

# National Energy Technology Laboratory Accomplishments FY 2000



## Message from the Director

In May 2001, the Bush Administration issued the National Energy Policy, which provides recommendations to promote the dependable, affordable, and environmentally sound production and distribution of energy for the future. The goals of the new U.S. energy policy include:

- Increasing energy conservation and efficiency,
- Protecting America's environment,
- Increasing domestic energy supplies,
- Increasing the use of renewable and alternative energy,
- Modernizing the energy delivery system, and
- Enhancing national energy security.



The National Energy Technology Laboratory (NETL) is the Department of Energy's fossil-energy research laboratory. NETL supports the goals in the National Energy Policy by developing technologies that can provide affordable energy without compromising the quality of life for future generations of Americans. Our portfolio of energy technologies encompasses coal-fired power generation, natural gas-fired power generation including fuel cells and combustion turbines, carbon sequestration, gas and oil production and transmission, and the production of clean liquid fuels for the transportation and other end-use sectors.

To carry out our mission, we partner with industry, universities, other national and federal laboratories, private research organizations, and other federal and state agencies. We have over 1,100 research and demonstration activities underway at locations across the United States and in numerous other countries. We also conduct on-site research at our laboratories in Morgantown and Pittsburgh.

In addition to our fossil energy activities, NETL also provides support to other parts of the Department of Energy. For the Office of Environmental Management, we support the development and deployment of environmental technologies to reduce the cost and risk of remediating the Department's weapons complex.

NETL supports the Department's goal to use best business and management practices. We run our organization like a business and are accountable for the results. The following report is a record of our accomplishments for fiscal year (FY) 2000.

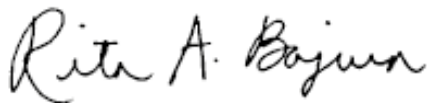
This report responds to the Government Performance and Results Act of 1993 by describing how NETL has spent taxpayer funds and the benefits achieved.

I am proud of NETL's record. Our partnerships for contracted research and our on-site research have resulted in:

- Higher efficiency, ultra-clean power generation technologies that conserve our energy resources and provide affordable, environmentally sound energy for consumers.
- Advanced technologies to produce energy from hard-to-reach resources, which expand our supply base and lower the cost of producing energy.
- Efficient methods for reducing emissions from our existing fleet of power plants, which enhance our environment and keep power production costs at reasonable levels.

Please take the time to look at this first annual accomplishments report. I believe the achievements speak for themselves.

Thank you,

A handwritten signature in black ink that reads "Rita A. Bajura". The signature is written in a cursive, flowing style.

Rita A. Bajura  
Director  
National Energy Technology Laboratory

# Table of Contents

NETL: Building America's Future .....	1
NETL Today .....	3
Mission .....	5
Vision .....	5
NETL's Contributions to the Energy Future .....	7
NETL's Programmatic Accomplishments – FY 2000 .....	8
Plans for the Future .....	24

# NETL: Building America's Future

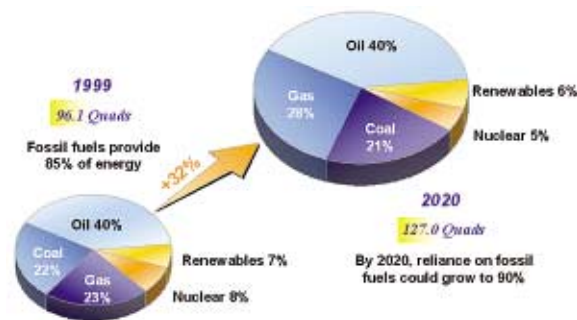
## Introduction

The history of the National Energy Technology Laboratory (NETL) dates back to 1910, moves forward to the early stages of synthetic fuel development in the 1940s, and opens a new chapter today, with its recently defined role as a national laboratory. Gaining new status as a national laboratory, along with its emerging leadership role in natural gas and oil research, NETL, more than ever can turn its legacy of achievements into public benefits. To capture those achievements, NETL has prepared this Accomplishments Report to illustrate how the programs NETL implements for the U.S. Department of Energy (DOE) serve as a tool for building America's energy future. This report examines NETL's achievements in energy supply, reliability, affordability, policy support, and environmental issues; our capability to reduce costs and expedite environmental remediation within the DOE Weapons Complex; and our contribution to best business practices within the Department. NETL's history, emerging national role, and record of achievements are indelibly linked to the nation's past and future need for fossil fuels.

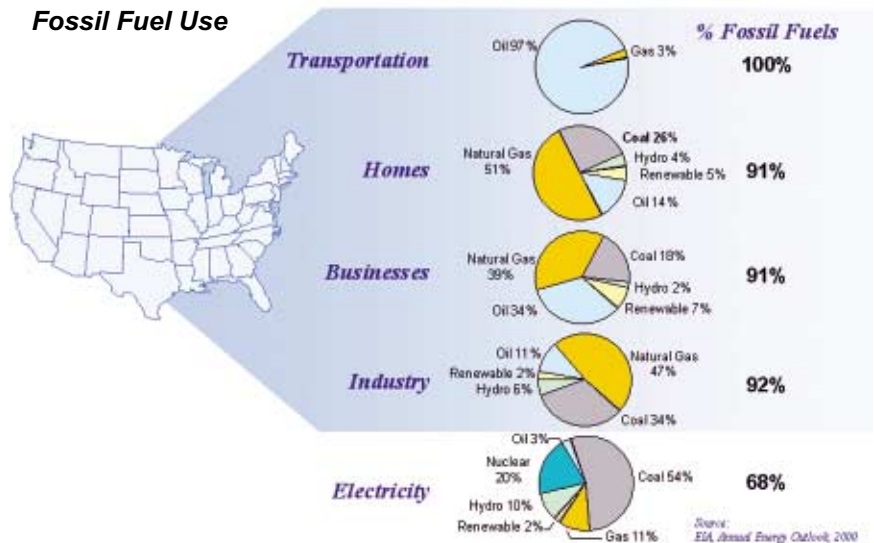
## Background

America's economic engine is fueled primarily by fossil fuels. Coal, oil, and natural gas supply 85 percent of the nation's total energy, 68 percent of its electricity, and nearly 100 percent of its transportation fuels. And, by 2020, largely because of the projected growth in natural gas consumption, DOE forecasts that fossil fuels will be supplying 90 percent of the nation's energy. In fact, America's abundance of coal and natural gas, and the low costs of these fuels, are the main reasons why U.S. consumers benefit from some of the lowest electricity rates of any free market economy. Our economy is strong largely because of these fuels. Our environment is becoming cleaner because we have invested in clean coal and other low-polluting technologies.

**America's Reliance on Fossil Fuels**



**Fossil Fuel Use**



The Fossil Energy program can trace its roots back to the early part of the 20th century. Concerns over crude oil dominated much of its early history. However, in the 1970s, environmental concerns became as important as energy security concerns. Federal fossil-energy research programs emphasized technologies that could reduce the emissions of sulfur dioxide and nitrogen oxides – precursors to acid rain and smog, respectively. Environmental protection efforts in the oil and gas industries came in the form of smaller “footprints,” and better handling of production wastes. Federal research facilities established in the post-World War II era to develop synthetic fuels shifted much of their research focus toward solving the environmental problems associated with fossil-derived fuels.

More recently, the research has shifted to answer the question, “How can we do it better?” The increasing threat of power outages spreading beyond California, recent explosions in aging gas pipelines and storage facilities in New Mexico and Kansas, power transmission bottlenecks in the Northwest and New England, gas pipeline constraints in the Northeast, continued uncertainty over the actions of OPEC and other crude suppliers, and concerns

over climate change all raise concerns over whether the United States can continue to rely on the fuels that have powered its economic growth.

