A GUIDE TO COMPRESSOR DRIVER SELECTION:
ELECTRIC MOTOR, RECIPROCATING ENGINE, AND DUAL DRIVE

BY MORGAN HENDRY

Some say electric motors are the best way to run compressors. Others swear by gas engines. Some applications do just fine using a gas engine, whereas others favor an electric drive. There are situations, too, that dictate greater flexibility that can come from a dual-drive approach.

Let's look at the pros and cons of each of these options.

ELECTRIC MOTOR–DRIVEN COMPRESSION

Here are some of the factors in favor of electric drive:

• *Incentives:* Electrification is very much in the spotlight. The vision is that all electricity can come from renewable sources that generate enough power for all energy needs. This dream has a long way to go, as shown during the summer of 2022 when the Governor of California urged citizens not to charge their electric vehicles to keep the lights on in the Golden State. Nevertheless, electrification is favored in many states. There may be incentives to opt for an electric motor over a gas engine, mandates and emissions regulations making it more difficult to install a gas engine, or local preferences based on environmental considerations.

• *Reduced Emissions:* The emissions picture gets a little complex. If emissions are purely measured at the location where the energy is delivered, then electric-drive compressors come out ahead of natural gas engines. This is the way local air quality districts usually measure emissions and provides an obvious advantage to electric motors. They are powered by the grid and avoid complications in permitting related to NO_x, carbon dioxide, and other exhaust emissions.

Electric drives are quieter than gas engines.

• *Lower Maintenance Costs:* Electric motors require anywhere from 10% to 20% less maintenance than gas engines. The savings can add up over the lifetime of the machine.

• *Noise:* Electric drives are quieter (approximately 70 dB) than gas engines (approximately 110 dB). Therefore, in locations where noise regulations are a factor or there is proximity to residential areas, they are often the preferred choice.

• *Reliability:* Both driver types are reliable, but electric motors are generally more reliable over the long term by a percentage point or so.

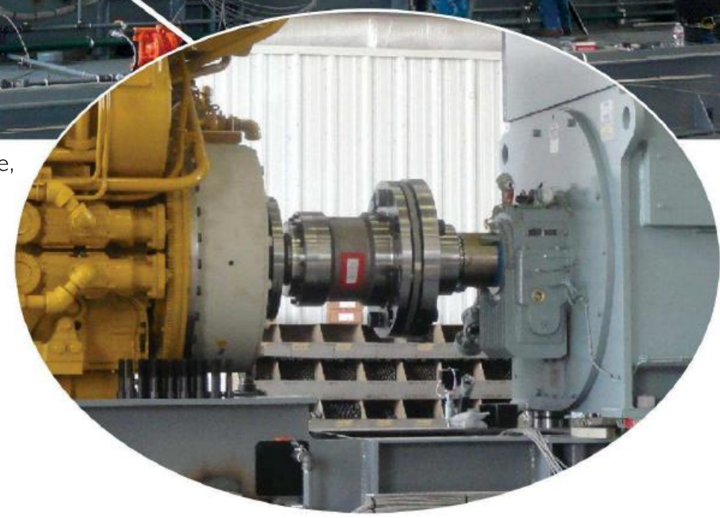
• *Capital Cost:* Fixed-speed motors cost less and are cheaper to install compared to engines, assuming that electric lines are nearby. The capital cost advantage of an electric motor ranges from 10% to 25% depending on the size and configuration. However, this advantage is lost if a variable frequency drive (VFD) is required to allow the motor to operate at variable speed, or if electrical lines need to be upgraded or added to a project.

Those are some of the pluses for electric motor drive. But there are disadvantages, too.

• *Grid Reliability:* Grid reliability is a growing concern. Whether it is rolling blackouts in California during summer or disastrous grid failures during Texas winter storms, the grid isn't always something you can count on. According to the North American Electric Reliability Corp. (NERC), two-thirds of North America is at risk of power shortages during summer because of the extreme electricity demand during periods of spiking temperatures.

The western United States, Texas, and the Carolinas face the greatest risk of rolling blackouts. All it takes is an extended heat dome, an unusually severe cold snap, wildfires, or extended periods of poor wind and solar output and the grid can be placed under severe strain.

"The emissions picture gets a little complex."



A typical dual-drive compression system features a natural gas engine, an electric motor, and an overrunning clutch.

• *Grid Proximity:* To make economic sense, electric-driven engines need to be installed near a reliable source of electric power. Erecting lengthy transmission lines and substations adds significant project costs. This also adds to lead times awaiting additional permitting and infrastructure construction.

• *Price Instability:* The electric power market is often more volatile than the gas market. Utility rates for electricity are

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more subject to peak rate hikes and other fluctuations. For a 2500-hp (1865-kW) electric motor–driven compressor operating at full load, if the cost of electric energy doubles from US$0.04 to US$0.08 cents per kW-hour, the electric bill would go from US$75/hour to US$150/hour. For a gas engine drive only, assuming an engine fuel rate of 8530 Btu/shaft kW/hour, if the fuel cost goes from US$3 to US$6 per MMBtu, fuel cost would go from US$48/hour to US$96/hour. There are places in the United States today where the spread between peak and off-peak electric rates is more than US$0.15 per kW-hour.

