results. We act as a customer-oriented public servant, working for our internal DOE customers, but ultimately for American taxpayers.

CMI—Achieve effective and efficient management of the Department of Energy by implementing the President's Management Agenda initiatives on Strategic Management of Human Capital; Competitive Sourcing; Improved Financial Performance; and Budget and Performance Integration.

NETL Earns PILLAR Award—NETL was one of two Federal agencies to receive the PILLAR (Performance, Incentives, and Leadership Linked to Achieve Results) Award in August 2002. The award represents the highest recognition given by the U.S. Office of Personnel Management and recognizes exemplary employee performance-management practices that contribute to a citizen-centered, results-oriented Government. Thirty nominations were received from 14 different agencies. NETL received the award for its innovative and effective performance management and awards system. This system is based on linking employees with organizational goals, performance measures, and a rewards system that reaches employees at all levels.

“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, “President's Message,”
The President's Management Agenda, Fiscal Year
2002.



NETL's Performance Management and Awards System

“Good beginnings are not the measure of success. What matters in the end is completion. Performance. Results. Not just making promises, but making good on promises.”

President George W. Bush, “President’s Message,”
The President’s Management Agenda, Fiscal Year
2002.



Excellence-in-Government Awards—The Pittsburgh Federal Executive Board annually recognizes outstanding employees in the Pittsburgh and Morgantown areas with Excellence-in-Government Awards. The annual event rewards employees in the Federal Government whose service demonstrates deep personal and professional commitment. Over 150 nominations were received from area agencies. Seven NETL employees and one NETL team received awards: three gold awards, one silver award, and four bronze awards.

Malcolm Baldrige Self-Assessment—NETL conducted its second Malcolm Baldrige National Quality Award Program criteria self assessment in FY 2002. The assessment addresses performance and helps to determine strengths and weaknesses relative to the award criteria. NETL employs a systematic approach that is responsive to the basic purposes of most items in the Baldrige criteria. The results of the assessment were used to improve NETL’s collection of performance metrics, and to create baseline trends as a foundation for performance improvement.

HBCU/OMI Program—NETL selected six projects under the Historically Black Colleges and Universities and Other Minorities (HBCU/OMI) program in FY 2002. The HBCU/OMI program recognizes that first-class scientific studies are needed to advance global industrial competitiveness, clean energy research, national security, and environmental quality. The program (1) serves as a technology base for developing ideas and data to generate new and improved products; (2) provides opportunities for developing mentoring relationships with industrial partners; and (3) assists in producing the next generation of scientists and engineers of diverse backgrounds.

Assistance to Headquarters Programs—NETL played a significant role in several DOE programs in FY 2002:

- **Investment Decisionmaking and Performance Measurement**—DOE’s FE office was one of the 20 percent of Federal Government agencies that completed the U.S. Office of Management and Budget (OMB) Program Assessment Rating Tool (PART) during FY 2002. NETL completed the 32-question PART appraisal for five program components: the Clean Coal Research Initiative, Fuel Cells (Stationary), Methane Hydrates, Gas Exploration and Production, and Oil Exploration and Production. PART assesses program purpose and design, strategic planning, and program management and results. In terms of performance measurement, NETL uses a Baldrige-like “dashboard” to assess performance against a set of high-level metrics, one of which is our performance against GPRA annual targets. During FY 2002, NETL met 10 of its 11 GPRA targets, with one delayed until FY 2003.

- **Value Engineering**—The NETL Center for Acquisition and Business Excellence (CABE) serves as the lead Federal support group for the DOE Office of Engineering and Construction Management in establishing and managing the Department's Value Engineering program. This year, the CABE completed development of a standard practice for value engineering that will be included in the upcoming revision of the DOE Project Management Practices Guide. The CABE also developed the value engineering training curriculum to be included in the DOE Project Management Career Development Program.



Staffing for the Future—NETL identified and analyzed a number of issues, such as prospective retirements, declining budgets, functional studies under the Federal Activities Inventory Reform Act, and skills-mix imbalances, that could affect our ability to meet current and new mission requirements. Management of human capital is an important part of the President's Management Agenda: agencies must demonstrate that their human capital strategy is aligned to support mission, goals, and organizational objectives. NETL's strategic analysis identified skills that may be lost by attrition, skills needed to support anticipated mission changes, and a proposed strategy for meeting the requisite skill mix through FY 2006.

