

# Commercialized Technologies and Significant Research Accomplishments

Oil and natural gas are the lifeblood of our economy, accounting for roughly 62 percent of the energy consumed in the United States in 2009. As the only U.S. Department of Energy (DOE) national laboratory dedicated to fossil energy, the National Energy Technology Laboratory (NETL) works to ensure that domestic natural gas and oil can remain part of the U.S. energy portfolio for decades to come. Research focused on accelerating the production of domestic unconventional natural gas resources has resulted in significant benefits all across the nation. The incremental production from unconventional natural gas resources since DOE's initial research investment in the 1970s totaled 27 trillion cubic feet (Tcf) in 2000 and 103 Tcf in 2010, and it is projected to reach 471 Tcf by 2035.

The highlights provided in this brochure are a compendium of research accomplished over more than 30 years through Fossil Energy's Oil and Natural Gas Program, managed by NETL. These brief synopses show the significant role that NETL played in fostering abundant and affordable supplies of domestic oil and natural gas resources that will continue to fuel our nation for decades to come.

## Research Themes



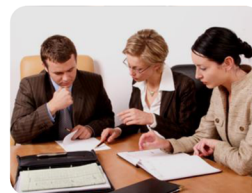
Deepwater Exploration & Production



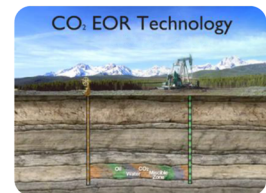
Unconventional Gas Resources



Methane Hydrates



Risk Assessment



CO<sub>2</sub> EOR Technology  
Unconventional Oil

*"In the opinion of the committee, DOE's program ... met its objectives of expanding the oil and gas resource base and increasing domestic production ... by utilizing DOE expertise .... Also, DOE supports smaller companies and independent producers ... which have limited resources to undertake R&D programs."*

— National Research Council, 2001

*"The combination [of FE's coal bed methane (CBM) research and other efforts] has raised CBM production from "essentially nothing to 2 trillion cubic feet of gas per year."*

— President's Council of Advisors on Science and Technology, 2010

*DOE's Eastern Gas Shales Program "helped expand the limits of gas shale production and increased understanding of production mechanisms. It is one of the great examples of value-added work led by the DOE."*

— Dr. Terry Engelder, The Pennsylvania State University, 2010

*"The Department of Energy was there with research funding when no one else was interested and today we are all reaping the benefits."*

— Fred C. Julander, President, Julander Energy Company, 2010

*"The U.S. position as one of the leaders in this field can be attributed to the overall high caliber of the research, the breadth of investigations undertaken, the training of new, highly qualified personnel under the program's auspices, and the successful collaboration between federal agencies conducting research on gas hydrates."*

— The National Academies, 2010



# Natural Gas and Oil Exploration and Production

## Enhanced Oil Recovery

NETL has advanced the science of enhanced oil recovery (EOR) through extensive laboratory and field demonstrations. Today, EOR using carbon dioxide (CO<sub>2</sub>) provides about 281,000 barrels of oil per day, or 6 percent of U.S. crude oil production. Using the next-generation CO<sub>2</sub>-EOR techniques currently being researched through NETL, an additional 67 billion barrels of oil could be produced economically at \$85 per barrel. As much as 18 billion metric tons of CO<sub>2</sub> could be sequestered during the process.

## Coalbed Methane Recovery

In the 1980s, NETL engineers helped bring coalbed methane to market. Today this one-time “waste” fuel accounts for almost 8 percent of our nation’s natural gas production.

## Microseismic Monitoring

From the 1970s to the 1990s, multiple NETL-funded research and development (R&D) projects 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.

## Diamond Composite Cutting Surfaces

In the late 1970s and early 1980s, NETL partnered with General Electric to develop and better understand diamond composite cutting surfaces and innovative bit designs to improve polycrystalline diamond compact (PDC) bits. By 2004, PDC bits accounted for approximately 50 percent of the revenue in the bit industry and nearly 60 percent of the well footage drilled by the oil and natural gas industry.



