



the **ENERGY** lab

PROGRAM FACTS

Strategic Center for
Natural Gas & Oil

Technology Solutions for Mitigating Environmental Impacts of Oil and Gas E&P Activity

The mission of the Environmental Program is to promote a reliable, affordable, and secure supply of domestic oil and clean-burning natural gas, by providing cost-effective environmental regulatory compliance technologies, enhancing environmental protections during oil and gas E&P operations, and facilitating the development and use of scientific, risk-based environmental regulatory frameworks.

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 slow the growth in energy imports for economic and energy security reasons remains strong.
- Stakeholders at all levels are increasingly interested in making holistic decisions regarding multiple land use options, using scientifically sound data that reflect the costs and benefits of energy development decisions.
- Conventional domestic natural gas production is declining, and the alternatives for replacing it (e.g., unconventional gas from coal and shale) involve the potential for incremental increases in water demand, wastewater disposal, and surface disturbances.

These trends have highlighted the need for scientific data and technology development to address issues facing both policymakers and energy producers. For example:

- Regulations have placed significant volumes of natural gas and oil resources off limits due to the perception that their development would involve a risk of environmental damage.
- Development of multiple gas shale plays has heightened concerns about hydraulic fracturing of these reservoirs using millions of gallons of water for each treatment, a large portion of which flows back and must be disposed of or reused.
- Produced water disposal constraints are limiting coalbed methane development.
- The potential for future development of unconventional oil resources in the Rocky Mountains has raised concerns over the impact of such development on surface, water, and air resources.
- Increased attention on future development of additional oil and gas resources in Alaska has elevated issues related to the unique challenges of operating in an arctic region, such as the environmentally acceptable use of fresh lake water for ice roads.

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U.S. DEPARTMENT OF
ENERGY

All of these challenges are the targets of the current portfolio of projects in the Environmental Program.

Project Portfolio

The Environmental Program aims to find solutions to these and other environmental concerns, by focusing on the following program elements: 1) fracture flowback and produced water treatment and management, particularly in gas shale development areas, 2) water resource management in oil and gas basins, 3) environmental impact mitigation, and 4) development of decision-making tools that help operators balance resource development and environmental protection.

Currently, there are 20 active or recently completed extramural projects in the Environmental Program, for a total value of roughly \$26.6 million (not including participant cost-share). Approximately \$9 million of this total is directed toward projects led by industry, \$7 million to projects led by universities, \$9.6 million to state agencies and national non-profit organizations, and \$1 million to national laboratories for technical support to other project partners.

The project portfolio is balanced between projects focused on technology development, data gathering, and development of data management software and decision support tools.

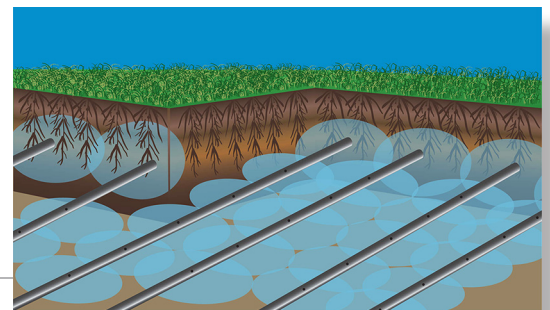
Individual project objectives are listed in the table below, with the project's lead organization and the associated Program Element indicated.

| Program Element | R&D Objective |
|---|--|
| <p style="text-align: center;">Fracture Flowback and Produced Water Treatment and Management</p> | <ul style="list-style-type: none"> • Develop an on-site filtration system for treating fracture flowback water; a five-stage modular design will allow efficient treatment of flowback in scenarios where water conditions change over time (West Virginia U.) • Develop a sustainable approach to water management in the Marcellus Shale play, including on-site treatment and reuse of fracture flowback water for hydrofracturing in adjacent wells (U. Pittsburgh) • Develop an internet-based decision support tool to minimize environmental impacts related to oil and gas operations in the Fayetteville Shale Play, in central Arkansas (U. Arkansas and Argonne Nat'l. Lab) • Develop strategies for managing produced water associated with coalbed methane development in the Black Warrior basin (Geological Survey of Alabama) • Develop a low-cost, mobile process that treats the low- total dissolved solids portion of the fracture flowback water and yields water suitable for re-use in hydrofracturing (GE Global Research) • Develop wetland systems for treatment and beneficial use of produced water and study ecological, environmental, and regulatory concerns that influence produced water management decisions (Clemson U.) • Demonstrate AltelaRain® fracture water treatment and re-use technology in the Marcellus Shale basin (Altela) • Develop a modeling system to allow operators and regulators to plan all aspects of water management associated with shale gas development in New York, Pennsylvania, and West Virginia (ALL Consulting) • Create an internet-based Water Treatment Technology Catalog and Decision Tool that will match an operator's water treatment cost and capacity needs to optimal water treatment technologies (ALL Consulting) • Develop and field test a mobile water treatment methodology for pre-treatment of produced brine and fracture flowback water (Texas Engineering Experiment Station and Los Alamos Nat'l Lab) |
| <p style="text-align: center;">Water Resources Management</p> | <ul style="list-style-type: none"> • Develop tools to manage the utilization of fresh water for building ice roads and snow roads, which are critical to oil and gas development on the North Slope of Alaska (Geo-Watershed Scientific) • Develop tools to assist industry and resource management agencies in optimizing the design of Arctic transportation networks (Idaho Nat'l Lab support to Geo-Watershed Scientific) • Develop a water resource geospatial tool that will facilitate decision making for potential oil shale resource development, environmental impact studies, and scenario analyses (Colorado School of Mines and Idaho Nat'l. Lab) • Characterize regional aquifers to facilitate water disposal permitting and protection of fresh water resources; identify water issues related to conventional oil and gas development as well as possible oil shale development in the Uinta Basin (Utah Geological Survey) |

