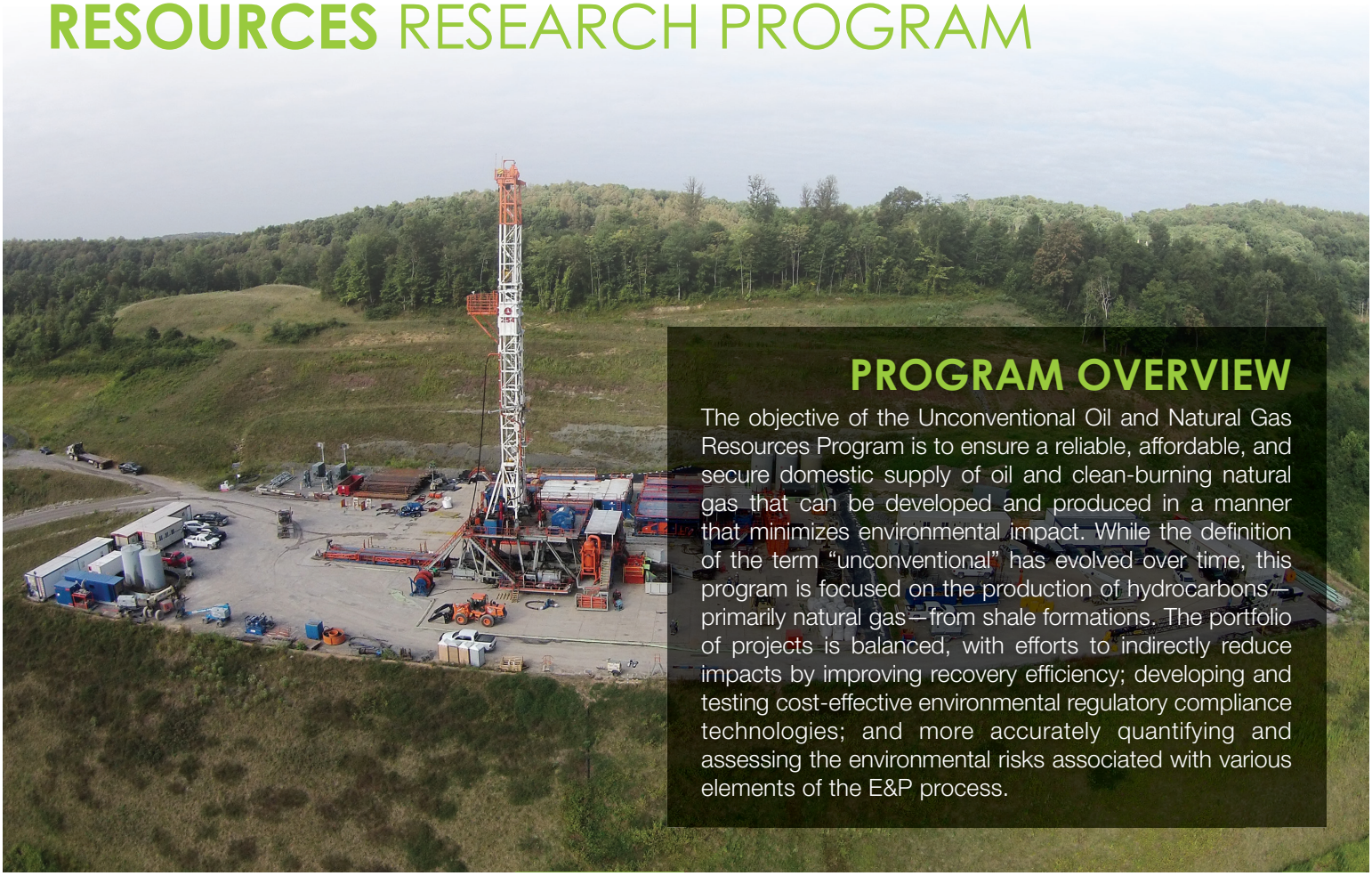
UNCONVENTIONAL OIL AND NATURAL GAS RESOURCES RESEARCH PROGRAM



PROGRAM OVERVIEW

The objective of the Unconventional Oil and Natural Gas Resources Program is to ensure a reliable, affordable, and secure domestic supply of oil and clean-burning natural gas that can be developed and produced in a manner that minimizes environmental impact. While the definition of the term "unconventional" has evolved over time, this program is focused on the production of hydrocarbons—primarily natural gas—from shale formations. The portfolio of projects is balanced, with efforts to indirectly reduce impacts by improving recovery efficiency; developing and testing cost-effective environmental regulatory compliance technologies; and more accurately quantifying and assessing the environmental risks associated with various elements of the E&P process.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

