Business & Technology Strategies

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C&I CASE STUDIES IN **BENEFICIAL ELECTRIFICATION**

Electrifying Natural Gas

Opportunities for Beneficial Electrification and Load Flexibility in Natural Gas Pipeline Compressor Stations

BY **PETER MAY-OSTENDORP** AND **KATHERINE DAYEM**, XERGY CONSULTING, MAY 2018

SUBJECT MATTER EXPERT FOR QUESTIONS ON THIS TOPIC

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INTRODUCTION

The wise use of electricity, Beneficial Electrification, has sparked widespread re-thinking of policies that encourage or mandate less electricity use and promote infrastructure planning. Advancements in electric technologies continue to create new opportunities to use electricity as a substitute for on-site fossil fuels like natural gas, propane, gasoline and fuel oil, with increased efficiency and control. It also offers local economic development and enhances the quality of the product used by the customer.

Electrifying industrial and commercial processes is a proven method to help local businesses stay competitive. Beneficial electrification strengthens the cooperative presence in the community and offers benefits to the electric system, such as environmental performance, reduced total energy costs to the consumer, and grid flexibility. Cooperatives can start by working with their C&I members to identify opportunities amongst potentially large loads. To provide examples of various approaches to working with C&I customers on beneficial electrification initiatives, NRECA is developing a **series of case studies**.

NRECA
America's Electric Cooperatives

This case study focuses on electric cooperatives in oil-and-gas country that have started promoting the adoption of electric and dual-drive (gas-electric) compressors for natural gas pipeline compressor stations. New electric or dual-fuel compressor technology allows operators to save on operating and maintenance costs, reduce site emissions, and provide valuable grid services. Innovative business models allow the equipment to be installed at or below the capital cost of conventional gas compressors, providing rapid return on investment.

MEMBER PROFILE

United Cooperative Services

Founded in 1938, United Cooperative Services (UCS) now supplies electricity to over 84,000 meters and 58,000 members in the areas to the south and west of the Fort Worth metro area. UCS is one of Texas' 67 electric cooperatives and purchases wholesale power from Brazos Electric Cooperative, a generation and transmission cooperative serving members in north and central Texas. UCS and Brazos also reside within the Electric Reliability Council of Texas (ERCOT) and are able to participate in its various unique power markets.

UCS's territory also overlaps with one of the nation's most productive gas fields, including the Barnett Shale formation, a 5,000 square mile region that has seen a boom in development over the past decade through hydraulic fracturing. The Barnett Shale region currently is estimated to produce over 3 billion cubic feet of natural gas per day and contains significant amount of pipeline infrastructure to distribute product to facilities across the country.

NATURAL GAS PIPELINES: AN OPPORTUNITY FOR ELECTRIFICATION

A network of over 300,000 miles of transmission pipelines carry natural gas from the wellhead to regional marketplaces (see **Figure 1**), where fuel is eventually distributed to homes and businesses — but, the fuel will not simply flow on its own. Transmitting gas through pipelines requires an accompanying network of compressors to keep gas flowing down the line. Compressors are large, expensive, mission-critical industrial equipment. Pipeline operators invest millions of dollars to build individual compressor stations, and pipelines require many such stations spaced every 50 to 100 miles.

Most compressor stations consume a small part of the gas in the pipeline to power gas engine-drive compressors. Like any combustion engine, natural gas engines produce exhaust containing a variety of pollutants, and operators need to be mindful of local air quality standards, especially in heavily developed gas fields.

Converting to electric compressors can reduce fuel and maintenance costs and eliminate site emissions, providing they can be located near a reliable source of power. Electric compressors also provide a large, highly stable load for electric cooperatives and should be a welcome addition to any electric utility's load profile. The vast majority of pipeline compressors in the country today (over 90 percent) are fueled by natural gas, so there is ample opportunity to convert operators to electricity.

