



DOE Oil and Natural Gas Water Resources Program

DOE Oil and Natural Gas Water Resources Program promotes oil and gas water management approaches that increase U.S. energy supplies while enhancing useable water resources for American consumers and protecting water quality and the environment.

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Issue

Water availability is and will continue to be a high priority in the U.S. and throughout the world, mostly because competition for water is becoming more intense. Water used for irrigation, power generation, industrial uses, and commercial and residential purposes places pressure on water resources, which may further be compounded by the impacts of climate change. Just as the Nation's energy needs depend on reliable supplies of water, the treatment and distribution of quality water rely upon readily available, affordable energy. This interdependence between water and energy is a common theme demonstrated in many industries, such as oil and natural gas production.

Water management plays a major role in oil and gas operations. Water is injected into many oil fields to improve production, and often water from an oil- or gas-bearing formation flows to the surface during production. This water, called produced water, is the largest volume by-product or waste stream associated with oil and gas exploration and production (E&P). About 20 billion bbl (barrels; 1 bbl = 42 U.S. gallons) of produced water are generated each year in the United States from nearly a million wells. Ensuring that this water is properly managed and does not adversely affect the environment is a key concern for oil and gas producers.

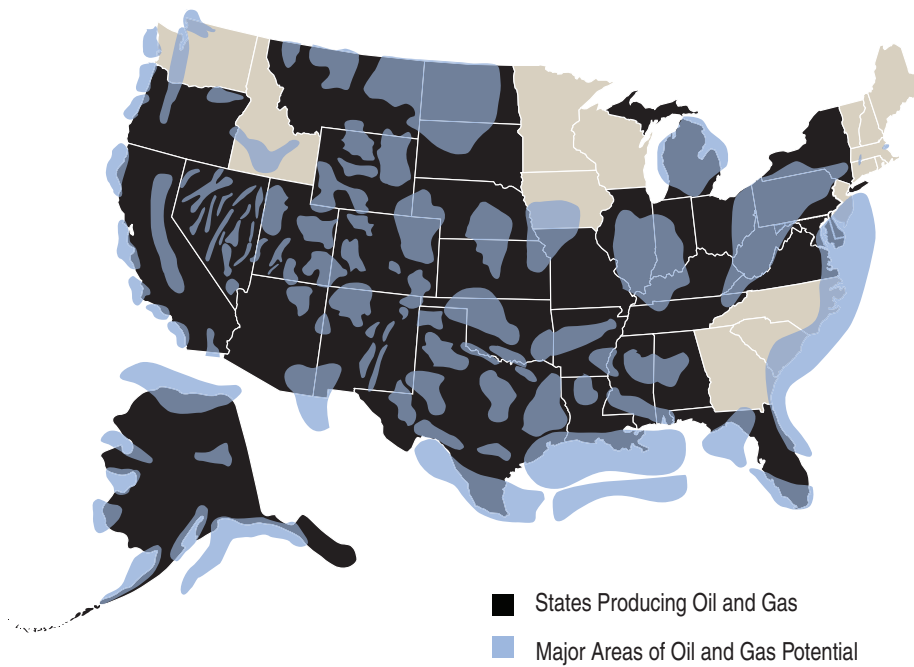
For many years, the Office of Fossil Energy (FE) has sponsored research and analysis projects related to produced water management in oil and natural gas operations.

Energy and Water Challenges in the U.S.

The U.S. has abundant oil and natural gas resources as depicted in Figure 1. Natural gas and crude oil provide two-thirds of our Nation's primary energy supply and will continue to do so for at least the next several decades, even as we transition to a more sustainable energy future. Figure 2 shows the total freshwater withdrawals from groundwater and surface water resources nationwide compared to projected population growth by region from 2000-2030. As population grows, the demands for energy and water resources will increase. Smart development of oil and natural gas resources will identify, consider, and minimize potential impacts to water resources. The DOE Office of Fossil Energy's Oil and Natural Gas Water Resources Program seeks to address some of the water and energy challenges this nation faces.

