NATIONAL ENERGY TECHNOLOGY LABORATORY

Taking Energy Innovation to Market

Technology transfer and commercialization lie at the heart of the National Energy Technology Laboratory's (NETL) mission, directly addressing U.S. energy research and development needs. NETL is committed to uphold America's trust through wise investment of U.S. taxpayer dollars. With this funding, we support technology innovation that private companies take to market to improve the cost, reliability, and environmental impact of our Nation's energy production and use. Spin-off technologies are also commercialized by the private sector to spur economic development and support national security.

Our partnerships are conducted in ways that ensure fairness of opportunity, promote U.S. economic interests, protect national security, support small and start-up businesses, and allow for competition within the private sector. Innovations emerging from NETL's programs are taking root and finding commercial success.

Fossil Energy Research—A Legacy of Benefit

10-fold increase in enhanced oil recovery using CO_2 injection **1985–2010** Natural Gas & Petroleum Technologies program	**50–70% cost reduction in mercury control at coal-fired power plants** **2000–2008** Mercury Control program	**12-fold increase in shale gas production** **2000–2011** Natural Gas & Petroleum Technologies program	**37 million additional tons of avoided SO_2, 16 million additional tons of avoided NO_x** **2000–2020** Clean Coal program	**$111 billion in benefits** **$13 return for every $1 invested** **2000–2020** Clean Coal program	**1.2 million jobs created** **Thousands of researchers trained** **2000–2020** Clean Coal program

Source: *Fossil Energy Research: A Legacy of Benefit* and *Clean Coal Technology Demonstration Program,* Office of Fossil Energy, 2011; *Benefits of Investments in Clean Coal Technology*, Management Information Services, 2009

In 2011, the Office of Fossil Energy evaluated the realized and estimated benefits provided by its programs. Implemented by NETL, these efforts leverage public investment in technology research, development, and demonstration to reap significant public benefit. Learn more at www.fossil.energy.gov.

Coal and Natural Gas Power Systems

Acid Rain

To reduce SO_x and NO_x emissions and neutralize the threat of acid rain, NETL's Clean Coal Technology program spurred commercialization of low-NO_x burners, wet scrubbers, selective catalytic reduction, and other technologies. Today, 75 percent of our Nation's coal-fired power plants use pollution-control devices that were supported by NETL during their research, development, and commercial-demonstration phases.

Fluidized Bed Coal Combustion

NETL's programs underpinned development of fluidized bed coal combustors, named in the 1990s "the [power generation] commercial success story of the last decade." Today, every major U.S. boiler manufacturer offers an atmospheric pressure fluidized bed system. The technology has seen more than $6 billion in domestic and $3 billion in international sales.

General Electric Company: H-Class Power Plant

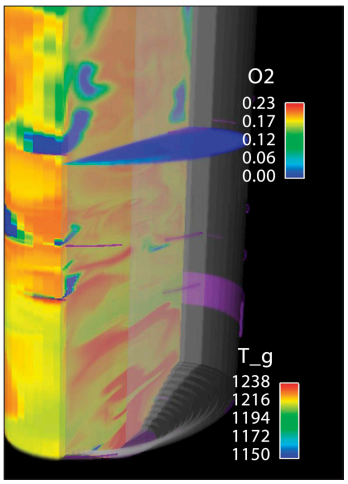
General Electric's H-class advanced 400 MW gas-turbine combined-cycle power plant breaks the 60 percent efficiency barrier. It attains the highest standards for low emissions, low cost, and high power output. Six of these plants have been sold worldwide. The technology was produced in cooperation with the Office of Fossil Energy and NETL.

Harbison-Walker Refractories Company: AUREX™ 95P

Developed by scientists at NETL and licensed to Harbison-Walker Refractories Company, AUREX™ 95P is the most significant improvement in gasifier refractories in over 25 years. It is now the material of choice for high-wear areas of advanced, high-temperature gasifiers. Its widespread use is accelerating gasification as a clean, efficient means of producing electric power and other products.

9Cr-1Mo High-Temperature Steel

NETL has helped the power industry realize significant efficiency gains by applying 9Cr-1Mo high-temperature steel to pulverized-coal power plants. Sales have reached $1.5 billion for application in boiler components worldwide. The high-strength material withstands temperatures up to 600° C at significantly lower cost than comparable austenitic steels.



NETL's MFIX software simulates power production processes. Here the software creates a detailed model of coal gasification.