Higher electricity rates and natural gas prices are affecting most Americans. Rising crude oil prices are reflected in increased gasoline and heating oil prices, creating an economic strain on consumers. And, while energy conservation remains an important objective, Americans now recognize the importance of a stable energy supply. Holding one-quarter of all the world’s coal and vast supplies of natural gas – although in increasingly harder-to-produce resources – the U.S. still has remaining nearly two-thirds of its crude oil reserves. Yet, we lack the technology to tap the full potential of these resources in an affordable and environmentally sound manner.

With concerns such as these in mind, NETL currently spearheads an extensive array of government-industry projects addressing environmental and energy supply issues. U.S. consumers can be assured that the nation’s leading scientists are applying the most advanced research methods to develop technologies for our nation and our future.

**Energy Production and Use Impacts U.S. Economy and Environment**



# NETL Today

NETL is the Fossil Energy laboratory for the U.S. Department of Energy, providing expertise in fossil energy supply, delivery, and end-use technologies.

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 1997, 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 15th national labora-

tory. A Strategic Center for Natural Gas and four on-site research Focus Areas were created. In 2000, the National Petroleum Technology Office in Tulsa became part of the NETL.

Today, NETL's extramural programs comprise more than 1,100 joint government-industry projects

## NETL Plays Key Role in Fossil Energy Supply, Delivery, and Use

### Electric Power



Coal Production



Power Delivery

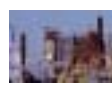


Power Generation

### Clean Liquid Fuels



Exploration & Production



Refining & Delivery



Transportation

### Natural Gas



Exploration & Production



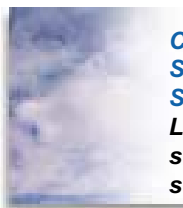
Pipelines & Storage



Power Generation

*Interwoven Considerations: Availability, Affordability, Acceptability*

## Conduct On-Science & Technology Research



**Carbon Sequestration Science**  
Large stationary sources of CO<sub>2</sub>



**Gas Energy Systems Dynamics**  
Gaseous-fueled power generation systems

- **Four Focus Areas and Two Technology Clusters**

- **Research Laboratories at Morgantown and Pittsburgh**

- **Involves 1/3 of Staff**

- **31 CRADAs**

**Ultra-Clean Fuels**  
For high-efficiency transportation systems



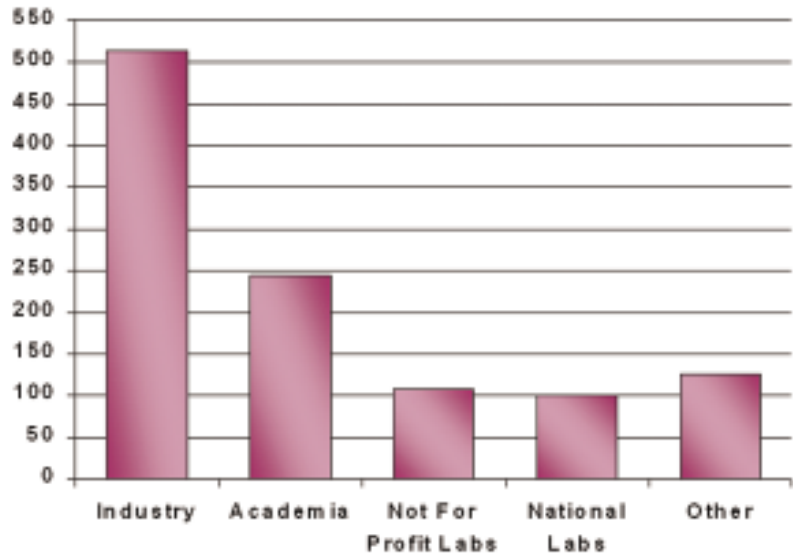
**Computational Energy Science**  
Virtual demonstrations of energy plants of the future



*Shaping, Funding & Managing Extramural RD&D*

- **1,100 research activities in all 50 states and 16 countries**
- **Total award value of \$7.9 billion**
- **Private sector cost sharing of \$4.0 billion**
  - Leverages DOE funding
  - Ensures relevance
  - Mission accomplishment only through commercialization
- **53 active MOUs and MOAs**

*Number of Projects by Partner Group*



in all 50 states. These projects are carried out at our on-site research laboratories and through cost-sharing arrangements with corporations, small-businesses, universities, and other national laboratories and government agencies. As a federal organization, NETL does not compete with its partners to commercialize technologies; NETL's partnerships help to successfully implement Research Development and Demonstration (RD&D) programs that lead to

commercialized products and services for the American public. Early in the RD&D process, these partnerships can benefit from intellectual contributions and cost-sharing with the private sector, bringing about a better understanding of end user needs and providing an intrinsic technology transfer mechanism to accelerate the deployment of new technologies in the market place.



# Mission

As DOE's newest national laboratory, NETL supports DOE's mission by:

- ***Resolving the environmental, supply, and reliability constraints of producing and using fossil energy resources to provide Americans with a stronger economy, healthier environment, and more secure future;***
- ***Supporting, developing, and deploying environmental technologies that lower the cost and reduce the risk of remediating DOE's Weapons Complex and commercial nuclear site; and***
- ***Contributing to best business and management practices within DOE.***

# Vision

NETL shapes its vision around the ever-increasing world demand for energy in the 21st century. To meet those demands, NETL focuses its vision on cleaner, more efficient, and affordable ways to use the nation's traditional fuels. NETL provides scientific and technological advances to help sustain, and even increase, the production and use of fossil energy. To do so, NETL's vision includes:

- ***Providing technology and policy options to ensure that the United States has a reliable, affordable, and environmentally sound energy supply.***
- ***Developing and deploying innovative environmental technologies.***
- ***Conducting on-site research activities in carbon sequestration, ultraclean fuels, energy system simulation, and gas energy system dynamics.***
- ***Achieving business excellence, as a safe and rewarding place to work and with ability to deliver results.***

# NETL's Contributions to the Energy Future

The federal government's historic investment in fossil energy has paid dividends. Technological advancement, driven in large part by DOE's partnerships with industry, is one reason why Americans continue to benefit from relatively low energy costs compared to the rest of the world. Six major outcomes from NETL's programs are identified.

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

The products of the Fossil Energy program include technologies, such as fluidized-bed combustors, that capture sulfur inside the combustion chamber (now sold by every major boiler manufacturer); low-NO<sub>x</sub> burners (now found in 75 percent of the nation's

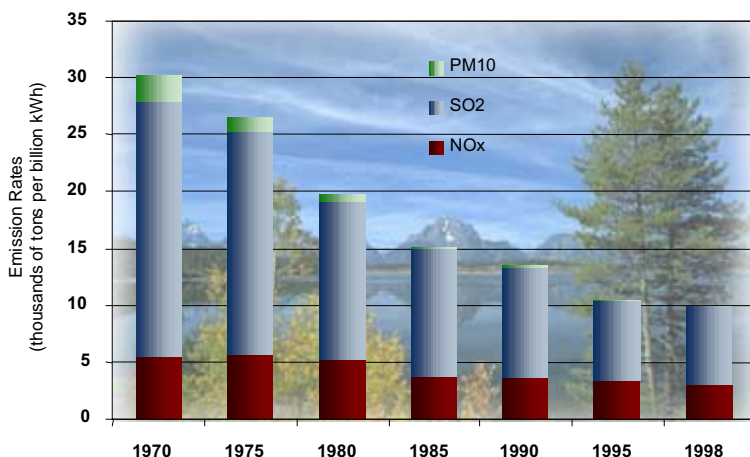
## Outcomes from NETL's Programs

- Technology** → Assist in providing US acceptable, affordable, and available energy in mid- to longer-term
- Policy** → Positively impact development of sound energy policies
- Competitiveness** → Help maintain technology competitiveness of US energy industry
- Stability** → Appropriately transfer technology to developing countries to improve geopolitical stability / global climate
- Workforce** → Provide trained energy workforce through university research programs
- Region** → Regional economic development

coal-fired power capacity); gasification combined-cycle power systems (now operating in Florida and Indiana); ultra-high efficiency gas turbines (planned for installation at a power plant in New York); and fuel cells (being demonstrated at many sites across the country).