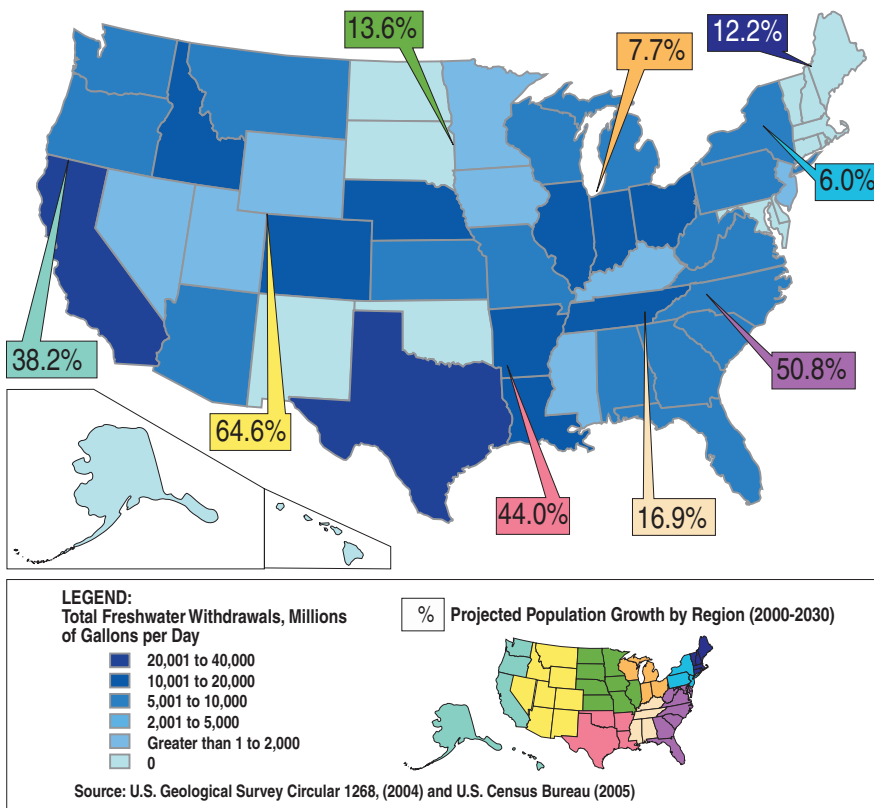


Figure 1. U.S. Oil and Natural Gas Basins



Today, oil and natural gas are produced in over 30 states. The U.S. is the world's second largest producer of natural gas and the third largest producer of oil. Nearly every region of the country has oil and natural gas potential.

Figure 2. Water Challenges Nationwide



R&D Overview

Environmentally-responsible water management in oil and gas operations is a high priority for the DOE Oil and Gas Water Resources Program. The management of water (including produced water and water used for hydraulic fracturing), treatment of waste water, and the availability of water continue to be environmental and economic challenges for operators. Since water used and produced during oil and gas production comes in varying qualities, there is no single, specific treatment or disposal procedure to handle the water in beneficial



Water – a most precious commodity

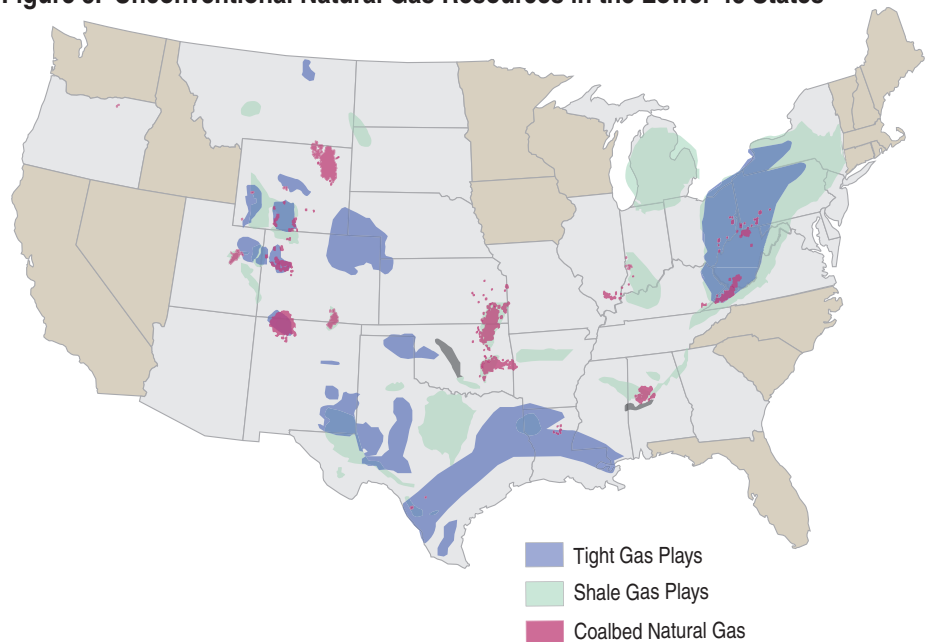
Highlights:

Oil and natural gas production use a small amount of the nation's water resources compared to other societal uses. Only 5% of the total water withdrawn in the United States from surface and groundwater sources is used for industrial activities (e.g., oil and gas production) and mining, compared to almost 49% for power plant cooling, 31% for irrigation, 12% for public supply and self-supplied domestic use, 2% for aquaculture, and about 1% for livestock. Source: U.S. Geological Survey.

ways, such as reuse during operations. Available technologies to handle this water are often costly and site specific. In addition, the lack of a market for treated water or for treatment byproducts (i.e., condensed salts or other minerals) create little economic incentive to invest in new water technologies.

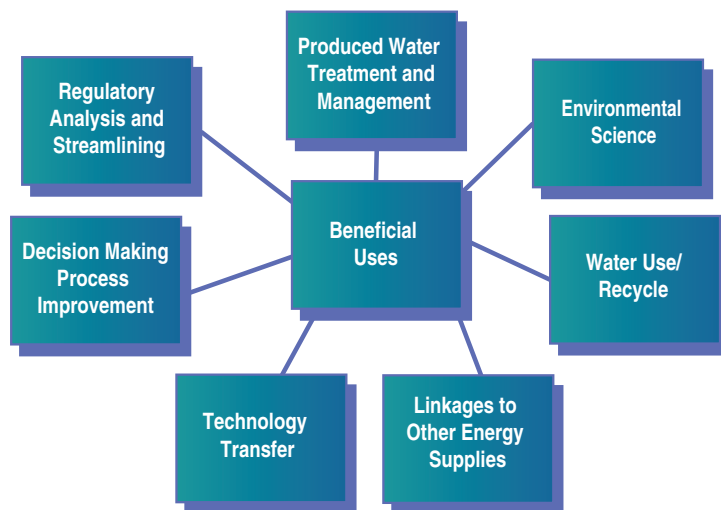
Since 1991, over 100 oil and gas water-related research & development (R&D) projects have been conducted through several DOE Oil and Natural Gas programs, especially since the inception of the Oil and Gas Environmental Program. Past projects and activities have provided information, science, and technologies to various stakeholders and DOE itself in the scientific, industrial, and regulatory areas. Extensive support on regulatory issues such as synthetic-based drilling fluids and management of coalbed natural gas produced water, including development of highly effective membranes for water treatment, are just some accomplishments not only for the program but also for the Nation's energy supply. Much has been learned about many issues associated with the responsible management of water used and produced in oil and gas operations. However, more knowledge in water disposal, water availability, and protection of water resources can be gained with future research. The program invests in oil and gas water management research that pursues improvements in regulatory decision making, supports development of new technologies, and helps promote energy policies that encourage beneficial uses of produced water.

Figure 3. Unconventional Natural Gas Resources in the Lower 48 States



Water plays a big role in natural gas production. Unconventional gas resources such as tight gas, shale gas, and coalbed natural gas contribute significantly to domestic natural gas supply and will continue to do so for the next decades.

Figure 4. Oil and Natural Gas Water Resources Program Research



The program focuses many DOE water-related projects on enabling beneficial uses of water produced, used, or recycled from oil and gas operations.

Highlights:

Shale Gas – Development of the Nation's abundant shale gas resources has brought increased attention to the water used and managed in hydraulic fracturing of the producing geological formation, in which water flows back to the surface and must be properly disposed of or reused.

Coalbed Natural Gas (CBNG) – Initial steps of CBNG development can produce large quantities of produced water. Constraints on produced water disposal may limit economical gas recovery.

