FRACING'S WATER-MANAGEMENT BOOM

Hydraulic fracturing of shales gives rise to a skyrocketing related business—water management.

ARTICLE BY
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Fracture-treating a shale oil or gas well can require between 25,000 and 140,000 barrels of water per well, and that's not counting the many gallons of flowback water that need to be handled after the frac is complete. It's a big expense, and a logistical headache, for operators in every play where horizontal fracing is the norm—and it leaves them open to criticism by local environmentalists, landowners and regional officials. So it's no wonder that water treatment has become a big business.

Indeed, the market for water-related services in oil and gas shale-fracturing operations is expected to increase by a multiple of about 15 through 2020. According to Lux Research Inc., a Boston company that tracks emerging technology companies, spending worldwide for frac-related water management will tally about $15 billion annually by 2020, compared to about $1 billion in 2011.

"The expanded water-management business will spur technology innovation and novel thinking about water disposal and reuse," says Brent Giles, lead author of a 2012 Lux Research report, "*Risk and Reward in the Frac Water Market.*" He and colleague Daniel Choi discussed the current water-management market during a recent interview with *Oil and Gas Investor*.

While opportunities abound, the field of water-management companies looking longingly at frac-related business is quickly becoming overcrowded, Giles says. Only companies with technical value and business execution will ultimately be profitable.

In a positive note for the E&P industry, as the water-management business has become more competitive and sophisticated, the cost of services has begun to drop. Prices vary greatly depending on location, but on average, water treatment that had cost about $4.50 to $5 per barrel is now below $3, Giles says.

"Fracing represents a significant water-treatment challenge," he says. "Hydrocarbons, heavy metals, scalants, microbes and salts in produced and flowback water present a water-treatment challenge on par with the most difficult industrial wastewaters."

Flowback water comes back out of a well shortly after a frac and consists of the water forced into the well to break up the rocks. Produced water returns over the course of the well's life, and is more heavily laden with salts and other native contaminants.

As noted above, fracing requires between 25,000 and 140,000 barrels of water per well and produces toxic-laden brine that can be more than six times as salty as the sea. Lux Research estimates that by 2020, some 260 billion gallons of water will be used to frac wells worldwide, a huge leap from the estimated 4.5 billion gallons used in 2012. Shale fracing is currently a North American phenomenon, but this is likely to change rapidly as producers throughout the globe tap into the technology. By 2020, North America will account for just a third of the world's fracing, Giles estimates.

A variety of complementary technologies will win. High-energy, high-cost desalination technologies will work alongside electro-coagulation and/or advanced oxidation methods to provide a full range of treatment needs.

Water has become a lightning-rod issue in a number of the shale plays. "Water-analytics companies monitoring aquifer quality will become a vital insurance policy against unfounded accusations in this politically charged market," Giles says.

Indeed, every political jurisdiction where fracing occurs or may occur has studied or is studying the procedure as well as water-related issues. At press time, the Texas Railroad Commission agreed on new, more stringent rules governing water management, a key concern especially in the arid Eagle Ford shale region of South Texas, where water usage is already a challenge.

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Recycling is focus

The oil and gas industry has gone through three waves of water-treatment strategies, all of which include the removal of heavy metals and biochemicals, Giles says.

Initially, after heavy metals were removed, local water jurisdictions were left to handle the water. That proved to be inadequate, as the municipal water districts were ill-equipped to handle such tasks, particularly bromide treatment, which was a problem in the Marcellus region.

The need for a different strategy quickly became obvious, and gave rise to the "knee-jerk" second strategy of desalination and then dumping the water into local streams or rivers. But as observers have noted, this strategy was energy-intensive and expensive. Further, when fracing began, the industry wanted to use fresh water,

so reuse involving fracing with salty water didn't seem to be an option.

"Technical progression enabled the third strategy," Giles says. "Gradually, the chemicals added for fracing were modified to accommodate higher salt levels, and the industry realized that saltwater produced less swelling of the geology, and thus a better frac than freshwater, which gave the less aggressive treatment options a chance in the market."