| Program Element | R&D Objective |
|--|---|
| Environmental Impact Mitigation | <ul style="list-style-type: none"> • Create database inventory of oil and natural gas industry compressor engines to evaluate emissions control technologies in lab and field tests (Kansas State U.) • Conduct pilot- scale field demonstration of process to capture and convert coal mine methane emissions into liquefied natural gas (Appalachian-Pacific Coal Mine Methane Power Co.) • Develop and test a snow control practice to enhance snow drift formation as a way to recharge depleted fresh water lakes for multiple uses, including oil and gas activity (U. Alaska Fairbanks) |
| Decision-Making Tools | <ul style="list-style-type: none"> • Develop a science, engineering, and technology support system for water resources planning and management related to oil and gas development on the North Slope of Alaska; provide solutions to concerns regarding economic, environmental, and cultural impacts of water use (U. Alaska Fairbanks) • Enhance the utility of the Risk Based Data Management System, by adding new components relevant to environmental issues related to hydraulic fracturing (Ground Water Protection Council) • Identify issues delaying or curtailing oil and gas E&P activities, identify and publicize practices that ultimately overcome these impedances or delays, and help to advance the development of underdeveloped resources in specific basins (IOGCC) |

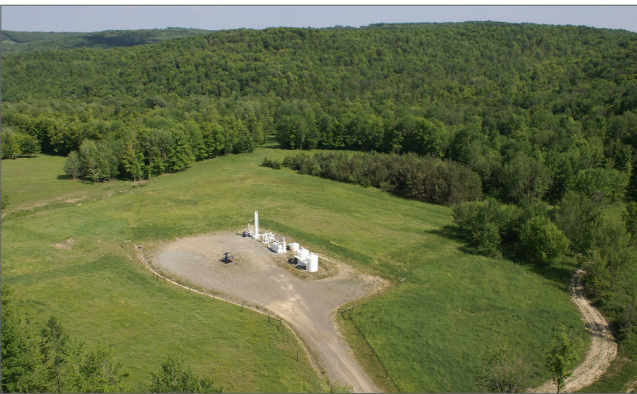
Onsite Environmental Research

In addition to managing these extramural projects, NETL is carrying out onsite research projects designed to complement these efforts. In the Appalachian Basin region, scientists and engineers at NETL are performing laboratory and modeling studies to determine best practices for minimizing the environmental impacts of fracture flowback water, using well data and samples from the Marcellus Shale. The research team is exploring the potential for using low-grade, waste heat from coal-burning power plants to thermally treat flowback water and using treated flowback water as make-up water for cooling circuits. In another project, NETL is conducting field-based research to determine the ecological impacts of oil and gas access roads and drill pads in the central Appalachian region. In a project focused on the Powder River Basin of the Rocky Mountain region, NETL is engaged in research to evaluate subsurface drip irrigation as a potential beneficial use for coalbed methane produced waters. This could provide a low-cost means to dispose of produced water while increasing crop production and improving relationships between natural gas operators and ranchers. NETL is also collaborating with universities and National Labs to study the impacts of oil and natural gas E&P activities on air quality in the Appalachian and Rocky Mountain regions. This work will include extensive field monitoring and numerical modeling to assess the impacts on visibility and air quality. NETL is also working closely with the Environmental Protection Agency to quantify the environmental footprint of drilling activity in the Marcellus Shale play of southwestern Pennsylvania.



NETL is gathering scientific data to determine if subsurface drip irrigation is an environmentally acceptable way to manage produced water from coalbed methane wells while at the same time providing needed irrigation water to farmers in the Powder River Basin.

These projects, along with the extramural projects described above, 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.



Large scale hydraulic fracturing for gas shale wells in the Appalachian Basin (shown above) and other areas has highlighted the need for tools to help manage flowback water from fracturing operations as well as produced water post-completion. NETL is managing R&D focused on these problems.



Helicopter drones are being used or employed by NETL to gather data for more accurately estimating the air quality impacts of oil and gas production.

WEBSITES RELATED TO PAST AND CURRENT RESEARCH

Modern Shale Gas Development in the United States: A Primer

<http://www.gwpc.org/e-library/documents/general/Shale%20Gas%20Primer%202009.pdf>

State Oil and Natural Gas Regulations Designed to Protect Water Resources

http://www.gwpc.org/home/GWPC_Home.dwt

Risk Based Data Management System

www.rbdmsonline.org

Produced Water Management Information System (PWMIS)

<http://www.netl.doe.gov/technologies/pwmis/index.html>

Fayetteville Shale Information

<http://lingo.cast.uark.edu/LINGOPUBLIC/>

Water Resources and Use for Hydraulic Fracturing in the Marcellus Region

http://www.all-llc.com/projects/shale_water_lifecycle/

Water Treatment Technology Catalog and Decision Tool

http://all-llc.com/projects/produced_water_tool/

Uinta Basin Water Study

http://geology.utah.gov/emp/UBwater_study

Drilling Waste Management Information System (DWMIS)

<http://web.ead.anl.gov/dwm/>