Project Management Training and Certification—In an effort to continually improve the quality of our workforce, NETL has institutionalized a project management training program. This program is based on principles of the Project Management Institute (PMI), an internationally recognized organization. Seven NETL project managers have received certification as Project Management Professionals, and 40 others have been accepted by PMI as qualified to take the certification examination this coming year. NETL's overall goal is to have 90 percent of project management staff certified by 2005.

Minority Mentoring and Internship Program (MMIP)—NETL completed the second year of this program, which provides internship opportunities to students. In addition to the six students in the MMIP, NETL also employs six students in the Student Career Employment Program. Hiring students is part of NETL's succession planning.



Senior Executive Service (SES) Mentoring Program—This program teams SES-level mentors with protégés selected from among applicants at general service (GS) levels 13 through 15 who have shown strong leadership potential. Thirteen protégés were selected from among 26 applicants and paired with mentors. Mentor-protégé pairs are pursuing objectives outlined in individualized mentoring agreements prepared for 1-year terms.

“I will expand the use of the Internet to empower citizens, allowing them to request customized information from Washington when they need it, not just when Washington wants to give it to them. True reform involves not just giving people information, but giving citizens the freedom to act upon it.”

Governor George W. Bush, “Making the Government More Efficient,” Philadelphia, PA, June 9, 2000.



Gallup Survey on Employee Engagement—NETL worked with the Gallup Organization to develop and implement an Organizational Improvement Training Program (OITP). Using a simple 13-question survey of employees, the OITP assessed the current strength of NETL’s workplace. Strength of a workplace is described as the level to which an organization engages employees in their work and work life. The 2002 OITP provided a baseline measurement, and successfully raised awareness of the importance of employee engagement—involvement and commitment to their work—as a critical component for achieving program and institutional results. It also provided managers with a tested process for work unit improvement.

CM2—Implement the President’s E-Government initiatives by developing a framework for existing Information Technology and building a roadmap for corporate direction.

Electronic Posting of Solicitations—Approximately 99 percent of all NETL competitive solicitations, including competitive financial assistance solicitations, were issued electronically through the DOE web-based industry interactive procurement system. Technical evaluators were able to review proposals and applications electronically, speeding up the review process while saving time and duplication, paper, and postage costs.

SECA Workshop—Conference attendees at the Third Annual SECA Workshop meeting were able to use one of DOE’s E-Government initiatives. Those who chose not to travel to the Pittsburgh conference location were able to access presentation materials in real-time via the Internet and participate in workshop discussions by telephone. Providing electronic access to workshops is one way E-Government can reduce travel time and expense and open meetings to a wider range of participants. SECA is a joint DOE-industry effort to develop an ultralow-cost fuel cell.

Electronic Compliance and Approval Process (ECAP)—The ECAP system was developed by the Texas Railroad Commission in partnership with NETL (through the NPTO) and the oil and gas industry. It is an electronic commerce system that eliminates paper by capturing, storing, and electronically transmitting permitting information on oil or gas wells. ECAP is expected to save \$3 to \$6 million annually, improve communication, and streamline regulatory processes through the use of Internet-based technologies, relational databases, document imaging, and workflow software. The process shortens approval from 2 to 4 days to 1 hour. Once the ECAP system is fully implemented to include other performance reports and compliance permits, total annual industry savings in Texas, based upon only 25-percent utilization of electronic filing, is expected to be \$17.5 million.

Environmental Cost Analysis System (ECAS)—The CAFE completed several enhancements to the web-based ECAS, which is used to maintain and analyze actual cost data for completed EM site cleanup projects. ECAS uses the Engineering News Record Construction Cost Index History to escalate costs for inflation. The CAFE also provided system support for the installation of ECAS at the Savannah River Site, the first site to actually enter project costs interactively into ECAS.

I-MANAGE—NETL is actively participating in DOE's Integrated Management (I-MANAGE) Navigation System project, which will provide each manager in DOE with current, web-accessible information on budgets, people, procurements, projects, performance, and spending. The first major application, the Standard Accounting and Reporting System (STARS), is due to be implemented on October 1, 2004, and will replace the Department's legacy accounting system, DISCAS.

CM3—Ensure secure, efficient, effective, and economical operations of the Department's Information Technology systems and infrastructure.