*DOE researchers gathering data from one of a series of cored shale wells in the Appalachian Basin in the early 1980s.*

## 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 downhole 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 significant resources associated with Marcellus Shale.

## **IntelliServ Broadband Network™**

The development of the IntelliServ Broadband Network, supported by NETL, is revolutionizing drilling technology. The networked drillstrings and the along-string evaluation capability provide high-definition downhole and subsurface operations. The system communicates downhole conditions in real time so that drilling operators can avoid less productive areas and find oil- and gas-bearing sweet spots more quickly, reducing exploration risks and costs. The broadband network and along-string evaluation service is commercially available through NOV™ IntelliServ.



Photo courtesy of NOV IntelliServ.

*Technician verifying electronics of a network node of IntelliServ Broadband Network™. These nodes can measure wellbore temperature and annular pressure at discrete intervals along the drill string.*

## **Wireless Electromagnetic-based Telemetry System**

With support from NETL, E-Spectrum Technologies has commercialized Spectra-Elink®, a wireless, electromagnetic-based telemetry system, to facilitate efficient natural gas drilling at depths beyond 20,000 feet. Using innovative technologies normally associated with interplanetary deep space navigation and missile guidance systems, the technology is designed to transmit data to and from downhole equipment in real time, enable surface processing of downhole sensor data, and control downhole tools directly from the surface. The technology allows the system to successfully operate at greater depths than other electromagnetic systems and to propagate signals through formations that typically weaken electromagnetic waves.

## **Fracturing Fluid Recycling**

GeoPure HydroTechnologies combines a membrane technology, developed through NETL's Oil & Natural Gas Program by researchers at Texas A&M University, with a proprietary patent-pending pre-treatment process to treat and recycle fracturing fluids used to increase well productivity. GeoPure installed its first commercial desalination unit in the Barnett Shale in early 2007 and now offers its cost-effective commercial services to the oil industry.

## **Foam Fracturing**

NETL introduced foam fracturing, a well stimulation method, to oil and gas operators in the eastern United States in 1975. Foam fracturing offers several benefits over water fracturing, including greater production from low-pressure formations and the need for significantly less water. Today, thousands of wells are fractured using this technology.

## **High Temperature Electronics**

With NETL support, Honeywell International Inc. developed its Reconfigurable Processor for Data Acquisition (RPDA)—a reprogrammable, multi-functional device that can operate at temperatures up to 250 °C (482 °F). The system is housed in a rugged package suitable for deep downhole oil and natural gas logging, measurement-while-drilling (MWD) operations, and permanent wellbore installation applications.

## Water Treatment System Cleans Marcellus Shale Wastewater

In an NETL-funded demonstration project, Altela Inc.'s AltelaRain® 4000 water desalination system successfully treated 77 percent of the hydraulic fracturing flowback water at a well site in Pennsylvania, providing distilled water as the product. The average treated water cost per barrel over the demonstration period was approximately 20 percent lower than previous total conventional disposal costs at the site. The system also significantly reduced the need for trucking wastewater from the site. As a result of the project, Altela designed larger towers for the system and four AltelaRain® 600 modules were sold and installed in Williamsport, Pa., to treat approximately 100,000 gallons per day of produced and flowback water from hydraulic fracturing.



Photo courtesy of Altela Inc.

*An AltelaRain® desalination unit and water treatment towers.*

## Downhole Seismic Receiver Array

With support from NETL, Paulsson Geophysical completed development of an advanced downhole seismic receiver array, capable of reliable operation at depths up to 25,000 feet, that provides two to five times the image resolution of previous tools. The tool is being used worldwide to provide better images of oil and gas reservoirs.