Multiphase Flow with Interphase Exchange, or MFIX

With NETL's computer simulation platform MFIX, engineers reduce the risk, time, and cost of conducting research to develop and optimize technologies for advanced fossil fuel systems. MFIX is currently used by more than 1,600 national and international laboratories, universities, and industries and is being applied outside the energy sector in fields like volcanology.

Advanced Process Engineering Co-simulator, or APECS

APECS, another NETL simulation software, helps researchers find solutions to systems-engineering challenges across the power plant lifecycle. APECS is helping industry to quickly and inexpensively design next-generation plants that will operate efficiently at low cost with near-zero emissions. APECS is in use by such purchasers as Aspen Technology and ALSTOM Power.

Pyrochem Catalyst Company: Chemical and Refining Processes

Pyrochem Catalyst Company will commercialize two NETL catalysts that reform diesel fuel to hydrogen and enable other chemical and refining processes. The licensing agreement marks the first time a start-up company has been established using NETL technologies. Through this effort, NETL looks forward to helping create new jobs in southwestern Pennsylvania.

AVESTAR™ – A Center for Virtual Simulation Training for Power Plant Operation

The Advanced Virtual Energy Simulation Training and Research (AVESTAR™) Center was created as a teaching solution to help achieve operational excellence for clean, electricity-producing power plants capable of carbon dioxide (CO_2) capture. The 3-D virtual reality technology adds another dimension of realism and extends the training scope to both control room and outside operators, allowing them to work as a team. The benefits include more realistic training scenarios, improved communication and collaboration among work crews, off-line evaluations of plant procedures, and training for safety-critical tasks and rare abnormal situations.

Cerium Oxide Coating for Oxidation Reduction

This NETL-developed cerium-oxide coating helps to increase the oxidation resistance of nickel-based superalloys, as well as ferritic and austenitic stainless steels, by diffusing into the metal and provides an easy, inexpensive method to apply a protective coating to complex metal parts of all shapes and sizes. The coating has applications in markets such as advanced, next-generation power plant components; solid oxide fuel cells; heaters and heat exchangers; or any other application where oxidation-resistant metals are needed. In most cases, this coating improved metal oxidation resistance by a factor of 2 to 3.

Natural Gas and Oil Exploration and Production

Enhanced Oil Recovery

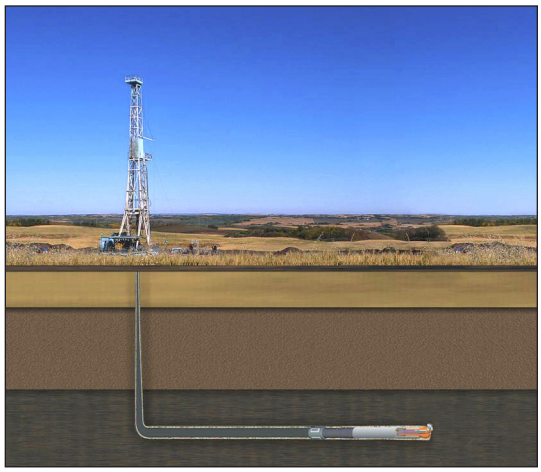
NETL has advanced the science of enhanced oil recovery through extensive CO_2, thermal, and chemical laboratory investigations and field demonstrations. Today, enhanced oil recovery contributes more than 10 percent of U.S. crude oil production, and that percentage will continue to grow.

Coalbed Methane Recovery

In the 1980s, NETL engineers helped introduce coalbed methane to market. Today this one-time "waste" fuel accounts for almost 8 percent of our Nation's natural gas production.

Shale Gas Technology Breakthroughs

In the 1970s and 1980s, NETL helped lead technology drivers for shale gas production. Horizontal drilling, hydraulic fracturing, and high-efficiency "down-hole" tool advancements have contributed to increased shale gas production, which now amounts to nearly 14 percent of dry natural gas produced in the United States. By 2035, that share is expected to reach 45 percent, including resources associated with Marcellus shale.



Horizontal drilling can reach isolated pockets of gas, greatly reducing the "drilling footprint" above ground.

Pinnacle Technology, Inc.: Microseismic Monitoring

From the 1970s to the 1990s, an NETL-funded research and development project pursued a technology that would optimize production of shale gas across the United States: microseismic monitoring of multi-stage hydraulic fracturing treatments. Commercialized by Pinnacle Technology, Inc., this service is now offered by every major oilfield service company and has been applied to tens of thousands of wells worldwide.