Information Management—NETL has adopted the rational unified process (RUP) as its software engineering methodology. RUP is a web-enabled set of software engineering processes that will help streamline NETL programming and program-development activities. The software supports object-oriented web-based applications development, which will mean better information technology solutions for NETL business processes.

Network Intrusion Detection—NETL initiated an upgrade of its network intrusion detection system as a result of a comprehensive cyber-security vulnerability assessment. NETL's cyber-security resources were enhanced by providing a centralized monitoring and reporting capability. This facilitates greater access to data correlation, and security personnel are better able to respond rapidly to cyber threats.

“Thanks to the advances of electronic Government, we envision a future that will be very different from—and very much better than—anything the Department has seen in its first 25 years. We will have a strongly defined information technology portfolio, closely tied to a comprehensive enterprise architecture, supported by a robust budget process with strong cyber security protection.”

Secretary of Energy Spencer Abraham,
“Remarks, DOE e-GOV Action Plan Rollout,”
October 16, 2002.



“The acquisition of knowledge is the mission of research, the transmission of knowledge is the mission of teaching, and the application of knowledge is the mission of public service.”

James A. Perkins, president of Cornell University, “The University in Transition,” Stafford Little Lectures at Princeton, November 3, 1966.



CM4—Provide analysis of domestic and international energy policy; develop implementation strategies; ensure policies are consistent across DOE and within the Administration; communicate analyses and priorities to the Congress, public, industry, foreign governments, and domestic and international organizations; and enhance the export and deployment of energy technologies internationally.

Provide Analysis of Domestic and International Energy Practices and Policies—NETL provided several technical reports for Government planners and energy policy leaders:

- **Report on Carbon Sequestration**—NETL developed a report analyzing the national benefits of carbon sequestration. The report examines the potential contribution of carbon sequestration R&D to achieving the President’s goal of 18-percent reduction in greenhouse gas (GHG) intensity by 2012. The analysis provided a scenario for stabilizing GHG emissions by mid-century and identified carbon sequestration as essential for that achievement. Carbon sequestration can account for at least 50 percent of the required emissions reduction.
- **Industry Perspective on Gasification Markets and Technologies**—NETL compiled a report on the gasification industry’s view of R&D needs to meet future market opportunities and environmental challenges. The report was based on confidential interviews with expert teams from 22 prominent organizations in the U.S. gasification industry.
- **New Regulation on Cooling Water Use by Power Plants**—NETL prepared two reports on the new EPA ruling on the use of cooling water intake structures in coal-fired power plants. The intent of the ruling is to ensure that aquatic organisms are not affected. The reports quantify the costs and regional impacts associated with retrofitting existing power plants to conform with the new ruling, and discuss the feasibility of such retrofitting at four existing steam-condensing power plants. NETL also reviewed and critiqued numerous EPA reports on the proposed regulation during the interagency review and subsequent public comment periods.
- **The Economics of Gas Turbines**—A region-specific study about the economics of gas turbines fueled by natural gas and gas turbine combined-cycle systems was completed by NETL. The largest competitive electricity market of the United States is the Pennsylvania, New Jersey, Maryland interconnect (PJM) region. Evaluation of a range of possible fuel price scenarios concluded that, at gas prices below about \$4.00 per MBtu, investors would continue to invest in new gas-turbine-based projects. However, at higher fuel prices (without a corresponding increase in the price of electricity), such an investment would not be made.

- **Fuel Cell Technology Benefits Quantified**—An NETL study for the EPA characterized the potential environmental benefit to the United States if fuel cell technology were to be deployed in our industrial business sector. Conclusions state that an annual pollution amount equivalent to 200 typical 100-MW power plants could be avoided.
- **GHG Emission Reductions in the Transportation Industry**—NETL authored a report for the DOE Clean Cities program aimed at national and international project developers and other entities. *GHG Emission Reductions and Natural Gas Vehicles: A Resource Guide for Project Development* provides a guide on how to estimate and document the GHG emission reduction benefits or penalties of natural gas vehicles. The manual is available the DOE Clean Cities Program webpage, on NETL's Climate Change Policy Support webpage, and on CD from NETL.
- **Rocky Mountain Gas Resources**—Gas-in-place resources of Rocky Mountain basins have been assessed by NETL researchers. This first-time, detailed, regional assessment analyzed hundreds of well-log suites to better understand geologic and engineering parameters. This scientific knowledge is guiding development of technology expected to someday allow resource recovery of natural gas that would otherwise be deemed unrecoverable.