Dual-drive compressor technology — "hybrid" compressor stations that can seamlessly switch between natural gas and electricity — allow pipeline operators to electrify compressor stations with the confidence that they can always be using the economically optimal energy

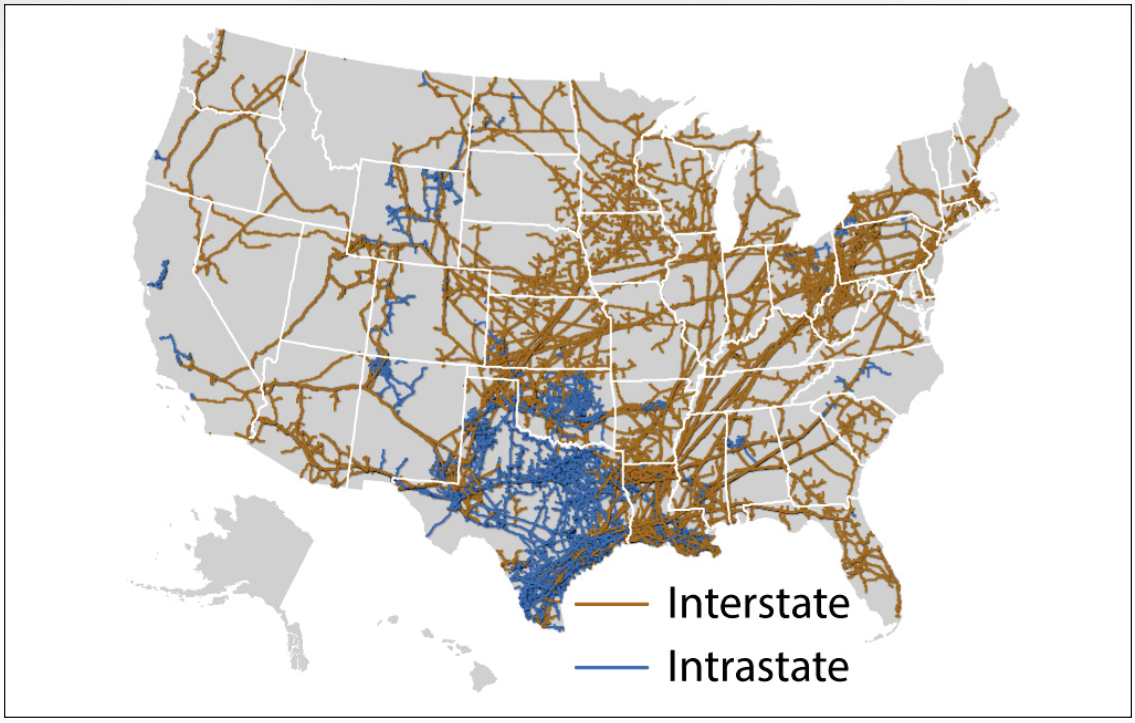

FIGURE 1: A significant portion of the nation's natural gas transmission pipelines and associated compressor stations fall within the boundaries of the co-op nation, presenting beneficial electrification opportunities for cooperatives. *Source: NRECA.*

source. These stations also provide cooperatives in oil and gas country with large, stable loads and opportunities for load flexibility under critical situations.

UCS, located to the south and west of the Dallas-Fort Worth metro area, experienced massive load growth from 2006 through 2010, due to the development of the Barnett Shale formation by the oil and gas industry. Over 200 MW of compressor load alone was added to the system during this time. Although Barnett Shale production today is down about 40 percent from its peak in 2012, UCS still maintains significant compressor loads of over 70 MW across 25 different accounts, with new compressor stations being planned and installed even today by pipeline developers and owners.

United has worked alongside Dual Drive Technologies on the implementation of dual-drive compressor stations, which utilize electricity when economical, but switch to gas when pricing or grid conditions warrant. For UCS, dual-drive compression has brought stable revenue streams, as well as flexibility in maintaining reliable electric services.

NEW TECHNOLOGIES ENABLING ELECTRIFICATION AND LOAD FLEXIBILITY

Most gas pipeline compressors today (over 90 percent) burn natural gas in a large, stationary engine coupled to a turbine to boost pressure in the pipeline. Compressors can vary in size from 1,500 to 5,000 horsepower depending on the capacity needs of the pipeline and the station's location.

Electric compressors work on the same principle, only using an electric motor instead of a gas engine. However, gas compression has traditionally been chosen over electric compression for several reasons. First, compression stations generally need to be located at specific points along a pipeline, and this may not always overlap with electric infrastructure, especially

Dual-drive compressor technology has helped to boost adoption of electric compression.