Technological advances have resulted in today's "footprint" for oil and gas wells (the land area required for drilling the well and its completion if the well is successful) being ten times smaller than for wells in the 1970s. Better detection and drilling tools have nearly doubled success rates in finding new oil and gas supplies, resulting in fewer dry holes and less environmental disturbance. Oil fields that would have been abandoned in Utah and Kansas continue to operate because of improved technology demonstrated in DOE's programs. DOE-private sector cooperation in developing horizontal drilling helped to revitalize oil fields in Michigan and gas production in the Rocky Mountains. "Secondary gas recovery" development has done the same for gas fields in South Texas and the Mid-Continent.

## Emissions from Coal Plants

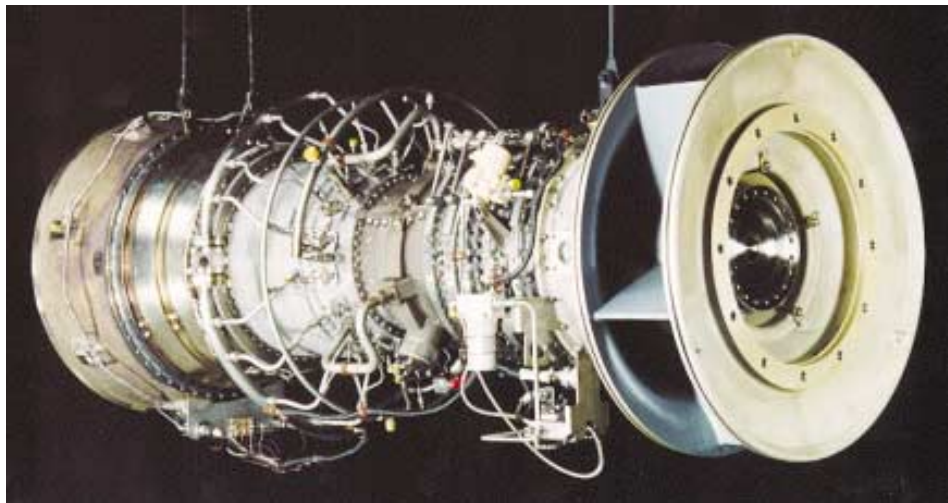


Emissions: National Air Pollutant Emission Trends, 1990-1998, EPA 454/R-00-002, March 2000; Generation: EIA Annual Energy Review 1998

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

- DOE-industry partnerships in developing advanced technologies have added more than 100 trillion cubic feet (Tcf) of producible gas resources, resulting in increased production while adding to our proven natural gas reserve base. These gains span several types of gas resources – tight gas formations, coalbed methane, and mature producing fields; and represent a wide spectrum of geographic locations – the Rocky Mountains, the Mid-Continent, and the Gulf Coast.
- DOE's investment in fluidized-bed technology has resulted in every major U.S. boiler manufacturer offering this cost-effective method for burning virtually any low-grade fuel, while reducing the amount of air emissions. In Pennsylvania alone, from 1990 to 2000, fluidized-bed combustors have saved nearly a quarter of a billion dollars by burning waste coal cleanly.
- The Advanced Turbine Systems government/industry partnership has produced a new generation of high-efficiency turbines, and the first commercial order has been booked. Turbines delivered through 2005 are expected to save consumers more than \$8 billion over the systems' 30-year life.
- Federal investment in selective catalytic reduction (SCR), a technology for reducing NO<sub>x</sub> emissions from power plants, has reduced the costs of this technology by nearly 50 percent, translating to a savings of more than \$17 billion over the lifetime of plants installed through 2005 throughout the United States.
- DOE committed to R&D for coalbed methane and gas production from shale when it was too risky to attract industry support. Our program helped develop technologies so that today, coalbed methane and gas from shale provide about 7 percent of the domestic production.
- Twenty-two oil field demonstrations of advanced and underutilized technologies, along with the transfer of successful technologies to adjacent, similar reservoirs may provide more than 10 billion barrels of additional production over 10 years. One Michigan project that used horizontal wells to tap previously unproducible oil is now expected to add 200 million barrels of oil to the nation's supply over 10 years.

#### *Advanced Turbine System*



# NETL's Programmatic Accomplishments – FY 2000

The goals of the U.S. Department of Energy are to advance the nation's energy, environmental, economic, and national security. According to DOE's *Annual Performance Plan for FY 2000*, goals are accomplished within DOE's four-business-line framework: **Energy Resources**, **Science**, **Environmental Quality**, and **National Security**. The business lines are supported by **Corporate Management**, which comprises safety and health, good business practices, and communication and trust.

The objectives used to determine NETL's FY 2000 accomplishments are based on objectives contained in DOE's Annual Performance Plan for FY 2001. More specifically, within each of the four business lines, there are specific objectives, measurements, and strategies for achieving DOE's goals. NETL plays an important role in ensuring that the Department meets those objectives.

*Note: Not all of the objectives within DOE's Annual Performance Plan coincide with NETL's mission and, as a result, only those objectives that align with NETL Programs are included.*

## Energy Resources (ER)

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

### ***DOE Objective ER1: Promote reliable, affordable, clean, and diverse domestic fuel supplies.***

#### NETL Accomplishments:

##### ***Strategic Center for Natural Gas (SCNG) –***

The SCNG was established at NETL in December 1999 to coordinate DOE activities in natural gas research and development (R&D), analysis, and policy development to support the national strategy for natural gas. NETL R&D programs allow conversion of remote or otherwise stranded natural gas supplies, such as

those in Alaska, to liquid fuels that can be more easily transported to markets, as well as recover quality fuel from low-quality gas to power steam generators.



**Natural Gas Upgrading** – As part of the Natural Gas Processing Program, the Institute of Gas Technology has conducted field demonstrations of advanced gas processing methods to show that pipeline-quality natural gas can be produced from low-quality natural gas resources. The Morphisorb acid gas removal process is one example of this technology, which has been made commercially available to the gas processing industry. As a result, previously abandoned U.S. gas can be treated and is now available as a resource.

**Advanced Drilling Completion and Stimulation** – Research has reduced costs by reducing the drilling footprint. Advanced drill cuttings transport saves millions of dollars in disposal costs. Under the National Laboratory/Industry

*Advances in oil drilling technologies have decreased production costs by 20 percent*



Partnership Program, advances have been made in the development of micro-drilling, slim-hole drilling, and coiled-tubing drilling. As a result: federal royalty revenues have increased \$4 million during FY 2000. Typical onshore drilling and completion costs have dropped by about 20 percent from an average of about \$500,000 per well in the 1980s to about \$400,000 per well today. Offshore drilling and completion costs

of about \$5.5 million per well in the 1980s have dropped to \$4.3 million today. New exploration and drilling technology has on average doubled the amount of oil or gas supplies developed per well since 1985.

