Optimizing shale gas production from well to wire

June 25 2015, by Amanda Morris

"Hydraulic fracturing" (or fracking) and "environmentally friendly" often do not appear in the same sentence together. But as the United States teeters on the precipice of a shale gas boom, Northwestern University professor Fengqi You is exploring ways to make the controversial activity easier on the environment—and the wallet.

"Shale gas is promising," said You, assistant professor of chemical and biological engineering at Northwestern's McCormick School of Engineering and Applied Science. "No matter if you like it or not, it's already out there. The question we want to answer is: how can we help this industry to make it more sustainable?"

You has designed computational models to analyze the "well-to-wire" life cycle of electricity generated from shale gas. His models account for a number of stages in the process, including freshwater acquisition, shale well drilling, fracking, gas production and processing, wastewater management, and electricity generation, as well as transportation and storage. By discovering optimal design and operations for the shale gas supply chain, You believes the United States will benefit both environmentally and economically.

Supported by the Institute for Sustainability and Energy at Northwestern, You's findings were published in the June issue of *ACS Sustainable Chemistry & Engineering*. Jiyao Gao, a PhD student in You's lab, was the paper's first author.

The economic benefits of shale gas are hard to ignore. According to the US Energy Information Administration, shale gas could become the dominant fuel source within 10 to 20 years, allowing the United States to become energy independent.

But many wonder if the environmental disadvantages outweigh the economic benefits. To extract shale gas from deep inside the earth, workers use a combination of fracking and horizontal drilling. Successful fracking requires 4 to 6 million gallons of freshwater per well, which is then mixed with chemicals and sand and injected into the drilled well to break up shale rock and release the gas hidden within it. When the water is flushed back up to the surface, it is contaminated with salt, pollutants, and even some radioactive chemicals. On top of this, the opened wells also release methane.

"We talk about carbon dioxide, and we think it's bad because it causes global warming," You said. "But methane is even worse. One unit of methane is 86 times worse than one unit of carbon dioxide from a two-year horizon in terms of its ability to trap heat in the atmosphere."

Through modeling, You found that these issues can be mitigated by restructuring the supply chain. First, You recommends using a network of pipelines to transport freshwater to drilling sites and transport shale gas to processing and power plants. By removing trucks from the equation, the industry would save on gas and cut exhaust emissions.

Next, You suggests developing a better drilling schedule. After drilling a vertical shale well, workers drill more wells horizontally to reach more targets. Horizontal drilling can result in 20 to 30 wells in one place. This requires more water, transportation, and storage then needed to meet demand, and it releases more methane. By evenly distributing drilling activities at each well site over the years instead of drilling all at once, the industry would avoid transporting the gas to long-term storage

facilities. It would also reduce the amount of water needed at one time. As a result, facilities can be designed with a more suitable capacity, reducing the capital investment and negative ecological impacts.

Finally, You evaluated ways to handle the highly contaminated wastewater that is a fracking byproduct. Some companies have been disposing it in abandoned wells. But because these wells are few and far between, they have to drive farther and farther distances to find wells with room for disposal. The other option is to treat the water, which is difficult because of the high volume.

"Onsite water treatment requires a lot of energy," You said. "Treatment technologies like reverse osmosis need electricity, which may come from a coal-fired plant. Disposing the water into a well is easier and cheaper but not for the long term. Through life-cycle analysis, we found that water treatment is actually a more sustainable solution."

While the treated water may not be fit to drink, it could be recycled back into the process and used again for fracking. This cuts the truck emissions and costs of transporting the water to far away facilities. And the more time a truck spends on the road, the greater the chances that the contaminated water will leak.

You said that because the shale gas industry is young, companies are still learning how to manage it. He believes that optimizing operations will help the industry have better control of the entire system. Not only will it benefit companies financially, it will do less damage to the environment.

"We wanted to see if there was a win-win strategy," You said. "Indeed there is."

More information: *ACS Sustainable Chemistry & Engineering*, pubs.acs.org/doi/abs/10.1021/acssuschemeng.5b00122

Provided by Northwestern University