Over the past decade, the focus of the program has turned toward reducing the environmental impacts of unconventional resource development. The current program goals are:

- Identify and accelerate development of economically-viable technologies to more effectively locate, characterize, and produce natural gas and oil resources in an environmentally acceptable manner.
- Characterize emerging oil and natural gas accumulations at the resource and reservoir level and publish this information in a manner that supports effective development.
- Catalyze the development and demonstration of new technologies and methodologies for limiting the environmental impacts of unconventional and natural gas development activities.

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THE ISSUES

Several trends are currently converging, amplifying the need for continued research into ways to reduce the environmental impact of domestic oil and gas production.

- Energy demand continues to grow, and the need to limit energy imports for economic and energy security reasons remains strong
- Natural gas remains an important element of any strategy to help the U.S. transition to a lower carbon energy footprint
- Conventional domestic natural gas production is declining, and the primary alternative for replacing it (e.g., natural gas from hydraulically fractured shales) involves an increased demand for fresh water, wastewater disposal, incidences of surface disturbances, and methane emissions
- Stakeholders are increasingly concerned about the environmental impacts of large-scale development of shale plays, and interested in basing decisions on scientifically sound data reflecting the costs and benefits of energy development

These trends have highlighted the need for good scientific data and more rapid technology development to address issues facing all stakeholders, from citizens to policymakers to energy producers.

ACCOMPLISHMENTS/ PROGRAM SUCCESS

Some accomplishments of the program to date:

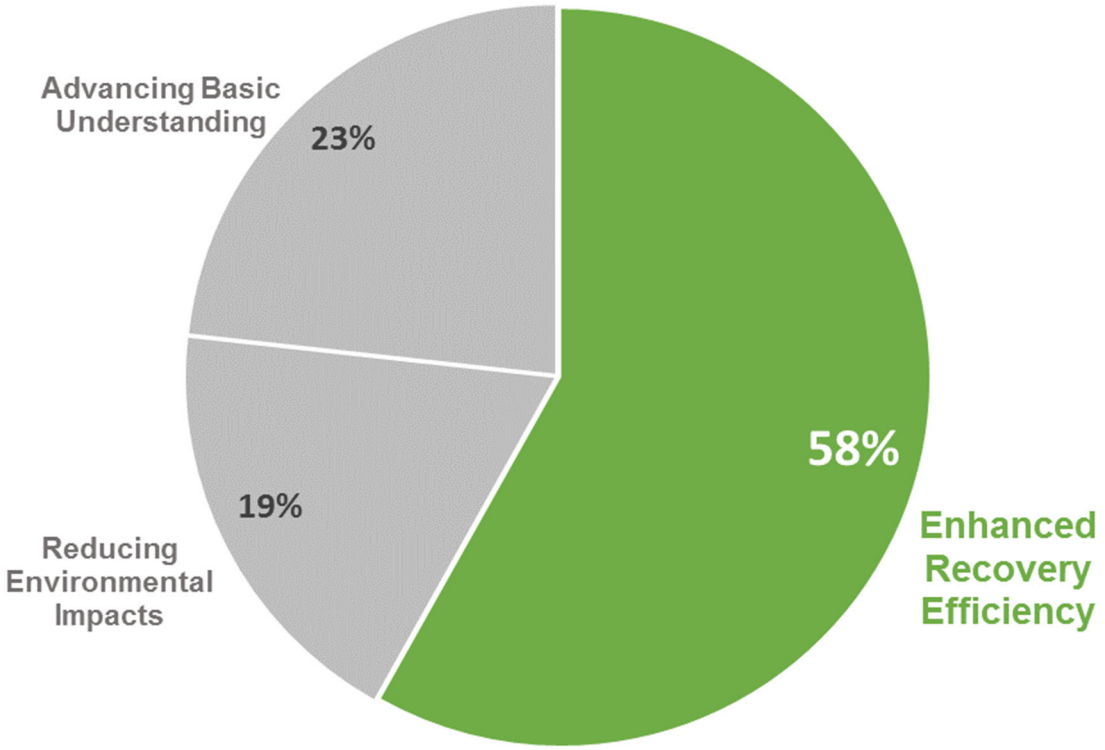
- Researchers at the University of Texas developed and tested a temperature-stable, nanoparticle-based drilling fluid that dramatically reduced fluid reactivity with shale formations. This new fluid formulation could be used to reduce the formation damage associated with drilling wells in reservoirs with significant volumes of water-sensitive shales.
- Lumedyne Technologies, Inc., has made a breakthrough that could lead to an alternative to the decades-old geophone used for seismic data gathering: a micro-electro-mechanical (MEMS) accelerometer with improved low frequency response, lower power consumption, lower unit cost, and longer product life. Such sensors could provide higher resolution spatial and temporal imaging, enabling “permanent monitoring” of critical reservoir processes through time-lapse seismic imaging at resolutions of less than a few meters on a widespread, routine basis.
- West Virginia University and its research partners developed an on-site, multi-media filtration system to beneficially reuse produced water. After successfully testing the process in the laboratory, the team designed, fabricated, and deployed a mobile treatment unit to complete two field trials. Over 600,000 gallons of water were treated during the field trials, with 98.6 percent of the water recycled.