Oil Shale – Development of oil shale resources in Colorado, Wyoming, and Utah may use significant amounts of water to extract and process tar sands and bitumen, depending on the composition of the resource and other factors.

Arctic Oil & Gas Resources – Large volumes of water are required for the construction and maintenance of ice roads and ice pads in support of oil exploration and production. Water balance and mitigating ecosystem impacts represent a challenge for water resource managers.

STRATEGIC FRAMEWORK

DOE OIL AND NATURAL GAS WATER RESOURCES PROGRAM

Research and Analysis on the Management of Water Associated with Oil and Gas Supply and Delivery

KEY DRIVERS

- U.S. oil and gas resources are key components of our nation's energy security.
- Clean and abundant water resources are vital to national economic prosperity and quality of life.
- Water management options and costs can constrain oil and gas production and infrastructure expansion.
- Expanding and diversifying U.S. oil and gas supplies and carbon management present new water challenges.
- Oil and gas recovery produces large volumes of potentially useful water.
- Availability of useable water supplies for American consumers is a looming national concern.

MISSION

Promote oil and gas water management approaches that increase U.S. energy supplies while enhancing useable water resources for American consumers and protecting water quality and the environment.

GOALS

- Maximize the recovery of U.S. oil and gas resources.
- Enable industry to improve its environmental performance and reduce costs.
- Protect the quality of the nation's surface and ground waters.
- Create new water sources – increase opportunities for the beneficial use of produced water.
- Expand the capability of states and federal government and Indian Nations to make more cost-effective regulatory decisions – promoting sound science and common sense.
- Improve communications and technology transfer among industry, government, Tribes and the public on water issues affecting the achievement of national energy, economic and environmental goals.

KEY STRATEGIES

- **Water-Energy Sustainability.** Enable oil and gas water management options that support regional and basin-oriented strategies to maximize the recovery of U.S. conventional and unconventional oil and gas resources and accomplish regional economic and environmental goals.
- **Technology Development.** Increase cost-effective and environmentally sound water management options for producers. Develop produced water treatment and other water management technologies that reduce environmental impacts and lower costs.
- **Environmental Science.** Develop credible scientific and technical information to serve as the basis for risk-based regulation and compliance and to increase understanding of environmental benefits and risks.
- **Regulatory and Policy Analysis.** Evaluate the energy, environmental and economic implications of proposed regulations and policies.
- **Information and Decision-making.** Provide the data management and decision support tools needed to make sound energy and environmental decisions.
- **New Water Sources.** Enable beneficial uses of produced water that provide water for agriculture, communities and industry, easing demand on traditional public water supplies. Conserve and recycle water in oil/gas fields.
- **Linkages with Other Energy Supplies and Carbon Management.** Develop linkages between water supplies and end-users, providing non-traditional water for power generation, renewable energy resources, and other energy supplies. Manage water associated with CO₂ enhanced oil recovery and carbon management strategies such as water resources for forestry.
- **Strategic Alliances/Regional Partnerships.** Collaborate with states, other federal government agencies, industry, and communities to leverage efforts to accelerate progress toward increasing U.S. energy supplies while enhancing useable water resources for American consumers and protecting water quality and the environment. Establish partnerships with universities and other institutions addressing regional energy-water challenges. Leverage efforts across DOE oil and gas programs.

DOE OIL AND NATURAL GAS WATER RESOURCES PROGRAM

Program Oversight – DOE Office of Fossil Energy and NETL Strategic Center for Natural Gas and Oil
 Traditional R&D Program – Strategic Center for Oil and Natural Gas
 EPACT Section 999 Consortium*
 EPACT Section 999 NETL Complementary Research – Office of Research and Development (ORD)
 NETL Arctic Energy Office
 DOE Rocky Mountain Oilfield Testing Center

FOCUS AREAS	LEADING ORGANIZATION					
Water Challenges of New Oil and Gas Supplies (e.g., coalbed, tight and shale gas) and Production in Mature Oil and Gas Fields	✓	✓	✓	✓		✓
Water Challenges of Strategic Unconventional Fuels (e.g., oil shale, heavy oil and tar sands)	✓	✓		✓		
Water Challenges of Arctic Oil And Gas Resources	✓				✓	
New Water Supplies and Linkages Between Oil and Gas Water Management, Other Energy Supplies, and Carbon Management	✓	✓	TBD	TBD	TBD	✓
Strategic Linkages/Partnerships**	✓	✓	✓	✓	✓	

* The Consortium, administered by the Research Partnership to Secure Energy for America (or RPSEA), is part of a cost-shared, competitively selected research program established by Sec. 999 of the Energy Policy Act of 2005, and which NETL oversees management of the program. The complementary in-house research for the Sec. 999 program is conducted by NETL/ORD.