## EMT Technology

Geoscience Electronics Corporation (GEC), with support from NETL, developed and tool-hardened the first prototype electromagnetic MWD system for horizontal air underbalanced drilling in the mid-1980s. After Sperry Sun purchased the rights to GEC's tool, NETL helped Sperry Sun commercialize the current version of their electromagnetic telemetry (EMT) technology, which is now being used to drill hundreds of horizontal Huron Shale wells in the Appalachian Basin.

## Mud Pulse Telemetry System

Originally funded by NETL in the 1970s, Teleco's mud pulse telemetry system led to an industry standard to transmit downhole data to engineers at the surface during drilling operations, allowing them to make more informed drilling decisions.

## Small Producers: Marginal (Stripper) Wells

### Gas Gathering and Flow Line Tool

Vortex Flow LLC's new SX tool, developed with support from NETL, has been deployed in more than 200 stripper well operations across the country. The tool increases production and decreases maintenance costs by using the produced natural gas to accelerate water velocity, reduce friction, and assist in lifting and removing fluids, which reduces the amount of down-time caused by water in gas gathering and flow lines.

## Submersible Pump

A hydraulic-diaphragm electric submersible pump for marginal 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, which now offers the pump commercially.

## GOAL PetroPump

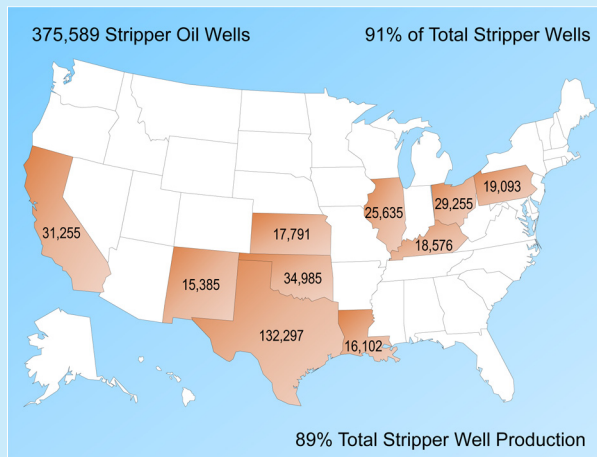
The Gas Operated Automatic Lift (GOAL) PetroPump developed by Brandywine Energy & Development Company with support from NETL removes fluid from the wellbore more consistently than currently available plunger lift systems. Test results on wells in New York showed a 50-130 percent increase in gas yield using the GOAL PetroPump. The tool is inexpensive to operate, requiring no external energy source and limited manpower.

## Pre-Pump-Off Controls

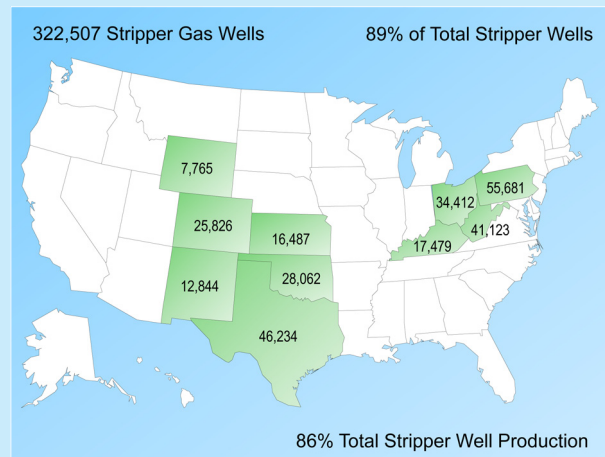
Pre-Pump-Off Controls, a set of technologies developed by Oil Well Sentry Inc. with support from NETL, eliminates fluid level issues in beam-pumped wells. The system monitors the amount of fluid in the barrel pump at the bottom of the well and shuts off the beam pump motor or engine when the well is “pumped off.” Use of the system has significantly increased production while decreasing motor/engine energy consumption by 30 percent.