**Effective Environmental Protection** – NETL research has resulted in the development of new procedures for sampling and measuring vapor pressure for oil storage tanks in California. The new procedures are expected to result in changes in California regulations, saving the in-

dustry over \$13 million. These efforts received an award from the California Air Quality Board. In addition, a laser leak-detection technology developed under NETL's program allows one or two inspectors to canvass an entire refinery in a fraction of the time required using the current method, meaning that emission sources can be identified and repaired sooner. Another example of environmental protection is the Risk Based Decision-Making System (RBDMS), an advanced data information system linking state energy resources and water quality planning. States using RBDMS have collectively realized cost savings of over \$20 million with greater confidence of having made decisions that are economically and environmentally smart.

**Advanced Diagnostics and Imaging** – Early results from seven multidisciplinary reservoir characterization projects show that additional oil reserves with a net present value of \$14 million have been identified in the Lambert-Aristocrat field in Colorado, and 15 million barrels of additional recoverable oil reserves have been recognized in the Tensleep Sandstone. In addition, Union Pacific Resources has successfully demonstrated horizontal well drilling technologies to establish the first commercial production of unconventional gas from deep, over-pressured, tight gas sand in the Greater Green River Basin, Wyoming. Finally, BOAST3, a new three-dimensional version of DOE's three-phase "Black Oil Applied Simulation Tool" (BOAST) was released. Several oil industry consulting firms have modified and used the program, resulting in the production of over 20 million barrels of oil and the return to the taxpayer of over \$1,000 for each \$1 of DOE funds invested.

**Reservoir Life-Extension** – Five NETL Field Demonstration projects received "Best of the Region" awards from *Hart's Oil and Gas World* (1999), reflecting innovative research in the Gulf Coast, Mid-Continent, Permian Basin, and Pacific Region. Joint industry projects have resulted in the development of effective reservoir efficiency processes, gas flooding, and steam flooding, which have contributed to the current

level of more than 10 percent of U.S. oil production coming from improved oil recovery. In addition, a steam flooding project in the Midway Sunset field in California has yielded millions of barrels of oil from existing, slow-producing fields. Sponsors predict that the advanced technologies ultimately will result in more than 4 million barrels of oil being produced.

***Ultraclean Fuels Program*** – With the nation’s automakers and fuel suppliers facing tight new federal emission standards later this decade, six contractors will work with NETL to pioneer a new generation of ultraclean transportation fuels and tailpipe emissions control. Three teams proposed using natural gas rather than crude oil as the starting point for making cleaner fuels. Rather than compressing the natural gas, they hope to chemically transform the gas into liquid fuels that could substitute for conventional diesel fuel or be used as a clean-burning fuel additive. Converting natural gas to liquid form allows it to be delivered and used without major changes in today’s existing liquid fuels infrastructure. Two other teams will lead development efforts on new refining processes that remove sulfur pollutants from crude oil. The sixth team will focus on a new type of emission control system for future automobiles and trucks. The system will employ a chemical

process that captures smog-forming nitrogen oxides from the exhausts of internal combustion engines.

***Ultraclean Fuels Collaboration with the U.S.***

***Air Force*** – NETL initiated a 5-year agreement with Wright-Patterson Air Force Base for RD&D efforts to provide affordable, clean aviation fuels from petroleum, natural gas, coal, and other energy sources to enable aircraft to achieve significantly lower pollutant emissions without adversely affecting performance. Joint research areas include sulfur reduction in aviation fuels, advanced analytical techniques, computational chemistry and materials stability.



***DOE Objective ER2: Promote reliable, affordable, and clean transformation of fuel supplies into electricity and related products.***

NETL Accomplishments:

***Fuel Cells*** – Under the NETL Fuel Cell Program, Siemens Westinghouse Power Corporation successfully completed testing its 100-kW solid-oxide fuel cell for over 11,000 hours with zero voltage degradation over its lifetime. The company also manufactured and began testing the first 220-kW fuel cell/turbine hybrid, which is expected to have an efficiency of 59 percent.

Fuel Cell Energy, Inc. (FCE) completed a successful market entry tall stack test — a grid connected, 250-kW fuel cell, which operated for over 11,800 hours with a degradation of only 0.4 percent per 1,000 hours. Also, FCE began expansion of its manufacturing facility to 50 megawatts per year to support an aggressive demonstration schedule that includes one year of commercial design validation and endurance testing of a 250-kW Direct FuelCell™ power

**220 kW Fuel Cell/Turbine Hybrid**

plant at Danbury, CT. The demonstration includes the longest running (over 10,000 hours), as well as the largest, carbonate fuel cell stack. The next step toward commercialization will be field trials of the packaged submegawatt product.

**Commercialization of the Phosphoric Acid Fuel Cell** – Deployment of over 200 units worldwide has created the first generation of ultra-clean, highly reliable power plants that produce high quality electricity and thermal energy.

**Solid State Energy Conversion Alliance (SECA)** – NETL, in partnership with the Pacific Northwest National Laboratory, has formed an alliance to bring industry, national laboratories, and universities together to develop high-power density, low-cost solid-state fuel cells. The \$350 million, multiyear SECA initiative is developing the technology and the technology base for producing standardized fuel cell modules in the 5-10 kW size range. A public workshop was held in June 2000 to gather stakeholder input on the opportunities and challenges for achieving the goal of low-cost, broadly marketable fuel cells by 2010. NETL has also collaborated with the U.S. Department of Defense to develop fuel cell modules for a variety of military applications, including auxiliary power units for trucks, field power units, and vehicular propulsion.

**Advanced Turbine Systems (ATS)** – Utility-scale turbine research has moved to the demonstration phase with Siemens-Westinghouse testing components of its ATS technology in Florida, and General Electric's 7H-ATS recently undergoing full-speed, no-load testing in New York. The H System™ gas turbine, the most advanced combustion turbine in the world, crossed the commercial threshold in FY 2000, passing a critical verification test. It will be the first gas turbine to top the 60 percent efficiency threshold – the four-minute mile in turbine technology.

**GE's H System™ Gas Turbine**

**ATS Program Bright Light Award** – This award honors five of the most recent consumer-oriented innovations selected from the top 23 discoveries or innovations conceived between 1999 and 2000. NETL captured one of those five for its Advanced Turbine Systems (ATS) Program. The award recognizes those innova-

**Bright Light Award**

tions that improve the quality of life, save money, satisfy consumers, and produce noteworthy results.

**Advanced Power Generation Systems** – The NETL High Efficiency Performance Power System (HIPPS) project conducted record-setting tests of a radiant air heater at 2000°F. The results imply that HIPPS plants with 55 percent efficiency are possible. The Low Emission Boiler System (LEBS) project with Cornbelt Energy has moved to the final phase, construction and demonstration. A 91-MWe plant using a DB Riley U-fired slagging combustor will begin operation in 2004. The boiler will be capable of operating at less than one-sixth of federal New Source Performance Standards.

**Clean Coal Technology Program** – This NETL program has resulted in the installation of low-NO<sub>x</sub> burners in about three-fourths of the U.S. coal-fired generating capacity; reduction of capital and operating costs for those units that have installed flue gas desulfurization systems (because they produce dry disposable wastes or valuable by-products); and reduction of greenhouse gases and pollutant emissions for units using the advanced systems.

**Power Plant Hall of Fame** – Under the auspices of the Clean Coal Technology (CCT) Demonstration Program, five project sites are among the first inductees into the Power Plant Hall of Fame, as selected by the editors of *Power Magazine*. They include a PFBC project at Brilliant, Ohio; two advanced scrubber projects near Chesterton, IN, and Newnan, GA; and two Integrated Gasification Combined Cycle (IGCC) projects at West Terre Haute, IN, and Mulberry, FL.