Water shortages and limited disposal options will drive reuse in most areas. Many current and emerging shale-gas plays are in arid regions that will require new thinking about the mix of water disposal and reuse. Giles expects a strong push for technologies that make it possible to reuse produced and flowback water.

A couple of companies—WaterTectonics and Ecosphere Technologies—seem well positioned for growth. WaterTectonics, with its exclusive long-term alliance with Halliburton, has both technology and business execution strengths. Its high-energy electro-coagulation technology addresses heavy metals, biological matter and hydrocarbons, but leaves the salt in place, meaning its use is restricted to areas where salt levels are moderate. Based in Everett, Washington, the company uses electric current to bind contaminant particles, allowing them to be filtered from the water.

Ecosphere, based in Stuart, Florida, is a leader in oxidation technologies. It combines ozone, cavitation and electrochemistry, using ozone as a disinfectant to clean water in a chemical-free process called advanced oxidation. Ecosphere says it has cleaned more than 2 billion gallons of water and eliminated the need for 1.7 million gallons of chemicals at approximately 600 wells in U.S. shale-gas fields, from 2008 through 2012.

Some traditional specialty chemical treatment companies, such as Kroff Inc., based in Pittsburgh, continue to play a central role. Kroff depends on its extensive knowledge of varying geologies to modify water treatment to give it a competitive advantage.

Turnkeys and innovators

Today, the oil and natural gas industry is taking a much more holistic approach to water issues. Water management—including everything from sourcing, treatment, storage, transportation and recycling to disposal and regulatory compliance—is now the buzz term

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CONTAMINATION DEBATE

Fracing advocates vehemently deny claims by environmentalists that fracing fluids have contaminated drinking-water aquifers, arguing that the science and facts don't support those allegations.

The industry's arguments are backed by a Stanford University professor of geophysics, Mark Zoback, who recently addressed the most often expressed concerns about fracing—water contamination, disposal, and additive chemicals.

Hydraulic injection is typically at depths of around 6,000 to 7,000 feet, and drinking water is usually pumped from shallow aquifers, no more than 1,000 or 2,000 feet below the surface, says Zoback, who also was a member of a Department of Energy panel addressing safety and environmental aspects of shale-gas production. "Fracturing fluids have not contaminated any water supply and with that much distance to an aquifer it is very unlikely they could.

Concerning frac chemicals and fluids, Zoback says most of the fluid is water, with small amounts of a thickening agent added—usually guar, the same thickening agent used in making ice cream. There is also some biocide, to kill bacteria in the water, as well as a small amount of a friction reducer.

Regarding disposal, Zoback says, "When the water comes back up the well, it has picked up chemicals present in the shale that aren't good for human health or the environment. The water that comes back can be very saline and contain chemicals such as selenium, arsenic and iron. That water has to be disposed of properly, which can mean injecting it into a storage well that has been permitted by the EPA to standards that will prevent leakage.

"Alternatively, it can be treated and reused, which is the preferable solution. More and more, that is what is being done in the northeastern U.S. So, the water goes right back into the shale from where it came."

A study by Harvard University also supports claims that fracing does not contaminate drinking water, but that poorly sealed wells could cause problems.

"The thick strata of impermeable rock separating the water tables from the shale-gas deposits should ensure absolute separation of one from the other," says Leonardo Maugeri, of Harvard's John F. Kennedy School of Government, Belfer Center for Science and International Affairs.

"The fact remains that poorly sealed wells or wells lacking adequate steel jackets could allow dangerous contamination," says Maugeri. He adds, "Cement sealing and steel jacketing of wells is a standard practice in the oil industry."

of choice, replacing simple treatment and disposal of frac water.

Several companies tout turnkey solutions, claiming not to push any one technology, but rather to provide customized solutions around each location's unique water challenges. They call themselves one-stop, or total management, service providers. Among such companies are Bosque Systems LLC (Fort Worth), Rockwater Energy Solutions (Greeley, Colorado), and Select Energy Services (Houston).