Develop Implementation Strategies—NETL developed implementation strategies for several DOE programs in FY 2002:

- **Strategies on Mercury and Other Pollutants**—In support of interagency strategy discussions on control of mercury and other pollutants, NETL analyzed the cost and performance of mercury and NO_x control technologies for coal-fired boilers. NETL-sponsored in-house research on mercury control was heavily referenced by the EPA in a report on controlling mercury emissions from coal-fired electric utility boilers. NETL's analyses and comments were submitted to the DOE Policy Office and to the Department of State on the United Nations draft global mercury assessment report. NETL conducted workshops and meetings with industry representatives and other key stakeholders to obtain input into future needs for mercury control technology R&D. Input was also obtained through meetings with industry, EPA, State environmental agencies, research organizations, and other interested parties to identify the potential implications of future mercury regulations on the sale and disposal of coal by-products and on research needs and opportunities.



Fuel Cell Vehicle



Wisconsin Electric's Pleasant Prairie Power Plant,
Mercury Control Test Site



FutureGen, the Integrated Sequestration and Hydrogen Research Initiative, is a Government/industry partnership to design, build, and operate a nearly emission-free, coal-fired electric and hydrogen production plant.

- ***CO₂ Capture and Sequestration Give IGCC an Edge***—Coal-based IGCC with CO₂ capture and sequestration would produce only one-fifth the specific carbon emissions of state-of-the-art natural-gas combined-cycle systems. If captured CO₂ can be sold at historically realized prices for use in enhanced oil recovery, electricity generation by IGCC with CO₂ capture can be profitable with no subsidy for avoidance of CO₂ emissions. There are prospects for deploying this technology in every State with oil production, notably including California.
- ***Theory-Based Process Modeling of Fuel Cells***—NETL has demonstrated that the standard components of commercial simulators can be used to formulate a thermodynamically consistent fuel cell model. Since the theory-based model can predict fuel cell performance for conditions outside actual test data, it has been used to identify potential new directions for several DOE programs, including hybridization of fuel cells with reciprocating engines, and systems that capture CO₂ from coal-derived fuel gases without the efficiency penalties of conventional systems.
- ***Natural Gas Potential in Powder River Basin***—The rich coal seams of the Powder River Basin in Wyoming and surrounding States may hold much more natural gas than previously believed. Advanced Resources International, working under contract to NETL, has completed a study of coalbed methane development and produced water management in the Powder River Basin. The study raises the Wyoming Geological Survey's estimate of recoverable coalbed methane from 25 to as much as 39 Tcf.



Enhance Export and Deployment of Energy Technologies

Internationally—NETL researchers actively market our clean, efficient technologies abroad. NETL also actively assists commercial enterprises in exporting their technologies, most of which were developed under various contractual mechanisms with NETL:

- ***Promoting Clean Coal Technology in the Asia Pacific Region***—Three coal technology meetings and a CO₂ reduction study for the power sector in Asia Pacific Economic Cooperation (APEC) economies were conducted by the Expert Group on Clean Fossil Energy (EGCFE), which is chaired by NETL. The meetings, which were held in Malaysia, included a seminar on the Asia Pacific coal trade, a clean fossil-energy technology seminar, and a workshop on trade and investment in the fossil-energy sector of APEC economies. Site visits to two coal-fired power plants were also conducted.
- Representatives from Australia, Canada, Chinese Taipei, Korea, Hong Kong, Indonesia, Japan, Malaysia, Mexico, Philippines, P.R. China, Thailand, the United States, and Vietnam attended the meetings. Also, under EGCFE guidance, a study was completed on options to reduce CO₂ emissions from electricity generation in the APEC region.

Nineteen technical options were identified that could be used to reduce CO₂ emissions from existing and future APEC power plants. A second phase of the project will include case studies of actual CO₂ reduction projects and action plans, and a third phase will disseminate project information to senior officials in the energy ministries and power sectors of APEC countries.