Electric motors are generally more reliable and require less maintenance than natural gas-powered engines.

in rural areas. Second, electric prices may not always be competitive with gas, especially when factoring in demand charges applied to larger customers. Finally, pipeline operators have traditionally preferred gas, because it is already available in the pipeline and reduces the possibility of service outages. Despite these obstacles, a number of pipeline operators still utilize electric compression in certain locations where infrastructure is already available and prices are competitive.

In the past decade, patented dual-drive compressor technology, a form of hybrid electric-gas compressor has helped to boost adoption of electric compression, particularly in Texas. They incorporate a natural gas engine and an electric motor, coupled through clutches, to power a compressor (Figure 2). Automated systems can switch fuel sources between natural gas and electric based on a schedule or rules that the operator specifies (manual switching is also possible). Dallas-based Dual Drive Technologies (DD) is currently the sole provider of dual-drive compressor technology in the U.S., holding a patent on the technology.

A typical compressor station may draw 10 MW or more, enough power to cool over a thousand homes on a hot summer day. With fuel flexibility and the possibility to curtail megawatts of load, a single station represents a sizeable grid management asset, rivaling the capacity of diesel gensets and on par with many of today's grid-scale battery projects. Through innovative shared savings models, this flexibility allows pipeline operators to potentially lower upfront capital costs by allowing DD to manage the station's operation for greatest cost efficiency.

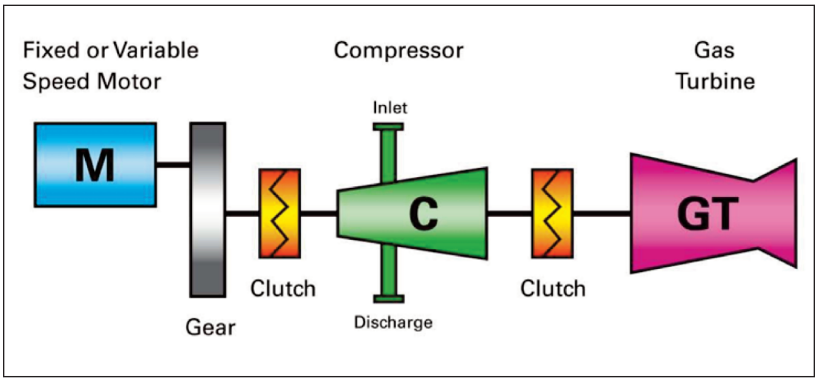

FIGURE 2: Dual-drive compressors can be powered either by electricity through a motor (blue) or by natural gas through a gas turbine or engine (red). *Source: SSS Clutch.*

THE CASE FOR PIPELINE OPERATORS

Electrified gas compressor stations can generate benefits for pipeline operators in several ways. Electric motors are generally more reliable and require less maintenance than natural gas-powered engines. This translates into cost savings over the motor's life and longer service intervals. Dual-drive compressors benefit from lower Operations and Maintenance (O&M) costs as well, since they may only run a small fraction of the time on gas. For larger compressor stations, this can translate into millions of dollars in O&M savings over the useful life of the equipment.

In crowded gas fields and in areas that have difficulty reaching criteria pollutant attainment levels set by state and federal regulators, electric compressor stations have a significantly lower emissions profile than gas engines, particularly for NOx and methane. This can help ease the air permitting process for new stations.

There may also be additional operational cost savings and potential revenue streams from electrification, provided the operators can work with their local distribution co-op and G&T to avoid peak demand charges and participate in available wholesale market programs. With all-electric compressor stations, this may involve curtailing product throughput during hours or peak use, which may not be palatable to the operator if they need to maintain flow and pressure at the time. However, dual-drive compressor

Large accounts from electric compressor stations can help co-ops improve the load factor of the system and drive down wholesale power supply costs, and maintain stable revenue.

stations can simply shift to gas compression whenever it makes economic sense and without any noticeable reduction in compression. Figure 3 illustrates a curtailment event at the Godley Gas Plant in Godley, TX, one of the compression facilities in UCS service territory. During the afternoon of June 23, 2017, DD shifted compression predominantly to its natural gas unit, shedding about 5.5 MW of load and avoiding the ERCOT peak. June 23 was also one of the four ERCOT critical peak (4CP) days used to establish larger customers' annual demand charge. By avoiding operation of the electric motor during this peak, the Godley plant reduced demand charges by approximately 40 percent, which is significant, especially when applied across all compressor stations.