Select Energy, formed in 2007, is now a $1-billion company. Its chairman and chief executive, John Schmitz, says, "As water requirements for hydraulic fracturing are increasing, energy producers are faced with the challenge of source-water limitations and the complexity of treating and disposing of produced water. Additionally, water solutions vary by basin and stage of development, making it difficult to secure cost- and time-efficient water resources.

"Producers are experiencing new pressures to utilize sustainable sources and methods. Water sources are often difficult to locate and secure access to, particularly in the quantities required for multiwell programs. Once located, the water must be delivered to the wellsite for utilization in the hydraulic-fracturing process."

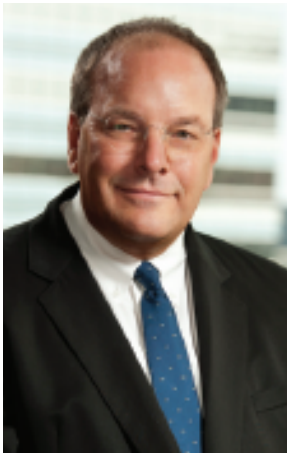
Ten to 50% of the water returns as flowback during the first several weeks following the frac process, and a large percentage of the remainder, as well as pre-existing water in the formation, returns to the surface as produced water over the life of the well. Both the flowback and produced water must be recovered, treated, and either recycled or transported offsite for disposal.

In response to the lack of suitable disposal wells at some locations, Select Energy provides temporary, aboveground portable containment, or a type of water "parking" service.

ThermoEnergy Corp., a technology company with more than 20 years experience in wastewater management and recovery, primarily in the power-generation industry, as well as in industrial, municipal and agricultural applications, brought its expertise and new products to fracing in 2012 and is now focusing on that market. The company has developed a proprietary process it calls Controlled Atmosphere Separation Technology, a flash vacuum-assisted distillation process designed for wastewater with high total dissolved solids and total suspended solids. It was recognized as a 2013 Energy Innovation Pioneer at IHS CERAWeek in March.

"Oil, gas and electric power production require tremendous quantities of water, and that means the future of the energy industry is inextricably tied to responsible water management," says James Wood, who in January was named the company's new chairman and chief executive. Previously he was the U.S. Department of Energy's deputy assistant director; he succeeds Cary Bullock, who founded the Worchester, Massachusetts-based company in 1988. In 2007, ThermoEnergy acquired CASTion, a producer of zero-discharge wastewater and chemistry products.

The company's systems enable flowback and produced water to be recycled for used as frac water, eliminating wastewater trucking to disposal sites. In addition to recovering usable water for reuse in frac operations, ThermoEnergy's systems can concentrate the chemicals



John Schmitz, chairman and chief executive of Select Energy Services, says, "Producers are experiencing new pressures to utilize sustainable sources and methods."

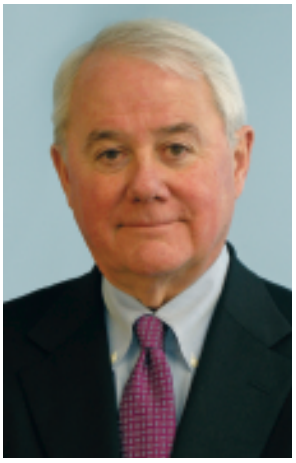
RECENT WATER NEWS

Basic Energy Services, based in Fort Worth, in December acquired Saltwater Disposal of North Dakota and its five saltwater-disposal facilities for $43 million. With the purchase, Basic now adds saltwater-disposal operations to its fluids handling and trucking operations that were already in the Bakken shale.

A research note from Raymond James Equity Research says, "Basic will use disposal income to increase its Bakken operations, as Basic expects its disposal business will add $14 million in revenue for 2013. Basic has been in the saltwater-disposal business in other markets for some time now, however, this adds the Bakken market to the list. Following the purchase, the company now owns 72 saltwater disposal facilities across North America."