### Operations Technologies

Three technologies with application to stripper well operations have been developed by Tubel Technologies Inc.: (1) a downhole wireless gauge that transmits pressure, temperature, and other parameters to the surface without the need for cables in the wellbore, (2) a plunger-generated acoustic noise detection and digital signal processing system to optimize plunger lift systems, and (3) a real-time remote field monitoring system for plunger lift wells to reduce down-time and increase production. NETL support of these technologies led to the purchase of Tubel Technologies by Ziebel AS, which has incorporated the technologies into their product lines.



**Top 10 Stripper Oil Well States  
(as of January 1, 2009)**



**Top 10 Stripper Gas Well States  
(as of January 1, 2009)**

Source: “Marginal Wells: Fuel for Economic Growth, 2009 Report,” Interstate Oil and Gas Compact Commission.

## Hydrate Characterization in Gulf of Mexico: JIP Program

In 2005, NETL's Joint Industry Project (JIP) program confirmed that available tools and procedures can be safely used to drill through gas hydrate-bearing sediments as they most typically exist in the Gulf of Mexico. As a result, deepwater wells can be located, and the shallow hazards managed, more efficiently.

In 2009, the JIP program completed a successful drilling and logging program, JIP Leg II, that measured gas hydrate saturations ranging from 50 percent to more than 90 percent in high-quality sands near the base of the gas hydrate stability zone. The deposits were found in close accordance with the project's pre-drill predictions, providing confirmation of the project's gas hydrate exploration and appraisal technologies. NETL provided one of the two science co-chiefs of the expedition, who helped plan the data acquisition program and guide its implementation in the field.



Photo courtesy of Helix Well Ops U.S. Inc.

## Well Enables Future Testing of Hydrate-Production Technology

ConocoPhillips, in partnership with NETL, safely completed field operations on the Iñnik Sikumi gas hydrate field trial well in 2011. The field program resulted in the installation of a fully instrumented well that will be available for field experiments as early as winter 2011–12. The well is designed to enable the initial field investigation of a potential hydrate-production technology that involves injecting CO<sub>2</sub> into sandstone reservoirs containing methane hydrate. Laboratory studies indicate that the CO<sub>2</sub> molecules will replace the methane molecules within the solid hydrate lattice, resulting in the simultaneous sequestration of CO<sub>2</sub> in a solid hydrate structure and the production of methane gas.

## Numerical Simulation

With support from NETL's Methane Hydrate program, DOE national laboratories—including Lawrence Berkeley National Laboratory, Pacific Northwest National Laboratory, and NETL—have developed numerical codes that simulate gas hydrate reservoir behavior. NETL leveraged the data obtained at the Mount Elbert site to convene an international modeling consortium to compare all known existing codes worldwide, which resulted in substantial improvements to all of the codes and assessments of production potential. With these codes, industry and federal scientists can assess, identify, and predict performance in gas hydrate reservoirs, increasing accuracy in methane hydrate analyses.

