

## The Future of Water Recycling Technology May Save Money *and* Water

Energy from unconventional resources such as the Newark East (Barnett Shale) Field in the Fort Worth Basin may represent almost 50 percent of the natural gas produced in the United States in the next 25 years, according to the Global Petroleum Research Institute (GPRI) at Texas A&M University. However, the processes used to recover that natural gas are very dependent on water resources. That's why A&M researchers and several private companies are focusing on technologies to recover freshwater from oil- and gas-produced brine.

Hydraulic fracturing, or fracing, is used to develop tight-gas reservoirs, such as those found in the Barnett Shale. Large volumes of fresh water are injected into a well at pressures so intense that the structure cracks, or "fractures." The water generally has been treated with a friction reducer, biocides, scale inhibitor, and surfactants, and contains sand as the propping agent, according to the Railroad Commission of Texas (RRC). This "slick" water, or light sand, fracing process of a vertical well completion can use more than 1.2 million gallons (28,000 barrels) of water, while the fracturing of a horizontal well completion can use more than 3.5 million gallons (more than 83,000 barrels) of water, according to the RRC. Other experts say a horizontal well fracturing operation may use 5 million gallons of water. In addition, the wells may be re-fractured multiple times after producing for several years.

Consider, for example, a well fracturing operation in the Barnett Shale using fresh water from the municipality of Cleburne, in Johnson County. Cleburne sells water to operators at retail rates to stimulate Barnett Shale wells. Flow back of the water at the drilling site, now containing mineral salts from the underground formation, occurs over a period of several days to months. Typically, flow-back water is captured in lined pits and transported to off-site disposal. Most of that water then goes to re-injection disposal in a deepwater disposal well that is often located miles away from the original well site. But with modern water recycling technologies, it is now possible for much of this brine to be re-used in subsequent well fracs, and a great deal can also be recovered as fresh water for beneficial use. The potential for re-use not only bodes well for the environment, but could help the oil and gas industry save money in the long run. Several companies and technologies are now competing to get a share of the water management market in the Fort Worth Basin.

### **Devon Energy and Fountain Quail**

Thus far, Devon Energy has been the one of the most proactive companies in seeking to recycle water in the Fort Worth Basin. In 2005, Devon began working in partnership with Fountain Quail Water Management LLC, a Texas-based subsidiary of Aqua-Pure, a Canadian company. Fountain Quail had developed mobile water recycling units called NOMADs, on-site vapor distillation units that apply heat to separate brine from water used to fracture gas formations. The companies tested a recycling process that could allow reuse of approximately 80 percent of the returned fracture fluid, according to RRC documents. When water injected to fracture formations

returns to the surface, it becomes unusable due to its high salt content. Under this system, instead of hauling unusable return fracture fluid to a disposal well, the fracture flow-back fluid is stored in tanks on location and piped into treating equipment. Natural gas produced on location is used to fire the distilling units that in turn boil the returned fracture fluid and produce fresh distilled water. The distilled water can then be used to fracture treat another Barnett Shale well.

The pilot project was so successful that, as of March 2008, Devon was recycling 90 to 100 percent of the flow-back water recovered, and recovering about 20 percent of the water pumped in, according Devon's Jay Ewing.

Fountain Quail's Business Development Leader Jack Pearson, who offices in Acton (near Granbury), said in May that Devon remains Fountain Quail's primary customer in the Barnett Shale (BS) for now. In May 2008, Fountain Quail (FC) had nine water treatment units on the ground in the BS at four Devon locations (Circle R near Bono, West Crossroads near Godley, Johnson near Decatur, and McCurdy near Justin).

"To date, we have recycled approximately 7 million barrels of frac flow-back water," Pearson said of his company's partnership with Devon. "Of that, we have returned approximately 85 percent (about 6 million barrels) as reusable distilled water," which is typically used for fracing.

Devon uses trucks or a surface line (pipeline) to deliver frac flow-back water from its drilling sites to the NOMAD locations. After Fountain Quail cleans the water, the resulting distilled water is then pumped via surface line to another drilling site for use on a frac job. "The intent is that this water is reused and recycled, reducing the demand on surface water and aquifers," Pearson said. "We're recycling the water that has been used and returning it for reuse."