- **United Nations Conference of Parties**—The 8th Session of the Conference of Parties of the United Nations Framework Convention on Climate Change recently met in New Delhi, India. NETL provided two adjunct events in cooperation with our regional partners, Winrock International, National Thermal Power Corporation, and the U.S. Agency for International Development (USAID)-Delhi. The two events were a combined heat and power and decentralized energy symposium, and a USAID international conference and exhibition. A compendium on cogeneration with an emphasis on renewable energy, and the NETL *Handbook on Sugar Mill Cogeneration* were presented to the Chief of the USAID mission and the U.S. ambassador for distribution at the conference. Approximately 400 attendees participated in the conference and adjunct events.
- **Promoting Fuel Cell Use in Foreign Countries**—NETL scientists and engineers are promoting the use of fuel cell technologies as environmentally sound power systems:
 - **Egypt:** NETL is managing a project funded by USAID-Cairo under a fuel cell cooperative agreement between DOE and Egypt. A fuel cell test facility is being designed for the Egyptian Electric Holding Company (EEHC). DOE engineers and support contractors performed a site inspection survey and obtained site-specific information to complete the design. EEHC officials visited the United States to (1) participate in a review of their design-build plan, (2) meet with representatives of U.S. fuel cell companies, and (3) visit an operating 200-kilowatt phosphoric acid fuel cell plant operating on natural gas and a fuel cell testing laboratory. The cooperative agreement supports foreign interest in developing fuel cell technologies that are environmentally sound while promoting U.S. exports and sustainable economic growth.
 - **Latin America:** Participants at a fuel cell meeting hosted by NETL agreed to pursue the establishment of a Latin America Fuel Cell Council to facilitate future collaboration, resource-sharing, and information exchange. Government and private sector representatives from Brazil, Argentina, and Mexico met with national laboratory and private industry personnel to discuss the technical and business aspects of fuel cell deployment in their countries.

“We have become a great Nation, forced by the fact of its greatness into relations with the other nations of the Earth, and we must behave as beseems a people with such responsibilities. Toward all other nations, large and small, our attitude must be one of cordial and sincere friendship. We must show not only in our words, but in our deeds, that we are earnestly desirous of securing their good will by acting toward them in a spirit of just and generous recognition of all their rights.”

President Theodore Roosevelt (1858-1919),
“Inaugural Address,” March 4, 1905.



*“You cannot escape
the responsibility of
tomorrow by evading
it today.”*

President Abraham Lincoln
(1809-1865).

- **Training Programs**—NETL conducted training for U.S. foreign-service officers, power company personnel from India, and Russian oil and gas professionals in FY 2002:
 - **Training for Foreign Service Officers**—NETL conducted the third annual week-long course on coal and power for the U.S. Department of State’s foreign-service officers. The training focused on important issues in the international energy arena, such as electricity deregulation, clean coal technologies, climate change, pollution control technologies, and ultraclean fuels. The U.S. Government and private industry must cooperate if the technological advances in coal and power supported through DOE programs are to be translated into world-market shares for U.S. industries. Benefits of this cooperation will spread to the worldwide energy arena to ensure safe, affordable, and clean energy for future generations.
 - **SABIT Program**—NETL partnered with the U.S. Department of Commerce (DOC) and Syntroleum Corporation to train 18 oil and gas professionals from Ukraine, Uzbekistan, Azerbaijan, Russia, Kazakhstan, Georgia, and Tajikistan. The training program was broad in scope but limited to exploration and production topics, including business and strategic planning, cross-cultural business practices, project management, new techniques, and environmental strategies and solutions. The training was part of DOC’s Special American Business Internship Training (SABIT) program. The SABIT oil and gas exploration and production program offers the unparalleled opportunity for energy companies in the United States to meet with the chief decision makers, procurement officers, and engineers working for potential clients and partners from the former Soviet Union. One of the goals of the program is to enhance the transition of these countries’ economies into market-oriented U.S.-friendly strongholds. To date, SABIT has helped generate more than \$200 million in revenues and has successfully trained more than 2,000 executives and scientists from the former Soviet Union.
 - **Training Indian Power-Company Personnel**—Two Indian power-company engineers/middle managers completed an intensive 5-week training program in the United States. The training was facilitated by NETL and included visits to power plants and power stations in Kentucky and Tennessee and the National Center for Coal and Energy in West Virginia. Sessions included information on heat rate and CO₂ monitoring software, sulfur and nitrogen oxides compliance, the U.S. power market, and U.S. power pricing and dispatching practices. The training was supported under the Greenhouse Gas Pollution Prevention Program funded by USAID-India.