** Ground Water Protection Council, Interstate Oil & Gas Compact Commission, Stripper Well Consortium, DOE/University Partnerships and Others.



Current DOE R&D Oil & Gas Water-Related Projects¹

Research Categories	R&D Objective	Leading Organization
Produced Water Treatment & Management	• Effects of Irrigating with Treated Oil and Gas Product Water on Crop Biomass and Soil Permeability (University of Wyoming)	NETL
	• Innovative Water Management Technology to Reduce Environmental Impacts of Produced Water (Clemson University)	NETL
	• Membrane Technology for Produced Water at Lea County, NM (Lea County, New Mexico and New Mexico Tech)	NETL
	• Coalbed Natural Gas Produced-Water Treatment Using Gas Hydrate Formation at the Wellhead (BC Technologies and Oak Ridge National Lab)	NETL
	• Cost Effective Recovery of Low-TDS Frac Flowback Water for Re-Use (General Electric Company)	NETL
	• Zero Discharge Water Management for Horizontal Shale Gas Well Development (West Virginia University)	NETL
	• Water Management Strategies for Improved Coalbed Methane Production in the Black Warrior Basin (Geological Survey of Alabama)	NETL
	• Pilot Testing: Pretreatment Options to Allow Re-Use of Frac Flowback and Produced Brine for Gas Shale Resource Development (Texas Engineering And Experiment Station)	NETL
	• Pretreatment and Water Management for Frac Water Reuse and Salt Production (GE Global Research)	RPSEA/NETL ²
	• Three-Stage Fluid Filtering System (Custom Water Solutions, Inc.)	RMOTC
	• Earth Grounding Rod Oil Water Separator (Eco1st Technology Group)	RMOTC
• Down-Hole Steam Generator for Production Enhancement Of Formation (Precision Combustion, Inc.)	RMOTC	
• Recapture Fresh Water from Oilfield Brine and Brackish Production Water (Deep Earth Water, LLC)	RMOTC	
Regulatory Analysis & Streamlining	• Water & Waste Regulatory Analysis (Argonne National Lab)	NETL
	• Risk-Based Data Management System (RBDMS) for Information Exchange between Regulatory Agencies and the Petroleum and Mining Industries (Ground Water Protection Council)	NETL
	• New Hydraulic Fracturing Module for the Risk-Based Data Management System (Ground Water Protection Council)	NETL

¹ Note that some projects can fit into several categories.

² Research Partnership to Secure Energy for America (or RPSEA) administers the Consortium which is part of a cost-shared, competitively selected research program, established by Sec. 999 of the Energy Policy Act of 2005, and which NETL oversees management of the program.