Canonsburg, Pennsylvania-based Aquatech, an industrial and wastewater technology company, in February was granted a permit to operate a central treatment facility in Tioga County, Pennsylvania, to service the region's shale producers. The processing units' services include filtration, disinfection, solids handling, pre-treatment and evaporation concentration. Aquatech cited a study by consulting firm Accenture that concludes that shale producers could benefit financially and cut water use by sharing water-treatment facilities with other operators in the same basin.

Calgary-based GasFrac could potentially disrupt the water-treatment industry. GasFrac uses gelled propane for fracing, which dramatically reduces the volume of water to be treated over the life of well operations. Lux Research's Brent Giles says the technology seems promising, but grabbing market share has been stalled by incompatibility with equipment of some operators.



"The future of the energy industry is inextricably tied to responsible water management," says James Wood, who in January was named ThermoEnergy Corp.'s new chairman and chief executive. ThermoEnergy's TurboFrac® recovers fresh water from high-total-dissolved-solids produced and flowback water created by the hydraulic fracturing of oil and gas wells, and recycles it into clean, usable water.

PHOTOS COURTESY THERMOENERGY

and other impurities for recycling or safe, cost-effective disposal.

Barges?

About 100 anti-fracing protesters in February raided GreenHunter Water LLC's water-handling facility in Washington County, Ohio, shutting it down for about six hours before police forcibly removed the protesters. The besieged property, located on the Ohio River, is the New Matamoras bulk storage and transloading facility, a central collecting station handling saltwater from oil and gas wells in Ohio, Pennsylvania and West Virginia. GreenHunter Water is a wholly owned subsidiary of GreenHunter Energy Inc., headquartered in Grapevine, Texas. It's active in the Marcellus, Eagle Ford and Bakken shale plays.

The company has drawn protesters to its facilities because of its proposal to ship frac wastewater on the Ohio River; the proposal is currently under review by the U.S. Coast Guard. GreenHunter Water recently acquired three liquid-storage tanks along the river that could be used as a transfer station between fracing sites and disposal wells.

River shipment is an attractive option for companies, since a tanker barge can carry up to 10,000 barrels of wastewater, compared to a tanker truck's capacity of about 80 to 150 barrels. GreenHunter says its barge shipping plans are on hold.

In an April 2012 press statement, Jonathan Hoopes, president and chief executive officer of GreenHunter, commented on the barging plan. "By taking advantage of our proximity to Appalachia's busiest navigable waterways, we are

MORE GAS PER GALLON OF WASTEWATER

Although fracing undeniably uses huge volumes of water per well, a recent study concluded that fraced natural gas wells in the Marcellus shale produce less wastewater per unit of gas recovered than conventional wells would.

Hydraulically fractured wells in the region produce only about 35% as much wastewater per unit of gas as conventional wells.

That is the conclusion of a study conducted by researchers at Duke University and Kent State University and published in the February edition of *Water Resources Research,* by the American Geophysical Union.

"We found that on average, shale-gas wells produced about 10 times the amount of wastewater as conventional wells, but they also produced about 30 times more natural gas," says Brian Lutz, now at Kent State, but who led the analysis while at Duke. "That surprised us, given the popular perception that hydraulic fracturing creates disproportionate amounts of wastewater."

Also of note from the study, well operators classified only 32.3% of wastewater from Marcellus wells as flowback from hydraulic fracturing; most wastewater was classified as brine. However, the study shows the total amount of wastewater from gas production in the region has increased by about 570% since 2004 as a result of increased shale production.

"It's a double-edge sword. On one hand, shale-gas production generates less wastewater per unit. One the other hand, because of the massive size of the Marcellus resource, the overall volume of water that now has to be transported and treated is immense. It threatens to overwhelm the region's wastewater-disposal-infrastructure capacity," Lutz says.

introducing a new transportation and logistics alternative to our growing base of customers for brine water. In addition to significant cost savings, we estimate that barging can reduce up to 60% of on-road truck hours, providing a tremendous benefit to the local communities in conjunction with increased safety."

