Water Quality and Availability

Responsible recovery of unconventional oil and gas (UOG) requires technologies that ensure the quality and availability of water. Where freshwater resources are already constrained, the cost of these technologies must be reduced so that they are more widely used. Technology advances are also needed to ensure that key data is collected to understand impacts on water quality. Investments by the Department of Energy's (DOE's) Office of Fossil Energy (FE) and the National Energy Technology Laboratory (NETL) have led to substantial progress in monitoring, protecting, and treating water supplies. Research projects have led to the development of new technologies that: 1) treat produced water so it can be reused rather than disposed of, and 2) improve how wells are designed and engineered.

Goals

One of the primary goals of FE's Office of Oil and Natural Gas is assessing and minimizing impacts of UOG recovery on water resources by: 1) establishing assessments that provide baseline measurements to detect changes in the quality and supply/availability of water resources; 2) reducing fresh water use by finding ways to reuse non-traditional water sources and using alternative fluids for hydraulic fracturing; and 3) developing technologies and best practices for mitigation and treatment, as well as preventing contamination.

What Is Known

Much research since 2008 has focused on the effects of hydraulic fracturing. The U.S. Environmental Protection Agency and the Department of Interior have reported that—based on available data, which has limitations—hydraulic fracturing has not led to widespread, systematic impacts on drinking water or surface water quality. However, the implications for potentially adversely effecting drinking water availability is higher in areas of low water supplies, such as certain regions of the Western United States. While hydraulic fracturing can affect water quality through surface spills or loss/failure of wellbore integrity, it is unlikely to affect aquifers at the depths where hydraulic fracturing takes place. Wellbore integrity remains a vital area of DOE R&D because well damage at geologic formations above the targeted reservoir can be a pathway for groundwater contamination.

Research Results

DOE research has led to the development of new technologies that: 1) treat produced water so that it can be reused rather than disposed of, and 2) improve how wells are designed and engineered. Some of these technologies have been commercialized.

Assessment: Increasing Access to Data

In addition to R&D, fast and complete access to data is needed to define the lifecycle of used and produced water. DOE funds the Groundwater Protection Council (GWPC) and its work on developing the national hydraulic fracturing chemical registry, FracFocus. The evolving FracFocus Database is an example of a successful voluntary monitoring program. Companies can record the volumes of water used for hydraulic fracturing and disclose the chemicals used in the fracturing fluid. FracFocus rapidly evolved from a small voluntary experiment to a widely used regulatory tool. In 2011, two states required producers to disclose fracturing chemicals in the FracFocus database. By 2015 that number had grown to 24 states. Recent improvements include full data downloads in machine readable format. FracFocus 3.0 is scheduled for release in 2016 and includes 1) improved data accuracy, 2) error trapping, and 3) systems approach for chemical reporting to diminish need for trade secret claims. This represents a significant additional separate database to the oil and gas well-level databases of the GWPC Risk Based Data Management System (RBDMS). Twenty-two states use RBDMS to track oil and gas recovery projects, salt water disposal volumes, and protect groundwater.

Advances in assessment capabilities include the development of decision-supporting software for treating and managing produced water. A water management model (Produced Water Treatment Beneficial Use Screening Tool) provides industry with tailored suggestions for water treatment and produced water management reuse options in the Rocky Mountain states (e.g., at the Colorado School of Mines).

Minimizing Water Availability Impacts: Reducing Freshwater Use and Increasing Wastewater Use

DOE funded R&D in water treatment and use is providing viable commercial options for treatment and beneficial use of produced water. For example, successful field testing through a DOE research project led Altela, Inc. to open two water treatment facilities in Pennsylvania. In addition, non-DOE research and improved practices have led to greater recycling of produced water and use of produced water in hydraulic fracturing.

Other accomplishments include:

- Mobile treatment options that recycled 99 percent of wastewater from sites in the Marcellus and Utica shales (West Virginia University).

- Laboratory-scale membrane filtration that can desalinize water with total dissolved solids of up to 200,000 ppm for reuse (Lea County, New Mexico government design).

- Osmosis-driven technology for wastewater treatment that offers cost savings of 45-60 percent compared to conventional disposal methods (Colorado School of Mines).

- Soil and water assessment tools for modelling surface water availability for watersheds and sub-basins (University of Arkansas).

- Nanofiltration technology that can remove 60-70 percent of salt contaminants from wastewater under high temperature and pressure (Eltron, Inc.).

Minimizing Water Quality Impacts: Enhancing Wellbore Integrity

The federal government's commitment to health and environment has been part of DOE's nanotechnology research framework. DOE-funded R&D on nanotechnology has led to the development of high tech well casing material for oil and gas well construction. Well casing cement is impregnated with nanotechnology, and these smart materials communicate with improved sensors for detecting weaknesses or potential leaks in wellbores. For example, a new "smart" cement called Nanite™ uses nanotechnology to prevent cracking and leakage and responds to changes in temperature, stress, and fracture. Newly designed acoustic-electrical techniques as well as new hardware and software monitor changes in the cement seals composed of the smart cement (Oceanit).

Other accomplishments include:

- Improvement of models for predicting failures between well piping and casing (CSI Technologies and the University of Houston).

- Evaluation of wellbore integrity in the presence of acid mine drainage through laboratory work that characterized chemical controls on cement integrity (NETL). Results are informing the Pennsylvania Department of Environmental Protection on the effects of existing abandoned coal mines on shale gas resource development.

- Modeling of the potential for methane migration in shallow aquifers during gas well drilling using a laser-based methane gas sensor adapted to monitor wells near shale gas sites (NETL).

Lined impoundments provide temporary storage of water needed for hydraulic fracturing. (NETL's E&P Focus Newsletter)

Direction for Future Progress

Technology development and research opportunities include design of new materials, reservoir characterization, and alternatives to hydraulic fracturing. An important next step is to find methods to increase the scale of existing effective water treatment technologies to process vast quantities of wastewater. Formulation, testing, and refinement of new wellbore cements is also necessary to ensure wellbore integrity under a range of fluid conditions. Reservoir characterization can enable producers to optimize hydraulic fracturing treatments to minimize potential negative effects. Finally, research and field testing of alternatives to water-intensive hydraulic fracturing techniques, such as liquefied natural gas and petroleum gas, will be crucial.

Policies and practices should emphasize data gathering and cost reduction. Water quality monitoring programs that focus on areas with oil and gas development are necessary. Field experiments to model the consequences of unintended fluid migration and to demonstrate how new cements can increase wellbore integrity will also be helpful. Research should focus not only on new technologies, but also on reducing the cost of existing technologies in order to encourage their commercial use.

For more information, please visit
energy.gov/fe/science-innovation/oil-gas-research

Published July 2016