Devon's Ewing estimated earlier this year that his company's cost to process water using NOMAD units has been about \$4.50 per barrel, with a net disposal cost for water of \$3.35 per barrel, as compared to a \$2 to \$2.50 per barrel normal well water disposal cost. Ewing also estimated that just less than 10 percent of Devon's revenue goes towards the cost of handling flow-back water.

Fountain Quail's current arrangement with Devon is essentially as a service company where FQ owns, operates and maintains the NOMAD equipment, charging Devon a fee to process the water. Right now, all of FQ's nine units are on either Devon-owned land or leases. However, FQ has plans in the works for expansion. In March 2008, the company signed a letter of intent with the City of Weatherford to purchase 2 million gallons per day of treated effluent (cleaned and treated municipal wastewater) from the city for resale to energy companies in the area, according to Pearson. Details of the purchase, spelled out in a news release on Aqua-Pure's Web site ([www.aqua-pure.com](http://www.aqua-pure.com)), state that the effluent water would be combined with fresh water produced by FQ's recycling facilities and used by energy companies to fracture gas wells in the Barnett Shale.

FQ proposes to set up its own water processing/recycling site in Parker County, where it can collect flow-back water from any interested energy companies (via pipeline or trucks), clean the water with NOMAD units, then combine the NOMAD-produced distilled water with the Weatherford effluent. The resulting "fresh" water would be delivered to frac sites through a FQ pipeline for reuse in the field.

“We propose to build a pipeline to service Parker County and possible future extensions into Wise and Jack counties,” Pearson said. FQ has obtained preliminary approval from the RRC and the Texas Commission for Environmental Quality for its proposed plan and has been working with a land company to secure rights of way for the water pipelines that would both deliver water to the Fountain Quail location in Parker County, then return it back to drilling sites after processing. Pearson said the company hopes to determine the exact routes of the pipeline according to producers that want to work with FQ. “We can route, within reason, that pipeline near to their drilling programs,” Pearson pointed out. “We have several major producers who have expressed interest in participating in our project. ... We anticipate as early as the third quarter of this year to start work.”

If all of its plans come to fruition, Pearson said FQ will need to build additional NOMAD water processing units. Although the first units were constructed in Alberta, Canada, he expects more of the component pieces of new units to be built in Texas.

Pearson said he believes Fountain Quail’s business model is working: “When I came down here (to Texas) two and a half years ago, we had nine employees. Now we have 73 employees in Texas.” However, FQ’s parent company, Aqua-Pure, in April announced financial results for 2007, reporting revenue at \$10.8 million, resulting in a net loss of \$4.3 million. Aqua-Pure Chief Executive Officer Jacob Halldorson commented on the financials: “In early 2006, when we committed to constructing and putting into service in the Texas Barnett Shale six new NOMAD evaporator units, we knew that there would be a learning curve required in tripling capacity in a little over a year from when the first new units came on stream. ... We began to see the results of our efforts in the fourth quarter (2007) with improved operating efficiency and margins. Our fourth quarter operating margins confirm the potential for profitability of our units, but the real impact of investments ... will show up later in 2008.”

## **Ecosphere Technologies**

Florida-based Ecosphere Technologies is also looking to get into the water recycling business in the Fort Worth Basin. The company provides mobile water recycling equipment and services specially designed to treat frac flow-back and produced waters. The Ecosphere Ozonix™ advanced oxidation and membrane process features a chemical-free treatment method, according to the company’s Web site ([www.ecospheretechnology.com](http://www.ecospheretechnology.com)).

“The major difference with our technology is that we treat the frac flow-back water right at the well site when it starts to flow back,” explained company founder and Chief Executive Officer Dennis McGuire. “The other technologies require the frac flow-back waters to be hauled to them, as they are not true mobile water treatment plants. We can treat the frac flow-back water as it is flowing back after the frac, eliminating the need to haul it off site,” McGuire added. We can process 75 percent of the water into clean water that “stays right at the well site to frac new wells. There is no trucking of the frac flow-back water to holding facilities or injection wells with our process. Eliminating the hauling cost of the frac flow-back water and replacing it with clean water to frac with is what we are all about.”