Research Categories	R&D Objective	Leading Organization
Environmental Science	<ul style="list-style-type: none"> Water-Related Issues Affecting Conventional Oil and Gas Recovery and Potential Oil Shale Development in the Uinta Basin, Utah (Utah Geological Survey) North Slope Decision Support for Water Resource Planning and Management (University of Alaska-Fairbanks) Improvement of Fracturing for Gas Shales (University of Houston) Determine the Ecological Impacts of Oil and Gas Access Roads and Drill Pads in the Central Appalachian Region (In-House) Study the Impacts of Natural Gas and Oil E&P Activities on Local and Regional Air Emissions in the Appalachian and Rocky Mountain Regions (In-House) 	<p>NETL</p> <p>Arctic Office</p> <p>RPSEA/NETL</p> <p>NETL-ORD</p> <p>NETL-ORD</p>
Decision Making Process Improvement	<ul style="list-style-type: none"> Produced Water Treatment Catalog and Decision Tool (ALL Consulting) GIS and Web-Based Water Resource Geospatial Infrastructure for Oil Shale Development (Colorado School of Mines and Idaho National Lab) Probabilistic, Risk-Based Decision Support for Oil and Gas Exploration and Production Facilities in Sensitive Ecosystems (University of Arkansas and Argonne National Lab) Comprehensive Lifecycle Planning and Management System for Addressing Water Issues Associated With Shale Gas Development in New York, Pennsylvania, and West Virginia (ALL Consulting) Integration of Water Resource Models with Fayetteville Shale Decision and Support Systems (University of Arkansas) An Integrated Framework for the Treatment and Management of Produced Water Related to Coalbed Methane and Gas Shale Fields. (Colorado School of Mines) Interactive Model to Predict Erosion or Flooding Caused by Produced Water Discharges (In-House) 	<p>NETL</p> <p>NETL</p> <p>NETL</p> <p>NETL</p> <p>NETL</p> <p>RPSEA/NETL</p> <p>NETL-ORD</p>
Water Use/ Recycle	<ul style="list-style-type: none"> Using Artificial Barriers to Augment Fresh Water Supplies in Shallow Arctic Lakes (University of Alaska-Fairbanks) Sustainable Management of Flowback Water During Hydraulic Fracturing of Marcellus Shale for Natural Gas Production (University of Pittsburgh) Barnett and Appalachian Shale Water Management and Reuse Technologies (Gas Technology Institute) Evaluation of Subsurface Drip Irrigation for Managing CBM Produced Water (In-House) 	<p>Arctic Office</p> <p>NETL</p> <p>RPSEA/NETL</p> <p>NETL-ORD</p>
Linkages to Other Energy Supplies	<ul style="list-style-type: none"> Binary Geothermal Power Generation System Using Hot, Produced Oil Field Water (Ormat Nevada, Inc.). 	<p>RMOTC</p>
Technology Transfer	<ul style="list-style-type: none"> An Integrated Water Treatment Technology Solution for Sustainable Water Resource Management in the Marcellus Shale (Altela Inc.) 	<p>NETL</p>

* Note that some projects can fit into several categories.

Potential Benefits of the Program

The greatest benefits from this program include increased U.S. energy security, environmentally-sound oil and gas operations, and usable water supply. Through sustainable water management and responsible oil and gas development, opportunities exist to meet regional economic, energy, and environmental goals as well as mitigate climate change impacts affecting the Nation's water demands. Domestic oil and gas can be responsibly developed with cleaner, smarter technologies and practices that create, protect, and enable reuse and recycling of water resources.

The Oil and Natural Gas Water Resources Program will help to ensure sustainable water management that makes technical, environmental, and economic sense. The program serves a supportive role, working collaboratively with regulators, industry, and the public, to encourage energy approaches and policies that reduce water volume needed and pollutants, protect surface and groundwater resources, and meet the energy needs of American consumers.

Measures of Success

- Deployment of innovative water management approaches that support regional and basin-oriented strategies to maximize the recovery of U.S. conventional and unconventional oil and gas resources and accomplish regional economic and environmental goals.
- Increased cost-effective and environmentally sound water management options for producers.
- Increased understanding of water management challenges of increasing U.S. energy supplies.
- Increased supplies of useable water for consumers and increased beneficial uses of produced water.
- Establishment and/or strengthening of strategic partnerships necessary to accomplish DOE goals.

Highlights:

Many opportunities exist for oil and gas operations to provide themselves, the landowner, the public, and nearby industry with produced and recycled water that does not result in the waste of this resource. Beneficial uses of produced and other recycled water resources support many societal needs including, but not limited to: irrigation, power plant cooling, recreational use, sediment control, and aquifer recharge.



Ice Road

For More Information

Oil & Natural Gas Program

www.fe.doe.gov/programs/oilgas/index

NETL Oil & Natural Gas Technologies

www.netl.doe.gov/technologies/oil-gas/

Arctic Energy Office <http://www.netl.doe.gov/technologies/oil-gas/AEO/main.html>

www.netl.doe.gov/technologies/oil-gas/AEO/main.html

Produced Water Management Information System (PWMIS)

www.netl.doe.gov/technologies/pwmis

Rocky Mountain Oilfield Testing Center

www.rmotc.doe.gov/

DOE Sec. 999 RPSEA Consortium

www.rpsea.org



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