PROJECT PORTFOLIO

The Unconventional Oil and Natural Gas Resources Program aims to find solutions to these environmental concerns: by focusing on (1) advancing basic scientific understanding of unconventional oil and gas resources, (2) increasing hydrocarbon recovery efficiency, and (3) reducing environmental impacts.

While many of the projects in the portfolio are set in the laboratory, a portion of the portfolio is specifically focused on research at "field laboratories." These locations function as observatories where scientists can carry out data-gathering and test methods that can only be done on location with actual wells and facilities. The two examples of this approach currently under way have already provided some important findings and an expansion to additional sites is under consideration.

Currently, there are 36 active or recently completed extramural projects in the Unconventional Oil and Natural Gas Resources Program, for a total value of roughly $86 million (not including participant cost-share of at least 26 percent). The project leads and team members are balanced across producers, universities, state agencies, and technology providers.



58 percent of the active or recently completed projects focus on Enhanced Recovery Efficiency. The remaining projects focus on Advancing the Basic Understanding of Unconventional Oil and Natural Gas Resources (23 percent) and Reducing Environmental Impacts (19 percent).

ONSITE RESEARCH

In addition to managing these extramural projects, NETL is carrying out on-site research projects designed to complement these efforts. Scientists and engineers at NETL are:

- Determining the physical, geomechanical, and thermodynamic phenomena that govern shale reservoir behavior to develop solutions (models, technology, best practices) that decrease development intensity
- Conducting integrated scientific monitoring of shale gas development impact on subsurface reservoirs, recovery efficiency, air quality, and water use, in concert with the extramural field observatories described above
- Investigating the long-term integrity of casing/cement bonding
- Investigating non-aqueous based (or reduced water) systems for hydraulic fracturing
- Investigating options for improving re-fracking operations applicable to tight oil and gas
- Developing technologies/best practices focused on enhanced recovery from tight oil and natural gas formations using CO_2
- Identifying pathways for converting underutilized U.S. natural gas resources into valuable liquid products along with cogeneration of heat and electric power

These projects, along with the extramural projects, form a portfolio that is balanced and responsive to the issues facing stakeholders. The data, technologies, and tools developed through this portfolio help industry and regulators make decisions and optimize operations in ways that will advance the goals of environmentally sustainable development of domestic oil and natural gas resources.

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