McGuire said in May that a company operating in the Barnett Shale has signed an agreement with Ecosphere for a pilot project using Ecosphere water technology. The

project is to commence in the Barnett Shale on July 1, 2008. The pilot project, which must first be approved by the RRC, will be located at a disposal site and will last for 90 days. Of the frac water processed by Ecosphere, 75 percent could be used for fracturing new wells; 24 percent would be very clean and bacteria-free but would have higher salts and would be appropriate for use as “kill” water. The remaining ½ to 1 percent would need to be disposed of. “It saves 99 percent of the water from going into the injection well, so it’s a huge environmental play,” McGuire said. “We’re giving them clean water right at the site where they’re drilling, so they don’t need extra clean water.”

The CEO believes several things differentiate his technology from others:

- **Mobility.** The system can be set up and operating in a couple of hours, whereas some other “mobile” systems might take a week to be assembled on site.
- **Noise reduction.** Ecosphere technology is very quiet, which is important in an urban environment. The diesel generator is attenuated and sound enclosed. The unit uses 350 horsepower to process 7,000 barrels per day, as compared to some other technologies that use 650 horsepower to process 2,000 barrels per day, McGuire said. “You have to walk up to our system to feel and hear the engine running,” he added.
- **Price.** “The present way everyone is thinking is that you have to treat these high salt waters by heating them up with a thermal-based system,” McGuire said. “That technology, just heating the water, costs \$1.26 a barrel. ... It’s a given that the energy cost is greater with a heated thermal distillation process. The energy companies are chasing a price they’re used to paying for hauling and disposing water (\$2.50 per barrel) and you can’t get there with a thermal distillation process. We can give them the process for \$2.10 per barrel because we don’t have that energy cost. ... We are able to clean the water through the use of ozone and ultrasonics in one large tank.”

Ecosphere technology oxidizes the heavy metals and organics that normally clog a membrane filtration system, McGuire explained. If a sophisticated pre-treatment system is not used before the fluid goes through the membrane, the process is very inefficient. “Ozone and ultrasound works fantastic when you put it in the same tank,” McGuire added.

## 212 Resources

A Utah-based company, 212 Resources, is working to bring its water recycling technology to the Fort Worth Basin. 212 offers a transportable plant, or pod, that uses thermal distillation and evaporation to process flow-back and produced water at well sites to create drinking-quality water for beneficial use. The system can separate and recover natural gas condensate, methanol (a chemical not widely used in the Barnett Shale), and brine to produce distilled water that can be reused in drilling, for completions make-up, or for discharge into environmentally sensitive areas (such as a river or creek), according to 212’s Web site ([www.212resources.com](http://www.212resources.com)). Using this process can help energy companies maintain low operational costs while being conservation minded, according to 212 Resources Executive Vice President Robert Waits.

“Basically, we have the ability to do complete phase separation of all the components in water that are associated with drilling and production,” Waits said. “You get methanol, total dissolved solids, minerals, metals – all these things that are in the water.” The 212 system can separate out these different components so that they may be recovered for reuse. With 212, “you get more usable water” than some other water recycling systems “because you’re concentrating the solids and you get less waste,” Waits pointed out. The concentrated, leftover solids can be injected into a salt water disposal well or reused by the energy industry as a “kill” fluid to be placed back in a well to keep pressure down the hole.

Waits added that, in some respects, the 212 process is not just recycling water, but is manufacturing new water found deep below the aquifer: “There’s a fresh water zone of drilling, usually to about 4,000 feet, and you must use clean water to drill through that so you don’t contaminate the aquifer. Once you get the piping set around that drill core, they start going much deeper and you reach water formations that are heavily salted brine water (such as the Ellenberger in the Barnett Shale) – that’s where it would stay forever if you didn’t drill the hole.” 212 can process this water that is more difficult to clean, water that would not normally be in the aquifer. At some point, enough wells are drilled that the amount of produced water will exceed the flow-back water. All of this water can also be cleaned for use, and it’s not unimaginable that the water could be enough to sustain a small city.