National Oilwell Varco: Intellipipe™

NETL's IntelliPipe™ is revolutionizing drilling technology. By communicating down-hole conditions in real time, IntelliPipe reduces the risks of drilling by increasing speeds and by reducing costs through such capabilities as directing the bit toward oil- and gas-bearing sweet spots and away from less productive areas, almost instantaneously. IntelliPipe is commercially available through National Oilwell Varco's IntelliServ® system.

General Electric: Diamond Composite Cutting Surfaces

In the 1980s, NETL partnered with General Electric to develop diamond composite cutting surfaces, which made polycrystalline diamond compact (PDC) bits possible. By 2002, PDC bits were favored for their drilling speed and increased bit life, and their sales accounted for one-third of the global drill bit market via commercial manufacturers around the world.

Lawrence Berkeley National Laboratory: TOUGH+/HYDRATE

With support from NETL's Methane Hydrate program, Lawrence Berkley National Laboratory has developed TOUGH+/HYDRATE, the first publicly available model designed exclusively to simulate gas hydrate reservoir behavior and production potential. With this model, commercial operators assess, identify, and predict performance in gas hydrate reservoirs.

Pumping Solutions, Inc.: Stripper Well Submersible Pump

A hydraulic-diaphragm electric submersible pump for stripper wells was developed by Pumping Solutions, Inc., in partnership with NETL. The pump moves sandy fluids through the well with much less power draw and purchase cost than comparable pumps on the market. Pumping Solutions was purchased by Schlumberger, who now offers the pump commercially.

Beyond Fossil Energy

U.S. Department of Defense: P-900 Cast Armor

NETL scientists worked with several U.S. Army commands to develop and continuously improve P-900, a unique slotted cast-steel armor for the Department of Defense. More than 200,000 castings of the high-strength material have been produced as part of a system to protect U.S. soldiers and military vehicles from IED threats.

Pouring a cast steel P-900 hatch for the Bradley Fighting Vehicle.

High-Speed Particle Imaging

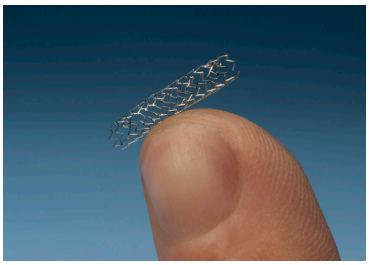
NETL uses its high-speed particle imaging (HSPI) system to study particle dynamics in fossil-fuel systems. HSPI also crosses research boundaries. It measured the leak rate of the 2010 Deepwater Horizon oil spill. Chemical-industry research consortium PSRI is using HSPI to improve industrial processes, and the University of Pittsburgh Medical Center's McGowan Institute has used it to visualize blood flow in artificial organs.

Cree, Inc.: XLamp® and LRP-38

The XLamp® and the LRP-38 are LED products offered by Cree, Inc., that incorporate a multichip technology developed by Cree in cooperation with NETL. Two buildings at the 2008 Olympics in Beijing, China, were illuminated by more than 750,000 XLamp LEDs. Walmart has replaced standard bulbs in the produce sections of 650 of its stores with LED-based LRP-38 lamps.

Boston Scientific Corporation: Coronary Stents

Boston Scientific Corporation and NETL developed a unique high-density, platinum-chromium alloy for coronary stents. A stent is a small, self-expanding metal mesh tube that saves thousands of lives every year by opening blocked arteries and allowing blood to flow freely again. The element platinum gives the stent high visibility with x-ray scanning. Better visibility means greater ease and precision in placement of the stent inside the patient's blood vessel. Since introduction in 2010, the platinum/chromium coronary stent series has become the leading stent platform in the world. Total sales since introduction have exceeded $4 billion.



A fully-deployed OMEGA™ Platinum Chromium Bare-Metal Coronary Stent from Boston Scientific.

About NETL

NETL is a U.S. Department of Energy national laboratory that produces technological solutions to America's energy challenges. For more than 100 years, the laboratory has focused on developing tools and processes to provide clean, reliable, and affordable energy to the American people. Three NETL research sites—Albany, Ore., Morgantown, W.Va., and Pittsburgh, Pa.—conduct a broad range of energy and environmental research and development activities that support DOE's mission to advance the national, economic, and energy security of the United States.

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