Communicate Analyses and Priorities—NETL's technical analyses often lead to suggested priorities—for example, for further research to expand the technical knowledge base or for commercialization of specific products or technologies. But to be effective, these analyses and the resulting priorities must be communicated:

- **Mid-Continent Carbon Sequestration Database**—Through a cooperative agreement with geological surveys in Illinois, Indiana, Kansas, Kentucky, and Ohio, NETL initiated development of web-based computer technology that will enable evaluations of the carbon sequestration potential in these five mid-continent States. When fully developed, the Mid-Continent Interactive Digital Carbon Atlas and Relational Database will allow users to locate and estimate point sources of CO₂ releases in relation to geologic features that could be used as potential reservoirs for CO₂ sequestration. When fully operational, this natural resource database and geo-information system could serve as a prototype for a national database on carbon sequestration.
- **Fuel Cell Handbook Published**—NETL published the 6th edition of its *Fuel Cell Handbook*. First published in 1988, the handbook now includes over 5,000 fuel cell patent abstracts and their claims, features a new fuel cell power conditioning section, and contains an overview of the hydrogen industry and rare-earth minerals market. This knowledge continues to stimulate emerging fuel cell technology innovations.
- **GasTIPS to Reach Users**—NETL reached out to thousands of potential new technology users by teaming with the Gas Technology Institute in 2002. They are communicating emerging R&D for cost-effective solutions to meet growing natural gas demands in the United States. NETL's SCNG is working with Hart Publications to provide a quarterly newsletter called *GasTIPS* that will describe these latest technology solutions.
- **Websites Offer Technology Solutions**—Websites are today's way of transferring information to the widest possible audience. NETL has been active in establishing new websites and upgrading and maintaining those already in existence:
 - **National Methane Hydrate Website Established**—Government, academic, and industry partners advanced efforts to better understand methane hydrates as a climate change agent, a subsea hazard, and as a natural gas resource. The research program, coordinated by NETL's SCNG, now involves 13 Government laboratories or agencies, 10 universities, and a dozen exploration and production (E&P)-related private companies. The SCNG established a methane hydrate website as a single reference point for updating and informing project participants, industry, and the public about evolving scientific findings. In addition, the SCNG now publishes a periodic newsletter, *Fire in the Ice*, to inform interested parties of workshop events and research activity.



*“Do not go where the path
may lead, go instead where
there is no path and leave
a trail.”*

Ralph Waldo Emerson (1803–1882),
U.S. essayist, poet, philosopher.



- **Clean Coal Power Initiative (CCPI) Website**—NETL established the CCPI website to provide public access to current, complete, and accurate information on the implementation of this cost-shared partnership between the Government and industry. Specific information, such as a copy of the final solicitation and schedules for all pre-award meetings and workshops, has been posted. A bulletin board on the CCPI homepage provides the latest news and current events for this program.
- **Clean Coal Technology (CCT) Compendium**—The NETL-managed CCT Compendium, which presents a worldwide web source of data generated from the CCT program and related CCT developments, was cited by a National Science Foundation (NSF) project that provides an on-line Internet source of the most valuable and authoritative science and technology literature. The NSF's biweekly periodical, the *National Science Digital Library Scout Report for Math, Engineering, and Technology*, cited the CCT Compendium in its July 19 issue. The CCT Compendium website (www.lanl.gov/projects/cctc) continues to receive large numbers of visits, occasionally exceeding 20,000 per week and often consisting of greater than 10 percent international accesses, from Australia and countries of the European Union, Asia, South America, Africa, and the South Pacific.
- **Key Conferences and Workshops**—Conferences, symposia, and workshops offer the best and fastest way to transfer technology: one-on-one meetings between the technology provider and the technology user. NETL was involved in meetings with stakeholders in many fossil energy technologies in FY 2002:
 - **Inaugural Gas Technology Conferences**—NETL's SCNG joined with the Gas Technology Institute to sponsor two technology exchange conferences: Natural Gas Technology—Investment in a Healthy U.S. Energy Future in May 2002, and Natural Gas Technologies—What's New and What's Next? in September 2002. These forums collectively involved over 700 attendees. Participants learned about emerging technology solutions of national impact, and provided feedback to government leaders for incorporation into R&D planning and prioritization.
 - **Government Research Pooled for Better, Faster Results**—Research results and plans for future methane hydrate research among Federal agencies were addressed at the first Methane Hydrate Interagency R&D Conference in March 2002. The collaborative conference was sponsored by FE, NETL, the Naval Research Laboratory, Minerals Management Service, U.S. Geological Survey, National Oceanic and Atmospheric Administration, and the National Science Foundation. Over 100 participants heard reports of technology advancements at the SCNG-coordinated event. Each agency presented research efforts by U.S. geographical region: Arctic, West Coast, East Coast, and Gulf of Mexico. Results are available on CD from the NETL website.

