

LNG is a game-changing fuel

By powering drilling rigs and fracturing pumps with LNG,
operators see lower costs and emissions.

Jonathan Harris and Bryan Luftglass,
Linde North America

Reportedly, less than 1% of US drilling rigs have been converted to use LNG. And, until recently, no full fracturing spreads have used LNG to power pressure pumping equipment. The reason? The complexity of safely and reliably sourcing and supplying LNG at sufficient volumes, flow rates, and pressures to support multiple high-hp engines has been a hurdle to adopting LNG as a viable fuel for this industry.

Yet with the price of natural gas at near all-time lows, the oil and gas industry is determined to find solutions to increase its use of LNG in drilling and completion. More than 700 MMgal of diesel were used in 2012 to power the pumps that inject sand and water at high pressures downhole to fracture formations. According to Apache Corp., the potential savings in LNG-powered fracturing are significant. The company estimated a single well fracture in the Granite Wash would typically use 36,000 gal of diesel. In early 2013 an operating fracturing spread moving from pad to pad would use as much as US \$1 million of diesel fuel per month, so the roughly 40% lower cost for LNG would translate into significant savings.

LNG combustion also produces fewer greenhouse gases and inherently lower mono-nitrogen oxides, particulate, sulfur oxide, and carcinogen emissions than diesel. In regions where high emission levels threaten future development, reducing emissions through the increased use of LNG could help avoid potential constraints on regional drilling activity.

Substituting even 60% of diesel with LNG significantly reduces costs and emissions. Those benefits justify overcoming the hurdles posed by conversion.

But what are the hurdles? It no longer appears to be technology. Engine conversion and combined LNG-diesel dual-fuel technologies now exist, so diesel engines can easily run with this combination of fuels. New engines and gas turbines also are being developed to run on 100% LNG.

Nor has cost been the issue. Conversion investments are easily paid back, typically within a year. Sourcing

LNG, getting an adequate supply of it to the site reliably and safely, and moving supply equipment from well to well at the speed required for fracturing jobs has posed some technical and logistical problems, but companies have been able to crack the code recently.

To ensure the safe and reliable delivery of LNG, several energy companies and service operators have looked to the experienced handlers of cryogenic gases who are capable of working with the upstream oil and gas industry. Companies such as these have demonstrated the logistical and safety knowhow to keep up with these complex operations.

Several E&P companies have partnered with Linde North America to help overcome challenges in LNG supply for drilling and completion. Apache, CONSOL Energy, and EQT Corp., working with Linde's Energy Solutions group, have announced successful dual-fuel projects. These oil and gas producers and many others have made a strategic commitment to incorporate LNG into powering drilling and completion equipment. Companies are demonstrating their leadership in sustainabil-



Converting a full fracturing spread to LNG requires working with experienced handlers of cryogenic gases who have demonstrated the logistical and safety knowhow to keep up with these complex operations. (Image courtesy of Halliburton)

ity, domestic sourcing, reduced emissions, and cost savings by committing to LNG as a fuel for these activities.

Using LNG as fuel for fracing equipment

In December 2012 Linde, Apache, and Halliburton completed the initial phase of the industry's largest dual-fuel project to date when a 12-pump, 24,000-hp full fracturing spread was powered with LNG supplied by Linde via its specially modified storage and vaporization units. Linde worked with its partners to tackle the technical and logistical challenges of LNG fuel supply by establishing a safe and efficient gas distribution system for the fracturing fleet. Further supporting this, Caterpillar developed dual-fuel engine conversion technologies so that natural gas could be used in combination with diesel to power equipment used in hydraulic fracturing – one of the most energy-intensive processes in the industry.

To support LNG use in dual-fuel, high-hp applications, Linde modified its mobile LNG storage and vaporization units. The modified systems supply in excess of 2,800 cu m/hr (100,000 cf/hr) of natural gas at a pressure of 100 psi. This was sufficient to power the equipment that pumps water, sand, and chemicals downhole at high flows and pressures. Linde designed and deployed LNG units that can be moved quickly from pad to pad, supporting the first conversion of an entire hydraulic fracturing fleet. This focus on mobility, with Linde fitting in to Apache and Halliburton's operations without any interruption, was critical to the success of the project.

"Taking advantage of the abundance of clean-burning, inexpensive natural gas in the US is good for our economy and our environment," said Mike Bahorich, executive vice president and chief technology officer at Apache. Apache CEO G. Steven Farris, also chairman of America's Natural Gas Alliance, encouraged his employees and the industry to increase the use of natural gas as a fuel for engines. "We selected Linde for this challenging assignment based on its broad experience in supplying LNG to oil and gas operations and its focus on safety and operational excellence," Bahorich said.

Using LNG as fuel for drilling rig engines

Within the past few years LNG has become an accepted



The return on investment in engine conversion and combined LNG-diesel dual-fuel technologies is easily paid back, typically within a year. (Image courtesy of Apache Corp.)

fuel in drilling rig engines. For example, in 2012 EQT partnered with Linde to test dual-fuel of engines and generators at numerous West Virginia well sites. This project demonstrated the safe, reliable, and cost-effective use of LNG in dual-fuel applications.

CONSOL also contracted with Linde to supply LNG and related equipment and services for a rig conversion trial. Following successful completion CONSOL decided to convert all of its drilling rigs in the Marcellus and Utica basins to natural gas. LNG will be used to power gas drillings, and its use may expand to CONSOL's hydraulic fracturing and even mining and marine operations. "The success of our initial collaboration with Linde to power our drilling operations with a hybrid fuel incorporating LNG gave us the confidence to expand our use of this economical, cleaner burning fuel," Jeff Boggs, vice president of drilling for CONSOL, said.

While compressed natural gas (CNG) and field gas also are being explored for dual-fuel or full-fuel operations, LNG presents advantages, particularly when CNG or field gas is not readily available. LNG is the easiest fuel to store on site in the necessary volumes required for drilling and hydraulic fracturing. It also is the fastest to deploy, rig up, and rig down from well to well. This makes LNG the best long-term solution for widespread adoption of natural gas to power fracturing spreads.

The success of these dual-fuel projects proves the feasibility, safety, effectiveness, efficiency, and logistical benefits of using LNG in high-hp applications, particularly when an experienced provider of LNG products and services to the upstream oil and gas industry is involved. **ESP**