**Vision 21** – NETL completed “The Vision 21 Technology Roadmap” – the result of a two-year collaborative effort with industry and academia. The roadmapping effort lays the groundwork for the development of enabling technologies, such as gasification, combustion, turbines, fuel cells, and computational modeling, for these revolutionary fossil-fuel-based, pollution-free energy plants. Thirteen advanced research, design, and engineering projects are under way to develop the critical building blocks of the Vision 21. These plants could be available for commercial construction by 2015.

**Watershed Characterization** – NETL conducted airborne remote sensing surveys at two West Virginia watersheds (Muddy and Roaring Creeks), as well as several mine sites in West Virginia and Maryland. The thermal infrared technique identified points where groundwater meets the surface on land and in streams and wetlands. These so-called “warm targets,” from an environmental perspective, indicate the presence of sewage. These surveys are important in terms of the labor-saving aspect, and because they can aid in hydro-



logical studies, identifying possible discharge points.

**Mercury Removal Systems** – NETL collaborated with the U.S. Environmental Protection Agency, Babcock & Wilcox/McDermott Technology, Inc. (B&W/MTI), and ADA Environmental Systems to demonstrate and evaluate cost-effective mercury-removal systems at a number of operating coal-fired utility boilers. The B&W/MTI approach involved enhancing wet flue-gas scrubbers to promote higher levels of capture of both oxidized and elemental mercury. ADA’s technology involved injecting dry mercury sorbent that is ultimately captured (with the mercury) by particulate control equipment.

TECO’s Clean Coal Project in Mulberry, FL





## ***DOE Objective ER4: Inform public policy makers, energy industries, and the general public by providing reliable energy information.***

### NETL Accomplishments:

***Assistance to India*** – NETL continued its lead role in the U.S. Agency for International Development/India Greenhouse Gas Pollution Prevention Project to introduce high-efficiency power technology to India and improve performance of existing power plants for large volume fly ash utilization and capacity development of the Centre for Power Efficiency and Environmental Protection.

*NETL's 1000-MW Rihand Power Plant, India*



***Advisor to Federal Lands Leadership Forum*** – NETL served on the Federal Lands Leadership Forum as an advisor on energy policy, resource, and technology issues. The forum, a group of federal agencies, has the goal, “to provide for a quality predictable and consistent National Environmental Policy Act process specific to oil and gas activities.”

***Multi-pollutant Control Study*** – NETL supported the Energy Information Administration and the DOE Policy Office on a multi-pollutant control study by providing data and costing algorithms for mercury control and by participating in the ongoing low-sulfur diesel fuel study.

## ***DOE Objective ER5: Cooperate globally on international energy issues.***

### NETL Accomplishments:

***Greenhouse Gas Emissions*** – NETL researchers and DOE contractors pursued innovative approaches for separating, capturing, and storing greenhouse gas emissions with the goal of beginning to deploy technologies by 2015 to help offset U.S. emissions. A series of policy-related studies was completed identifying the types of pollutant control and the changes in greenhouse gas emissions, including technology options for reducing SO<sub>x</sub> and NO<sub>x</sub> and the impact of these options on CO<sub>2</sub> emissions.

***Methane Hydrates Research*** – NETL is leading the development of a program to address a vast and promising new source of energy – methane hydrates. NETL worked with other federal

agencies (U.S. Geological Survey, Naval Research Laboratory, Minerals Management Service, National Science Foundation, and the National Oceanographic and Atmospheric Administration) to address critical questions concerning the chemical and physical properties of natural gas hydrates.

***Carbon Sequestration*** – NETL initiated a robust portfolio of CO<sub>2</sub> sequestration projects. Over 20 research projects were awarded to demonstrate the technical, economic, and environmental feasibility of large-scale carbon sequestration to reduce the greenhouse gas emissions from fossil fuel utilization systems. Based on collaboration among the Albany Research Center, Los Alamos National Laboratory, and Arizona State University, and researchers in

NETL's Sequestration Focus Area, a potentially permanent CO<sub>2</sub> sequestration approach involving mineral sequestration has been demonstrated in laboratory-scale experiments. In addition, NETL investigators established the technical criteria to select suitable sites for geologic sequestration of CO<sub>2</sub>. Twenty-two geologic formations were identified as potential storage sites based on criteria gained from analysis of oil, gas, and saline formations.

**SO<sub>2</sub> and CO<sub>2</sub> Control Technologies for China** –

NETL participated in a Fossil Energy Memorandum of Understanding with the Ministry of Science and Technology in China to explore various SO<sub>2</sub> and CO<sub>2</sub> control technologies applicable to China's power generation infrastructure. NETL also signed a cooperative agreement to perform feasibility studies and training to encourage a variety of uses for fuel cells in Egypt.

**Carbon Sequestration Research Areas**



## Science (SC)

On-site research activities are making important contributions in carbon sequestration, ultraclean fuels, energy system simulations, and gas energy system dynamics. The research coincides with the Department's goal to deliver scientific understanding and technological innovations critical to the success of our mission and the nation's science base.

***DOE Objective SC1: Provide the leadership, foundation, and breakthroughs in the physical sciences that will sustain advancements in our nation's quest for clean, affordable, and abundant energy.***

NETL Accomplishments:

***R&D 100 Award*** – Two NETL researchers, Dr. Ranjani Siriwardane and Mr. Daniel Cicero, received the prestigious R&D 100 Award for inventing RVS-1, a regenerable sorbent that removes sulfur from gasified coal streams. (RVS stands for the initials of the inventor, Ranjani V. Siriwardane.) The RVS-1 sorbent, which resembles pea-sized pellets, removes sulfur from the gas used to power turbines for generating electricity. The result is coal-fired power generation without the sulfur oxide emissions – considered precursors to “acid rain.” The inexpensive nature of the sorbent and its ability to be reused over hundreds of cycles will enable advanced generation facilities to produce cost-competitive energy.

***RVS-1 Sorbent***



***Dr. Siriwardane and Mr. Cicero***



**Energy 100 Awards** – The U.S. Department of Energy, Office of Consumer Affairs, presents these awards in two categories: Energy @ 23 Awards and Bright Light Awards. Energy @ 23 Awards are selected from a list of 100 scientific and technological innovations developed by DOE between 1977 and 2000. They represent the highest-ranked innovations that have demonstrated benefits to the American public; contributed to U.S. competitiveness in the global marketplace; and have the potential for significant future growth. The following Energy @ 23 Awards were received in FY 2000 by NETL:

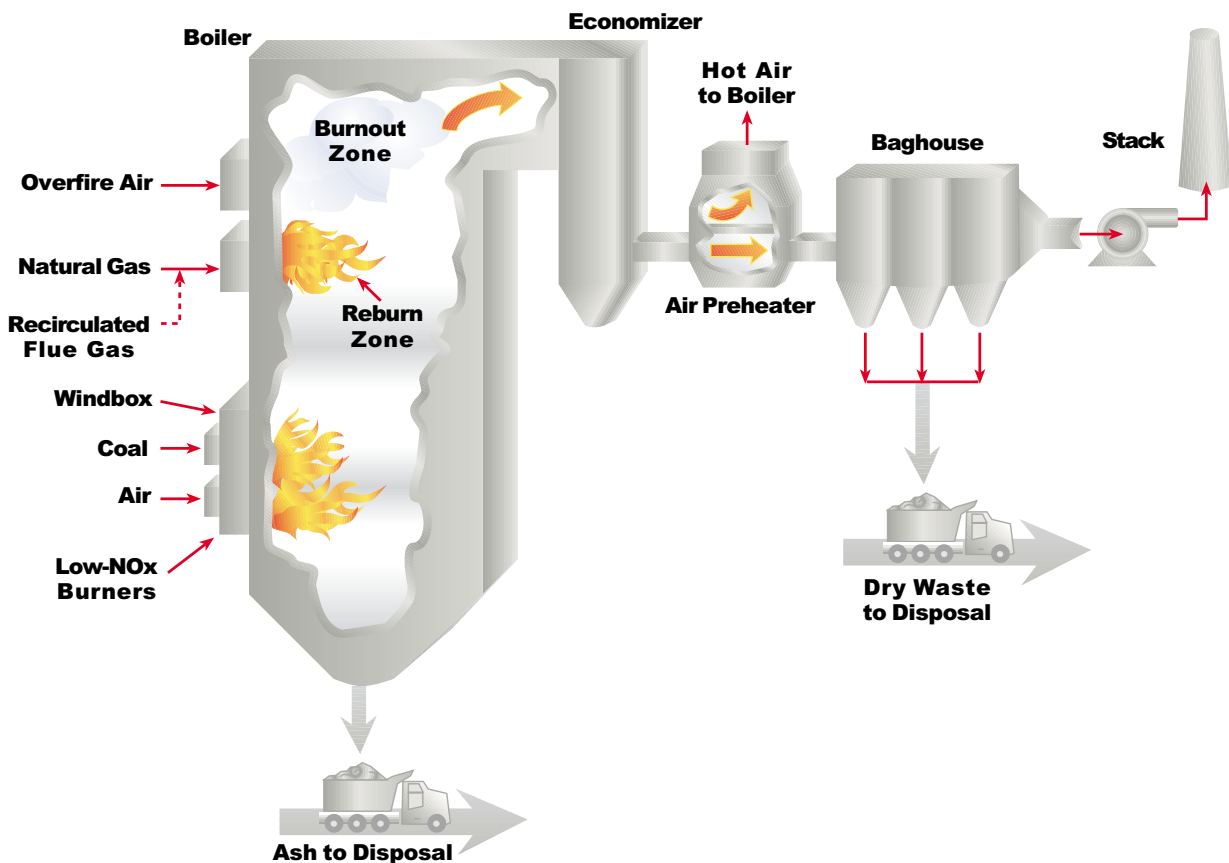
**Low NO<sub>x</sub> Burner Technology.** This technology has resulted in significant reductions in the amount of NO<sub>x</sub> generated by coal-fired, electric utility plants. The technology is used

commercially in more than 60 percent of all U.S. coal-fired plants.

**Atmospheric Fluidized Bed Combustor (AFBC):** This combustor provides clean and efficient electric power and steam production, while burning a variety of feedstocks, including coal of various ranks, gob, culm, petroleum coke, and other low-heating value solid fuels. The combustor has received wide commercial acceptance in the U.S. and throughout the world.

**Advanced Turbine Systems (ATS) Program.** The program developed advanced turbines that are more efficient, cleaner, and less expensive to operate than existing turbines. These turbine systems are expected to result in a 10 percent decrease in the price of electricity, while emitting less greenhouse gases.

Low NO<sub>x</sub> Burner



## Environmental Quality (EQ) and National Security (NS)

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. These contributions align with the Department's Environmental Quality and National Security business lines. NETL scientists and contractors are developing technologies for the cleanup of DOE's 53 remaining contaminated nuclear sites. Under the Decontamination and Decommissioning Focus area, scientists aim to safely and expeditiously dispose of waste generated by nuclear weapons and civilian nuclear research and development programs. Demonstrations are conducted to reduce the life-cycle cost of environmental cleanup and to maximize the beneficial reuse of land from residual contamination.



***Objective EQ1: Safely and expeditiously clean up sites across the country where DOE conducted nuclear weapons research, production, and testing, or where DOE conducted nuclear energy and basic science research. After completion of cleanup, continue stewardship activities to ensure that human health and the environment are protected.***

### NETL Accomplishments:

***Deployment of Decontamination and Decommissioning (D&D) Technologies*** – Thirty-seven innovative D&D technologies developed by industry and labs under NETL's Deactivation and Decommissioning Focus Area (DDFA) were deployed in 99 instances within

***The pipe explorer is one of 37 innovative technologies being developed under NETL's D&D Focus Area***



the DOE complex. Twenty-four of these technologies were deployed for the first time. This number of deployments is five times greater than the 19 originally planned for FY 2000.

***Mound Tritium Large-Scale Demonstration and Deployment Project (LSDDP)*** – NETL's DDFA successfully demonstrated eight innovative technologies for cost-effectively treating tritium waste, as well as facilities and equipment contaminated with tritium. The Integrated Contractor Team for the Mound LSDDP includes BWXT of Ohio, IT Corporation, British Nuclear Fuels Limited, Westinghouse Savannah River Company, and three national laboratories: Lawrence Livermore National Lab, Princeton Plasma Physics Lab, and Los Alamos National Lab. Florida International University's Hemispheric Center for Environmental Technologies and the U.S. Army Corps of Engineers provided evaluation support and analyzed cost and performance data.

**Idaho National Engineering and Environmental Laboratory (INEEL) Fuel Pool LSDDP** – NETL’s DDFA demonstrated six innovative technologies for fuel pools and associated structures and equipment. Based on the deployment of a suite of innovative D&D tools, the estimated savings for INEEL over a 10-year period will be \$20 million. The Integrated Contractor Team for the INEEL LSDDP includes BWXT of Idaho, Parsons Engineering, TLG Services, British Nuclear Fuels Limited, and Idaho State University. Florida International University’s Hemispheric Center for Environmental Technologies and the U.S. Army Corps of Engineers provided evaluation support and analyzed cost and performance data.

**Canyon Disposition Initiative** – The DDFA deployed three improved technologies to complete characterization of the Hanford 221-U Plant, a Phase III feasibility study was initiated. The DDFA supports Bechtel Hanford, Inc., in this effort to collect the technical data needed to help DOE, Washington State Department of Ecology, and the U.S. EPA determine the future of Hanford’s five massive chemical processing plants, or “canyons.”

**Copper Cable Recycling System** – Nukem Technologies developed this system and demonstrated it on 13.5 tons of copper cable at INEEL. The system shreds and grinds the cable, separating the clean copper from contaminated cable insulation by air classification. With the waste volume reduced by 80 percent, recovery of the recyclable copper was determined to be more cost-effective than disposal of it.

**Selective Membrane Cartridge** – NETL has deployed this technology, developed by 3M Corporation through NETL’s Industry Program, at the Savannah River Site’s R-Basin. The technology is being used to remove radioactive cesium and strontium from over 5 million gallons of water. The remediation effort is expected to save over \$5 million and to be completed 6 years sooner than the base-line remediation option.

**3M Selective Membrane Cartridge removes radioactive cesium and strontium from water and was selected as a winner of Vice President Gore’s Silver Hammer Award.**



## ***DOE Objective NS4: Reduce the global danger from the proliferation of weapons of mass destruction (WMD).***

### NETL Accomplishments:

***Surplus Plutonium Disposition*** – NETL supported DOE’s Non-Proliferation efforts by helping to promote design changes for Russian nuclear reactors and preparing the final EIS and Record of Decision for the Surplus Plutonium Disposition.

***Conversion of Weapons-Grade Plutonium to Mixed-Oxide Fuel*** – NETL supported the issuance of the Environmental Assessment related to the Paralex Project to demonstrate the feasibility of converting Russian and U.S. weapons-grade plutonium to mixed-oxide fuel.