GreenHunter Water says it takes a "technology-agnostic approach" to provide "total water-management solutions in the oilfield, with an understanding that there is no single solution to E&P fluids management." Those solutions include mobile water-treatment systems, expanding capacity of saltwater-disposal facilities, modular aboveground storage tanks, and water-hauling services.

The company is led by veteran oilman Gary Evans, chief executive of affiliated E&P Magnum Hunter Resources Inc., who says he understands the importance of keeping expensive rigs running on schedule by efficiently lowering the costs of handling, recycling, hauling and disposing of produced and flowback water.

Consol's water division

Consol Energy, a company that for decades made its mark as a leading Appalachian coal producer, entered the natural gas production business a few years ago. Now, it has a third business sector: water.

Consol Energy treats an average of 34 billion gallons of water each year, says Bart Hyita, chief operating officer of energy operations for the company. "The goal of our water division, which was formalized and launched in June of 2012, is to identify and implement innovative ways to minimize our water footprint across all of our operations and to leverage our fresh water and acid mine drainage (AMD) treatment assets, which are strategically located in the fairway of the Marcellus shale and can serve as a reliable source of water supply for gas operators," he says.

"As such, we are exploring opportunities in four key focus areas: water sales, advanced water treatment, technology development and application, and water liability reduction."

Consol invested $500,000 to take a minority interest in Epiphany Solar Water Systems, a New Castle, Pennsylvania-based company. Epiphany is developing solar-powered water-recycling systems at Consol's drilling sites in western Pennsylvania and eastern Ohio. The heat causes water to evaporate into steam, which then recondenses into clean water, leaving behind all of the impurities.

The company's advanced water-treatment plant in northern West Virginia is in the final phase of construction and is on track to start operating in May. The plant will use a purification method known as reverse osmosis to remove total dissolved solids, such as chlorides, discharged from its mining activities. The facility is designed to process 3,500 gallons per minute and will treat water from three mining operations in northern West Virginia, ensuring compliance with increasing regulatory requirements, Hyita says.

"We also continue to test the use of treated AMD water in our own drilling and hydraulic-fracturing operations, with the goal of creating a closed-loop system that eliminates the use of ground and freshwater sources," he says. "Consol Energy has off-take agreements for our mine water with several leading gas operators who see the value of a reliable water supply, and we are working to expand our customer base for this abundant asset."

Water 'mediators'

The water-treatment industry can serve as a mediator in the heated debate between the pro- and anti-fracing sectors, says Eli Gruber, president and chief executive of Ecologix Environmental Systems, an Atlanta-based wastewater-treatment company. Gruber says Ecologix has designed a mobile, integrated treatment system for frac water that can remove 99.9% of total suspended solids at a flow rate of up to 900 gallons per minute.

"Because the water-treatment industry has progressed to the point where it can provide efficient, high-volume, well-side water-treatment systems, the frac-water problem really is not as controversial as it seems," he says.

"While the stances of environmental groups and oil and gas companies might seem to be intractable, that's not the case. When it comes to the No. 1 concern, water, their needs are not mutually exclusive. Nearly 100% of flowback water from fracing operations can be treated and reused or safely released back into the environment."

Gruber says when drillers use a water-treatment solution that cleans water to the point where it can be safely reused or returned back to the local environment, they reduce the strain on local water resources. Plus, cost-effective water treatment at drilling sites reduces the need for water transport. "Fewer deliveries mean lower costs for the oil and gas companies, less road traffic, and an overall cleaner mode of operations."

By recycling frac water, freshwater resources can be left untouched and water hauling can be reduced by hundreds of trucks. Proper water management vs. purchasing/transporting fresh water will result in a savings of $70,000 to $100,000 per well, Gruber says.

Brine water can replace freshwater in the frac mixture, and then it is not the salt, but the suspended solids, that must be removed.

Mediation and use of more smart water-management techniques will create a path for stakeholders to move forward together and make progress in their ongoing conversations. As E&P companies share water-management facilities in localized regions, and try new options, the use of water in fracing will become one more strategy that aids the bottom line, and companies should be able to avoid confrontation with opponents of water use for fracing. □

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