For example, Waits calculated that 7,000 wells with 40 barrels of produced water per day in a year would create approximately 4.5 billion gallons of water (The February 2008 producing gas well count was more than 16,000). If one person uses about 44,000 gallons of water a year, “you’ve just created from 7,000 wells enough water to sustain a city of 100,000 people. So the reality is as the gas companies become more sophisticated in their drilling and water management processes, they’re actually creating net gains to the aquifer.”

212 has been in “deep discussions with several companies in the Barnett Shale,” Waits continued. “We are hoping that this will lead to service contracts and move forward.”

Although 212’s pods are transportable, when assembled on location they resemble a plant in an enclosed building, Waits said. “In Wyoming (where pods are currently in use), every six to eight months we’ll move to a new well location because they are drilling some 32 wells at a single pad. They’ll use 40 to 50 thousand barrels of water to drill a well and they have to haul the water in,” Waits continued. So being able to reuse the water on site helps reduce the amount of water transported.

Although Waits said their pod system has been successful in Wyoming and the company plans to be doing work in Colorado before the end of 2008, it remains to be seen how the pods would work in an urban environment such as is found in parts of the Barnett Shale.

“It depends on whether the water will be trucked or piped, how it will be reused, where it will be discharged (to a river, etc.),” Waits said. “We certainly haven’t determined all this yet -- whether in an urban setting it would be better to locate near wells or be out in a central facility and have water brought to it. For example, we could have three to four pod locations in an area. ... In many ways you can still reduce truck traffic because a truck that was bringing in dirty water for treatment could then take

clean water back for use in drilling.” The truck tanks would be cleaned at the site before being refilled with cleaned water. Other options would include piping water and/or locating the plant near a discharge location. “Every circumstance is different,” Waits pointed out.

Operating in an urban environment might be new to 212 Resources, but their company, under the name H2Oil, already operates a successful crude oil tank bottom disposal/recovery plant in Andrews. After being in operation for only two years, the Andrews facility serves more than 300 oil companies and some 64 trucking companies, Waits said. The Andrews facility cleans crude oil waste from tank bottoms and trucks, then recovers the oil for recycling.

### **Global Petroleum Research Institute/GeoPure**

Texas A&M’s GPRI, working with a consortium of energy producers and service companies, has developed a pretreatment and reverse osmosis (RO) process specifically adapted to oilfield wastewater purification. This fresh water recovery technology was licensed to GeoPure Water Technologies LLC to commercialize the process. GeoPure has been installing and supporting the desalination systems for oil and gas operators, as well as service providers, throughout the United States. In the Barnett Shale, GeoPure installed a 200 gallon-per-minute commercial system that has been successfully recovering fresh water from fracturing fluid flow-back for an oil and gas operator since 2007. **Is this operation still going and who is the operator?**

The pretreatment process reduces suspended solids, metals and some salts to a level where the processed water can be effectively processed by the GeoPure RO system.

One hold-up to improvements on GPRI’s current desalinization research, according to A&M researcher and petroleum engineer David Burnett (also director of technology for GPRI), is that manufacturers need to produce “new types of membranes that will work at higher temperatures and higher pressures. But the oil and gas market for this is small, so you don’t have a lot of incentives for manufacturers to bring this product out.”

Burnett also believes that another way to manage water use in the energy industry is to use less water during the fracing process. “I’m trying to convince my industry brethren to cut down on the amount of water they’re using,” Burnett said. “I think it’s possible for them to get the same results with less water.

In the meantime, Burnett and his students are working on how to optimize the drilling process, including where it’s drilled, how to stimulate it to produce gas, and when to go back and re-stimulate. “The science of reservoir engineering is all about how to contact the maximum extent of the reservoir possible with the least effort,” Burnett explained. “The key to Barnett Shale productivity is the advent of the horizontal well and the use of water fracs to contact as much of the formation and microfractures as possible. So the trick is to do that with the minimum expended energy. And our industry is doing a good job. We’ve increase our subsurface footprint 6,400 percent in the last 30 years.”