THE CASE FOR COOPERATIVES

Electric compressor stations provide co-ops with large and stable electrical loads with high load factor, all of which is good for revenue. Even though the Barnett Shale formation development activity is past its peak, UCS still enjoys a relatively stable 70 MW of load across 25 different compression-related accounts, and three new projects will soon bring another 40 MW online. Large accounts such as these can be crucial to maintaining stable revenue, especially at a time when electric sales are otherwise in slow decline. "Having electric and dual-drive based compression on our system has been a great benefit to all of the members of our cooperative in improving the load factor of our system, and as a result, driving down our average wholesale power supply costs that we pass along to our members," says Cameron Smallwood, CEO and General Manager of UCS.

Dual-drive compressor stations provide added benefit through fuel flexibility, allowing co-ops (distribution and G&T alike) to free up megawatts of capacity during hot weather or other critical situations. In the case of UCS, this load flexibility proved to be crucial during critical peak conditions. During February 2011, several generators in ERCOT had failed all while temperatures across much of the region remained below freezing for several days. This resulted in system-wide capacity constraints and calls from ERCOT for rolling load shed. To mitigate UCS' exposure and fulfill calls for curtailment, the co-op was

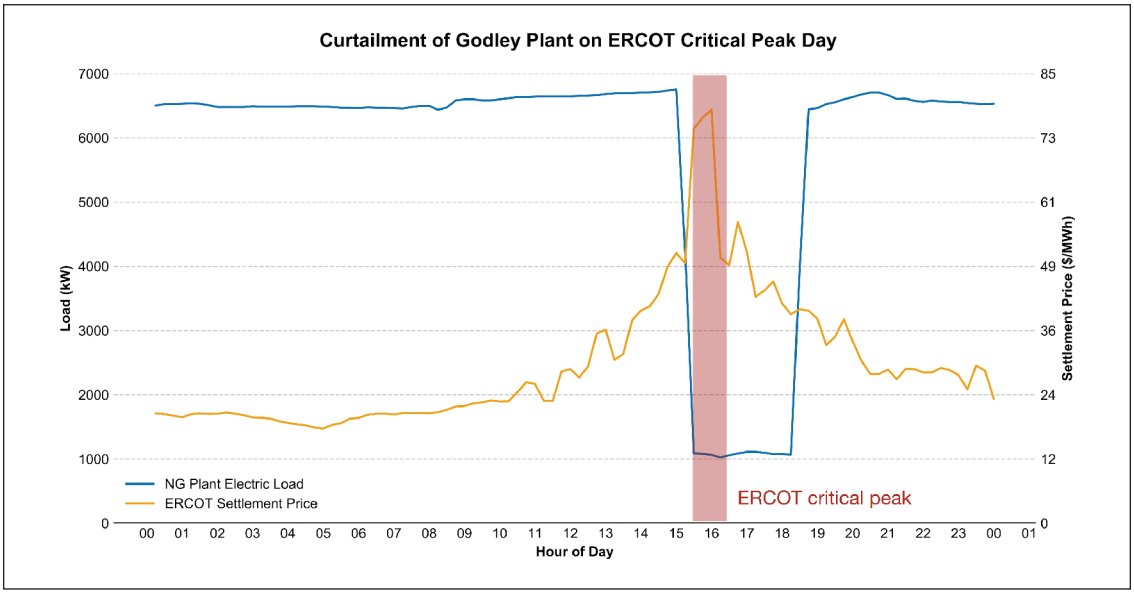

FIGURE 3: By switching to gas during ERCOT's peak window, the Godley Gas Plant released 5.5 MW of capacity to the grid and helped dramatically lower demand charges for the following year.

simply able to call on several dual-drive compressor operators to switch to gas operation. "We were able to contact Dual Drive Technologies and request they temporarily curtail their electric compression load by moving it to natural gas via the dual-drive compressors; they were able to quickly do this which effectively reduced the rolling outage impact to our membership," recalls Smallwood. "This was a great benefit to our membership during that difficult time that would not have been available had it not been for the dual-drive compressors."