***Arctic Military Environmental Cooperation (AMEC)*** – As part of NETL’s AMEC efforts

with the Office of Environmental Management (EM-21) and the U.S. Department of the Navy, the design, fabrication, and delivery of 100 certified-steel containers for storing solid radioactive waste was completed for the Zvezdochka Shipyard. The waste resulted from destroying 31 Russian nuclear-powered submarines and Intercontinental Ballistic Missiles (ICBMs) under the START-I Treaty. The containers were built by the Russians and accepted by the Russian Navy under a Tri-lateral Agreement between the U.S., Russia, and Norway. The Agreement ensures that the wastes will not be dumped into the Arctic Region.

## ***DOE Objective NS6: Ensure that the Department’s nuclear weapons, materials, facilities, and information assets are secure through effective safeguards and security policy, implementation, and oversight.***

### NETL Accomplishment:

***Nuclear Materials Stewardship Initiative*** – NETL provided technical expertise and coordinated the preparation and issuance of a Report to Congress dated June 2000 on DOE’s Integrated Nuclear Material Management Plan titled “A Strategic Approach to Integrating the Long-Term Management of Nuclear Materials.”



## Corporate Management (CM)

NETL provides a safe and rewarding workplace, recognized for both business excellence and its ability to deliver results, thereby contributing to best business and management practices throughout the Department. Outstanding measurements in terms of safety and health, etc., translate into successful Corporate Management.

### ***Objective CM1: Ensure the safety and health of the DOE workforce and members of the public and the protection of the environment in all Department activities.***

#### NETL Accomplishments:

***Seven Guiding Principles*** – NETL has successfully implemented Integrated Safety Management (ISM) into all facets of its programs. NETL has also developed and implemented a process by which NETL's Contracting Officer Representatives can monitor external R&D contractor compliance with the environmental, safety, and health requirements by using seven Guiding Principles.

***ISM Verified*** – NETL successfully passed the Department's Integrated Safety Management (ISM) Verification Review with no deficiencies, leading to recognition by the Deputy Secretary that Fossil Energy was the first to implement ISM in the Department.

***Focused on Training and Metrics*** – NETL enhanced its ES&H training and met metrics that resulted in 95 percent of all federal and contractor employees completing the training. In part due to our training success, NETL's OSHA Total Recordable and Lost Workday Case Rates are low compared to industry standards. As evidence, NETL received an outstanding achievement award from the Western Pennsylvania Safety Council in recognition of outstanding accident prevention performance in occupational safety. In addition, NETL's



OSHA Cost Index was reduced from \$24.02 per 100 hours worked in the first quarter of FY 2000 to \$4.02 in the fourth quarter – an 83 percent cost reduction.

***Emergency Preparedness*** – NETL conducted periodic emergency management exercises involving local media and state and local emergency preparedness organizations; responded to real emergencies through activation of the Emergency Operation Center (EOC); ensured the safety and health of employees, the public, and environment; and maintained external relations with government entities, regulators and the public.



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

### NETL Accomplishments:

***Enhancements of CHRIS Database*** – NETL manages and recently enhanced the Department’s Corporate Human Resources Information System (CHRIS) to include employee-training information.

#### **Total Man-Years of Effort Involved in NETL Programs**

	FY 2000
Federal Employees	574
Support Contractor Employees	
On-Site	520
Off-Site	201
<b>Total Support Contractor Employees</b>	<b>721</b>
Research Associates*	28
<b>Total NETL Employees</b>	<b>1,323</b>
R&D Contractors**	3,500
<b>Total NETL</b>	<b>4,823</b>

\* This number does not include 20 Student Partners, 8 HBCU and Other Minority Institution Summer Interns, and 15 summer intern positions under ORISE.

\*\* This number includes industry, university and other federal laboratory personnel performing R&D under federal contracts, grants, and agreements.

***Diversity Efforts*** – NETL has improved the diversity profile of its workforce. Over the past two years, women and minority groups represented two-thirds of all newly hired and transferred employees. Monthly diversity programs were held for all federal and contractor staff. Two promotion awareness seminars were presented: Blacks in Government and the Federal Women’s Program.

***Labor-Management Partnership*** – NETL continues to operate a local Labor-Management Partnership Council that is at the forefront of partnerships within the Department. The Council provides a forum for the constructive exchange of ideas and concerns between management and labor. Policies and procedures regarding time and attendance, security, fundraising, and directives have been developed.

***Training Needs Assessed*** – NETL has required each federal and contractor employee to complete a training survey to determine general and specialized training needs for each job. NETL identified high priority training, including ES&H training, and offered new training courses, including computer-based training.

## ***DOE Objective CM3: Manage financial resources and physical assets to ensure public confidence.***

### NETL Accomplishments:

***NPTO Integration*** – The National Petroleum Technology Office (NPTO) was reorganized into NETL to enhance Fossil Energy R&D programs by incorporating gas, coal, and oil under a single research organization – NETL.

NPTO will continue to be the “portal to federal petroleum R&D activities,” but with greater support resources, more R&D opportunities, and management representation.

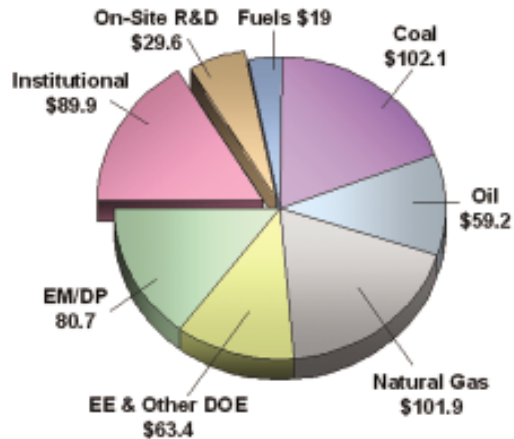
**Facility Planning** – NETL developed a Strategic Facilities Management Plan to guide updates to facilities and reduce operating costs. The Plan incorporates support for NETL’s on-site research, including the four major Focus Areas and two general research areas, all of which were created in FY 2000. As part of the Plan, NETL developed four Focus Areas: Gas Energy System Dynamics, Computational Energy Science, Carbon Sequestration Science, and Ultraclean Fuels. These Focus Areas will serve as a road-map for NETL onsite research over the next five years. Budgets have been established and laboratories and staff have been realigned to achieve nationally significant R&D efforts.

**Greater Financial Accountability** – NETL has placed great emphasis on its financial accountability. Based on an audit by the IG and an independent auditing firm, KPMG, (in connection with the Department’s audit of the FY 2000 financial statements), no specific findings were identified at NETL and the Department received a “clean” audit opinion. The successful financial results at NETL can be attributed to improved financial reporting and improved cost recovery procedures. An approved accounting methodology for developing indirect rates for customer billings was developed and approved by the Chief Financial Officer.

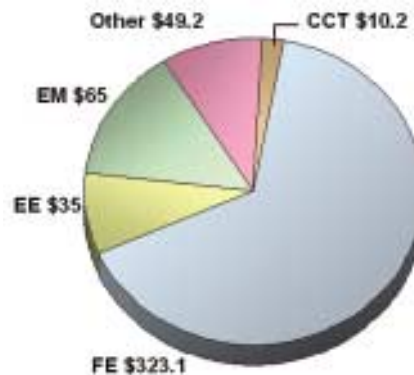
**Funding Stability** – NETL received new funding in FY 2000 of \$463,532,646 and 95.9 percent was obligated. NETL received significant new funding in FY 2000 from the following organizations: Assistant Secretary for Energy Efficiency and Renewable Energy (Energy Conservation), Office of Fissile Materials Disposition, Assistant Secretary of Defense Programs, Environmental Protection Agency (EPA)-Reimbursable Work for Others, and the Department of Defense (DOD)-Reimbursable Work for Others.