## Gas Hydrate Field Assessment Technologies

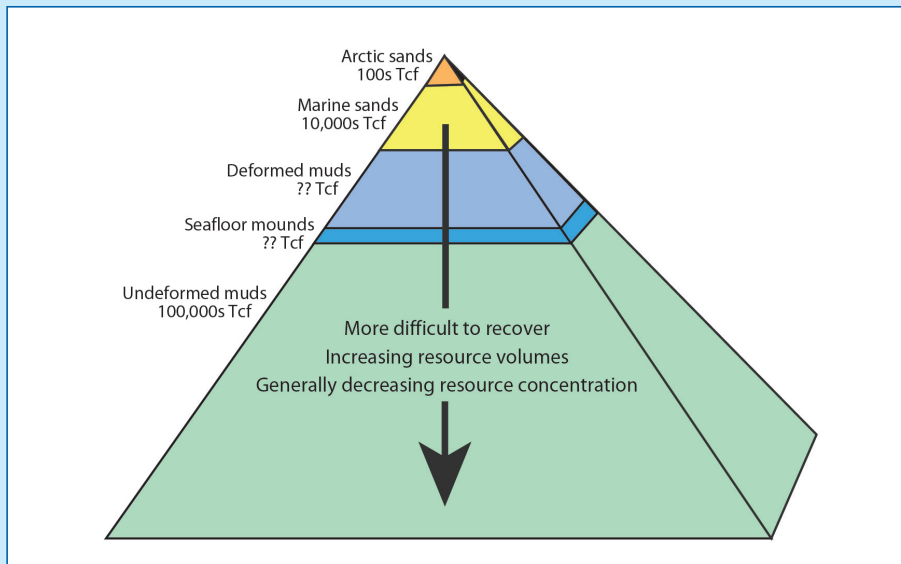
In partnership with the National Science Foundation and other research organizations, NETL has supported the development and use of an array of devices that are now standard tools in gas hydrate field programs. These devices include downhole temperature probes, pressure-coring technologies, and pressure core analysis tools, such as the Integrated Pressure Test Chamber.

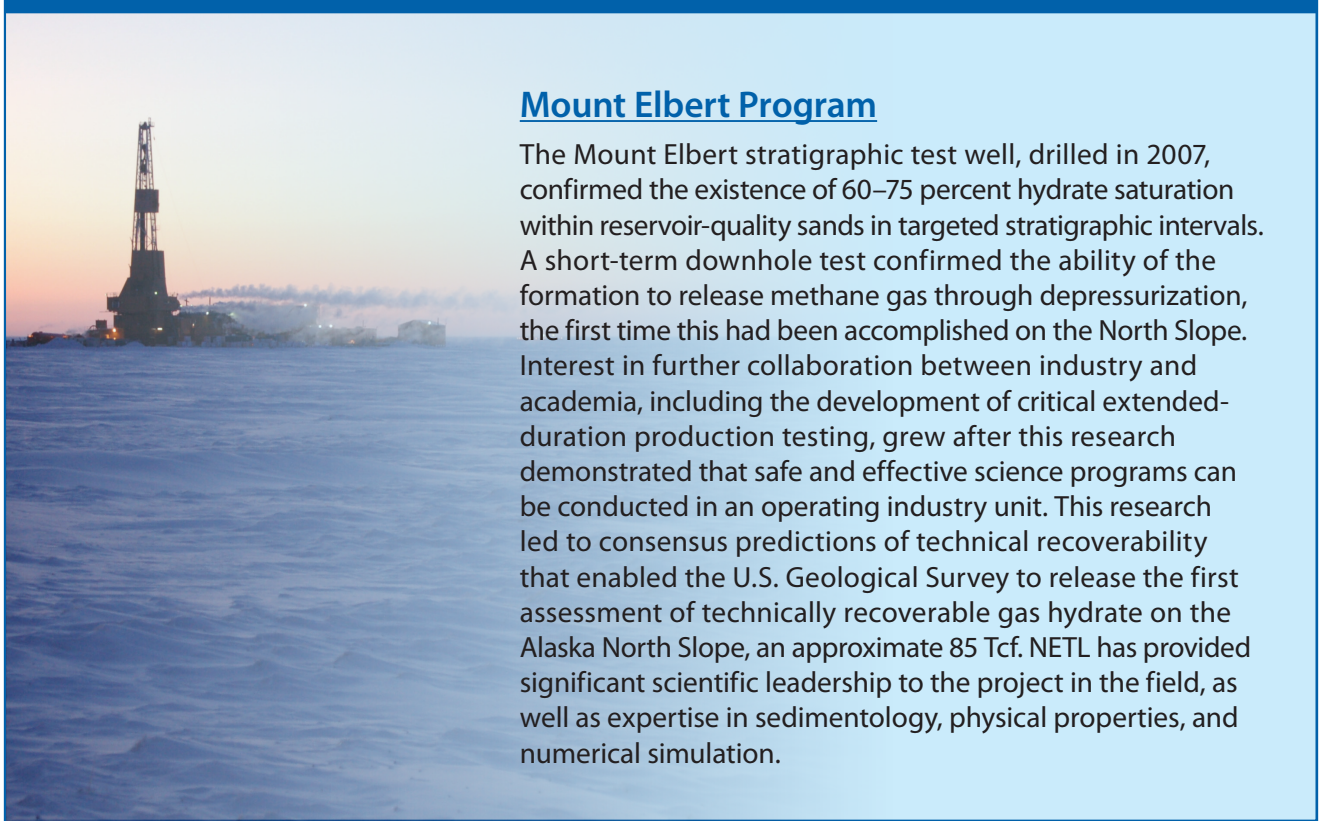
## International Methane Hydrate Collaboration