Electrifying gas compressors benefits the environment through lower emissions.

THE CASE FOR EMISSIONS REDUCTION

Beneficial electrification efforts generate value for member-owners, the co-op at large, as well as the environment. As with a variety of other beneficial electrification strategies, electrifying gas compressors benefits the environment through lower emissions. Natural gas-driven engines, commonly used in the oil and gas industry to drive rotating equipment, are a point source of the criteria pollutant nitrous dioxide (NO_2). NO_2 is key to smog formation and can exacerbate respiratory conditions like asthma. Electric compressor stations emit no NO_2 on site, and even when accounting for power plant emissions, they emit 80 percent less NO_2 than a comparably sized natural gas-driven compressor.[1] In the case of dual-drive compression, operators can place a runtime limit on natural gas operation. The smaller the gas runtime, the larger the emissions savings. Currently, DD operates units so that the natural gas engine runs less than 15 percent of total runtime, yielding 85 percent or more of the emissions savings of a fully electric compressor station.

Gas engines and compressors also release significant amounts of methane (CH_4) due to incomplete combustion and fuel slippage. Methane is a greenhouse gas roughly 30 to 50 times more potent than CO_2.[2] No matter where a compressor electrification project is located, it will eliminate over 99 percent of the associated methane emissions. As noted above, dual-drive savings will vary depending on the runtime of the gas engine.

MAKING IT HAPPEN

Fortunately for cooperatives, if conditions are ripe for compressor electrification, co-op staff may not need to make a very hard sell to operators. The question is: *How does a co-op know if their service territory is a good match for this strategy?* Beyond having active gas development in the region, some other conditions that may be positive indicators are:

- **Relatively low electric rates in comparison to local natural gas prices —** Ultimately, the pipeline operators will need to make an economic evaluation, but if your co-op already services some electric compression load, this should serve as an indication that rates might already be competitive in your area.
- **Distribution infrastructure in proximity to existing gas compressor stations —** Cooperative GIS information can be coupled with satellite imagery to identify compressor stations that may be good targets for electrification based on proximity to co-op assets. Distribution cooperatives in Oklahoma are beginning to explore this approach.
- **Opportunities for industrial accounts to bid into power markets —** Compressor stations in ERCOT, for example, can readily generate revenue by bidding into the market as a Load Resource. This is an important "stacked" benefit that accrues in addition to other operations and maintenance savings. In other markets, G&T cooperatives with capacity

[1] Based on an analysis of similarly sized natural gas and electric compressors, using emissions data from Caterpillar (natural gas engine) and the Electric Reliability Council of Texas (ERCOT).

[2] Methane's potency as a greenhouse gas declines over time. It is roughly 50 times as potent after 20 years, 30 times after 50 years and only 6.5 times after 100 years.

constraints may need to play a larger role in facilitating the right economic incentives.

- **Heavily developed gas fields where electric compression will provide significant reductions in point emissions and assist with air permitting —** Regions with heavy gas development, such as portions of Texas and the Marcellus Shale formation in the northeast may benefit from electrification due to air quality concerns.

If your cooperative meets any of the above criteria, it may be time to internally evaluate the business case for electrifying these facilities, including the level of investment required to extend service to these facilities. In most cases, the developers of electric compressor stations are willing to partner with co-ops to facilitate mutual beneficial electrification projects. "We were able to work with gas compressor owner-operators and Dual Drive Technologies to show them that the fuel savings of electrification were significant enough to cover the cost of line and capacity upgrades, as well as the dual-drive units," according to Smallwood. "We have worked well together with Dual Drive to maximize benefits for all involved parties — a win-win-win." ■

About the Authors

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Dr. May-Ostendorp has been investigating emerging energy savings and distributed energy opportunities at the building-grid interface since 2004. He has authored dozens of publications on product efficiency, building controls, and smart systems, and his research has led to mandatory efficiency standards, voluntary labeling programs, and utility efficiency programs. He utilizes his expertise in building systems, building energy modeling, controls, and energy data science to research, develop, and evaluate new clean energy technologies on behalf of diverse clients from the public and private sectors. He lives in the foothills of the San Juan Mountains with his wife and three children in Durango, CO and is a member of La Plata Electric Association.

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