**New Timecard System** – NETL implemented the Timecard System, allowing employees to specifically identify how work hours are spent and enabling management to use the information as a tool to analyze how resources are being used.

**Expenditures**



**Funding**



## ***DOE Objective CM4: Manage information technology systems and infrastructure to improve the Department's efficiency and effectiveness.***

### NETL Accomplishments:

***Contractor Accountability*** – NETL created high-level metrics and improved lower-level metrics used to measure performance of its Site Support Contractors and determine award fee. A Project Management Information System (ProMIS) was fully implemented to track and monitor the performance of R&D contractors against budgeted costs and milestones.

***Enterprise Architecture Approach Initiated*** – NETL committed to using a consistent enterprise architecture system to better align information, applications, data, and technology, and to raise the efficiency of the NETL organization.

## ***DOE Objective CM5: Use appropriate oversight systems to promote the efficient, effective, and economical operation of the Department of Energy.***

### NETL Accomplishments:

***Competitive Contract Selections*** – NETL ensured that 80 percent of available funds were awarded competitively. It also made significant improvements to increase competition for financial assistance awards through better financial assistance planning and the use of broad-based solicitations.

***Improvement of DOE Project Management*** – NETL's Center for Acquisition and Business Excellence is leading a Departmental initiative to improve Project Management. NETL signed a Memorandum of Agreement with the Office of Engineering and Construction Management, supporting project management, external independent reviews, cost engineering, and value engineering.



## Plans for the Future

NETL's strategy will be to address the metrics outlined in DOE's Strategic Plan. The Laboratory agenda will be guided by three Strategic Objectives: **Science and Technology Leadership; Excellence in Supporting Business Practices; and Valued Contributor to Policy Analysis.**

In terms of **Science and Technology Leadership**, NETL plans to:

- **Reduce the environmental constraints associated with the use of fossil energy through programs such as,**
  - A **Distributed Generation** program that provides electric power to smaller industries, businesses, and homes by developing technologies that provide for compact, ultraclean, efficient, quiet, and safe generation of electricity that is available and affordable.
  - **Vision 21**, a new initiative for developing the technology needed for ultraclean, 21st century energy plants that will effectively remove, at competitive costs, environmental pollutants associated with the use of fossil fuels for producing electricity and transportation fuels.
  - The **Carbon Sequestration** program, which focuses on developing the scientific understanding and suitable technologies to define the role of sequestration in addressing stabilization of atmospheric levels of carbon dioxide.
  - The **Clean Coal Technology-Power Plant Improvement Initiative**, which will improve the reliability of the U.S. electrical power system. The initiative involves demonstrations of advanced technologies to increase the efficiency, lower the emissions, and improve the economics and overall performance of coal-fired electric power plants.
- The **Ultraclean Fuels** program, which promotes the development of environmentally responsible "transitional fuels" to enable a smooth evolution from today's petroleum-based liquid fuels to tomorrow's sustainable sources of energy for the transportation sector.
- **Increase the supply and availability of fossil fuels by:**
  - Focusing on the timely development of technologies needed to economically find and produce future supplies of gas and oil through the **Exploration and Production** program.
  - Growing a **Methane Hydrates** program that develops the knowledge and technology necessary to commercially produce methane from natural gas hydrates and address associated environmental and safety issues.
  - Developing a **Mining** program in collaboration with the Office of Energy Efficiency and Renewable Energy's Industries of the Future, that emphasizes strategic alliances with customers, investors, employees, and suppliers to produce new products and processes with both near-term and long-range benefits to the mining industry and U.S. economy.
  - Implementing a **Natural Gas Infrastructure** program with research in four technology areas: pipelines and distribution

systems, environmental protection, systems integration, and gas storage.

- **Decrease the Costs and Risks for Environmental Cleanup of Energy and Defense Sites:**

- The **Deactivation and Decommissioning Focus Area** will continue to be used to rapidly deploy innovative and improved technologies across the DOE complex and reduce environmental management costs.
- The **Deactivation and Decommissioning of Commercial Nuclear Power Plants** program will facilitate an exchange of information developed under DOE environmental management activities to efficiently address issues facing commercial nuclear power plants.
- A **Remediation of Fossil Energy Sites** (e.g., mines, slurry ponds, ash piles, refineries, and power plants) research program will focus on increasing industry capabilities for environmentally benign energy production.

- **Delight Stakeholders:**

- **On-site focus areas** will seek to achieve national and international recognition of our capabilities and performance in research and development.
- A focus on **program management and outreach** will be used to strive to become a more valued community and regional asset.
- An **NETL-wide Advisory Committee** will review both program and institutional plans and progress to ensure that our research programs are relevant.
- **Merit reviews** will be conducted to improve our work output.

In striving for **Excellence in Supporting Business Practices**, NETL will:

- **Enhance Human and Physical Resources:**

- Financial resources will be obtained to improve our **facilities infrastructure**.
- **Premier Focus Areas** for energy research that are recognized as vital to the nation's energy strategy will be established at NETL.
- Our **integrated project management** approach will continue to deliver innovative solutions to the nation's energy needs.
- **Employee morale** will be measured and improved to ensure that we have a productive and satisfied workforce.
- **Internal customer needs** will be assessed routinely to develop effective means to achieving our mission.

- **Improve Operational Efficiency and Productivity:**

- **Business practices and systems** (finance, procurement, project management) will be integrated to maximize productivity and efficiency of operations.
- Our **recruitment and training program** will provide the necessary skills to address organizational needs.
- **International Organization for Standardization (ISO) 14001 Certification** will be obtained by implementing a verified environmental management system.
- An **Integrated Safety Management (ISM) Action Plan** will be fully implemented to continually improve environment, safety, and health programs, processes, and tools.

- We will use **metrics** that are useful, measurable, and relevant to achieving our mission.
  - **Increase Visibility:**
    - We will make others aware of the quality work being performed at NETL by **publicizing our accomplishments**.
    - The **Institutional Plan** will communicate the significance of our work activities to key stakeholders (e.g., Congress and the Administration) and others.
- And, finally, to be a Valued Contributor to Policy Analysis, NETL will:
- **Improve NETL's standing as a trusted voice on issues impacting production and use of fossil fuels:**
    - We will work to provide accurate information on environmental performance and cost of fossil energy to **improve the public perception of these fuels**.
    - A **comprehensive communication strategy** will be used to ensure that timely information is delivered to our stakeholders.
    - Our **activities, accomplishments, and programmatic benefits** to society will be quantified and understood by our stakeholders.
  - Agenda items for **conferences and program reviews** will focus on enhancing knowledge of our work among stakeholders.
  - Our **alliances** will be expanded to include a full spectrum of stakeholder groups.
  - **Support a Federal Role for Energy RD&D in National Energy Policy:**
    - We will work to support **policy development** activities.
    - **Energy policy analysis** opportunities will be sought that allow us to use our specialized knowledge and information to address issues of importance to the nation.
  - **Support Policy Analysis for Decision-Makers:**
    - A **strategy** for policy analysis support activities will be formulated to ensure that key federal and state energy issues are addressed.
    - **Policy analysis capabilities** will be enhanced to establish NETL as a reliable and trusted source of information about the performance and cost of fossil energy technologies.
    - We will **build alliances** with other entities in the policy arena to enhance our capabilities.





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