- **Electricity Generation and Water Issues**—NETL conducted workshops and meetings with industry and other key stakeholders on emerging electricity generation and water issues, including Clean Water Act 316(b) regulations dealing with cooling-water-intake structures. The purpose was to identify R&D needs.
- **Coal Combustion**—NETL participated on industry and EPA working groups to develop improved analysis protocols to characterize the leachates from coal combustion by-products.
- **Health Benefits Study**—NETL sponsored a Health Benefits Study to assess the feasibility of using existing models to evaluate potential health benefits that may accrue to the public through application of coal-based technologies developed by NETL.
- **Coal Utilization**—NETL participated in review meetings with the Coal Utilization Research Council to establish milestones for strategic R&D on coal technologies, and to identify partnerships and resources that could accelerate commercial deployment of coal technologies being developed by NETL or being demonstrated as part of the President's CCPI.
- **Geologic Sequestration**—NETL met with representatives from the American Association of State Geologists and the Interstate Oil and Gas Compact Commission to discuss development of policies and guidelines for geologic sequestration that would reduce regulatory uncertainties associated with geologic sequestration.
- **Terrestrial Sequestration**—NETL met with representatives from the U.S. Department of Agriculture to identify research needs for establishing the technical viability of terrestrial carbon sequestration. Research needs include methods for measuring and monitoring GHG in the atmosphere and carbon in the soil in order to establish the type of rigorous accounting system needed to determine the effectiveness of candidate methods for terrestrial carbon sequestration.

*“If you have built castles
in the air, your work need
not be lost; that is where
they should be.*

*Now put the foundations
under them.”*

Henry David Thoreau (1817-1862), essayist,
poet, and practical philosopher.



“ Our first responders nationwide need standardized training. They need procedures and equipment that will allow them to communicate with each other during a crisis. We intend to enhance cooperation across the Federal Government.”

Secretary of Homeland Security Tom Ridge, “Governor Ridge Speaks at Homeland Security and Defense Conference,” November 27, 2001.



A canine named Adam has been trained to find missing or lost persons, cadavers, narcotics, and bombs. He demonstrated his prowess at a training meeting held at NETL, remaining focused but good natured as he practiced responding in unfamiliar territory.

CM5—Reduce adverse security incidents, worker injuries, and environmental releases through policy development, counterintelligence, intelligence, and oversight of the Nation’s energy infrastructure, nuclear weapons, materials, facilities, and information assets.

Attaining ISO 14001 Certification—Attaining International Organization for Standardization (ISO) 14001 certification is a process by which a company or organization establishes and manages its environmental goals. NETL conducted four internal audits in FY 2002 in preparation for final ISO certification. The NETL goal is to obtain certification in FY 2003.

- **Environmental Management System (EMS) Leads to Waste Reductions**—NETL surpassed its FY 2002 targets for minimizing waste and pollution. Hazardous and non-hazardous waste generation were minimized through increased recycling, and pollution was reduced through greater use of less-polluting, more-efficient, alternate fuel vehicles. Toxic-release inventory chemicals were decreased below the target levels. Other EMS achievements include implementation of a records management system and a directives process for managing policies, plans, and procedures; and continued review of documentation and processes for compliance to the ISO 14001 standard.

ESS&H Achievement Award—NETL’s integrated model for responding to bomb threats earned NETL employees Jeff Buterbaugh, Rodger Dotson, and Cindy Mullens the DOE FE Environment, Security, Safety, and Health Achievement Award. The procedure was developed to conduct improved bomb searches and to manage bomb threats in the post 9-11 era. The model encompasses assessment of bomb threats, working with bomb-search dogs and community emergency response teams, documenting findings in diverse industrial complexes, and assessing the safety of employees returning to their work areas after a threat.

Outstanding Award for Accident Prevention—For the sixth consecutive year, NETL earned the Outstanding Achievement Award in recognition of exceptional accident prevention performance in occupational safety from the Western Pennsylvania Safety Council. The award is given to western Pennsylvania organizations with representative Standard Industrial Classification Codes who maintain the lowest lost workday case rates under the Occupational Safety and Health Administration.



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