NETL collaborates with international partners on a variety of hydrate research projects. Since 2006, NETL has led an international gas hydrate modeling consortium that includes scientists from the United States, Japan, and Canada. In 2006, NETL contributed scientific leadership and technical support for India's multi-site logging and coring expedition in the Indian Ocean. In 2007, NETL participated in China's logging and coring research expedition in the South China Sea. In 2007 and 2010, NETL participated in Korean logging and coring expeditions in the Ulleung Basin, East Sea, Korea. NETL provided expert advice on the selection of drill sites for the 2010 Korean expedition and has been invited to do the same for an upcoming 2012 India expedition. These collaborations have helped confirm the geologic models that guide the major U.S. field programs, enabled fundamental advancements in modeling capability, and provided key insights into optimal field program operational and sampling protocols and technologies.

### Recovery Potential Quantified

NETL, in collaboration with other federal agencies, has enabled the identification and initial quantification of that portion of the global gas hydrate resource that is compatible with safe and environmentally sound drilling and production practices. NETL's Methane Hydrate program has developed and demonstrated technologies by which these deposits can be identified in both Arctic and marine settings. These advances have led to development of the Gas Hydrates Resource Pyramid, shown here, which presents an idealized view of the world's gas hydrate resource. This view has been widely adopted internationally and has been used by NETL researchers providing advice and consultation to government R&D programs throughout the world.





## Mount Elbert Program

The Mount Elbert stratigraphic test well, drilled in 2007, confirmed the existence of 60–75 percent hydrate saturation within reservoir-quality sands in targeted stratigraphic intervals. A short-term downhole test confirmed the ability of the formation to release methane gas through depressurization, the first time this had been accomplished on the North Slope. Interest in further collaboration between industry and academia, including the development of critical extended-duration production testing, grew after this research demonstrated that safe and effective science programs can be conducted in an operating industry unit. This research led to consensus predictions of technical recoverability that enabled the U.S. Geological Survey to release the first assessment of technically recoverable gas hydrate on the Alaska North Slope, an approximate 85 Tcf. NETL has provided significant scientific leadership to the project in the field, as well as expertise in sedimentology, physical properties, and numerical simulation.

## Methane Hydrate and Global Climate

In recent years, NETL has supported experts from universities and other national laboratories in quantifying methane flux from a variety of hydrate-bearing environments in order to define the potential impacts of methane hydrate formation and dissociation on the global carbon cycle. The work has resulted in the first numerical simulations of the potential response of gas hydrate to changing climates, and their potential impact on greenhouse gas inventories and ocean ecology.

## About NETL

NETL is a DOE 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. NETL has three research sites—in Albany, Ore., Morgantown, W.Va., and Pittsburgh, Pa.—that conduct a broad range of energy and environmental R&D. NETL also has small offices in Sugar Land, Texas, and Fairbanks, Alaska, that address challenges unique to those energy-rich regions. All five locations support DOE's mission to advance the national, economic, and energy security of the United States.



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