NATURAL GAS ENGINE–DRIVEN COMPRESSION

Like their electric motor–driven cousins, there are pros and cons to using natural gas engines to run compressors.

• *Reliability & Availability:* The United States has perhaps the best natural gas pipeline and supply network in the world. There are currently more than 300,000 miles (482,803 km) of interstate and intrastate pipelines. Gas is rarely far away. The network doesn't go down during a power cut unless the pipeline uses an electric motor drive. If natural gas is used to fuel pipeline compression, it takes freak conditions to bring down the system, like what happened in Texas during the winter storm of 2021. The Texas blackouts shut down electric compressors in a natural gas compressing field, which reduced the supply of fuel available to run gas-fired generating stations. The lack of gas being collected from the ground coupled with record demand for heating caused a drop in pipeline pressure. Such events, though, are rare.

• *Price:* Natural gas has been a cheaper option than grid electricity on average over the last 20 years, often by a large margin. Gas suffered price hikes throughout 2022 that changed the picture, but it has now settled back below US$3 per million Btu. Natural gas doesn't suffer so much from the sudden surges in price that impact grid power. Viewed over the last quarter of a century, there have been only two periods where gas averaged more than US$4 per million Btu for a year. Those were at certain points between 2006 and 2009 and during 2022.

Dual-Drive Compressor

• *Energy Security:* Overreliance on electrification with no Plan B means a power cut shuts down everything. Having pipelines operating on natural gas rather than relying on electric grid supply means gas can keep flowing, stoves and fires can continue to burn, and natural gas-based power stations can ramp up output. This is a key facet of energy security.

• *Variable Speed:* The inherent variable speed capability of the gas engine allows the compressor to perform during a wide range of conditions. As mentioned, motors can be made to operate at variable speeds but that can diminish their capital cost advantage.

Of course, there are some disadvantages to natural gas drives.

• *Operations & Maintenance:* These costs are usually higher for natural gas. As noted earlier, natural gas has higher maintenance costs on average. But the previous 2500-hp example highlights the fuel/running cost factor, which is in favor of natural gas over an electric motor.

• *Emissions:* As noted earlier, NO_x and other emissions are a concern. Local regulations can make it difficult to receive approval for a natural gas drive or limit the number of hours a gas engine–driven compressor can be permitted to operate each year.

• *Noise:* Gas engines are noisier than electric motors, though reciprocating engines are available with features to minimize noise.

• *Capital Cost:* Gas engines have higher capital costs than electric motors with the gap being dependent on the size of the machine and its configuration.

DUAL-DRIVE COMPRESSION

Clearly, there are sensible arguments in favor of electric-driven compression and counter arguments for natural gas. This has given rise to the concept of dual-drive compression to maximize the advantages of each and minimize their shortcomings.

• *Optimized Energy & Operating Costs:* Dual-drive systems can switch from gas to electric drive and back again. It is a good way to optimize energy costs and operating expenditures, maintain reliability, meet emissions targets easily, and offer ancillary services to the grid. In an era where grid reliability is under threat, an energy switching capability is becoming an operational necessity for some. Switching back and forth only takes about 30 seconds and can be accomplished remotely. A company in Texas has a business model that takes advantage of dual-drive economics as follows: For the cost of an additional 5000-hp (3730-kW) electric motor, VFD drive, clutch, flexible coupling between clutch and motor, and the additional length of baseplate structure, about US$1 million is incurred in additional capital costs. Because of energy and operating cost optimization, the payback occurs within about two years because of arbitrage of energy and time of day avoidance payments. This company will even provide the additional electric motor to create a dual drive in exchange for the right to trade the energy.

• *Avoidance Of Oversizing:* A typical dual-drive compression system features a natural gas engine, an electric motor, and an overrunning clutch. Each of the drivers can power the compressor on its own. The clutch enables rapid switching from one to the other without loss of throughput. At times, both drivers can operate together to meet a rare but important operating condition that can't be handled by the engine alone. This feature avoids the expense of purchasing an oversized engine that is rarely used at its capability. An oversized engine would also use more fuel on average.

• *Flexibility:* The dual-drive approach helps an operator take advantage of fluctuations in utility pricing markets while maintaining emissions flexibility and saving on maintenance. For example, if electricity rates surge or when peak price periods are about to kick in, the asynchronous self-shifting clutch allows the engine to start up and smoothly engage with the already running compressor. The breaker on the motor is then opened and all the compressor load is handled by the engine. When electrical rates return to acceptable levels, the process is reversed, and the electric motor takes over.

A freewheeling clutch automatically engages and disengages a set of concentric gear teeth using helical spines on the input and output sides of the clutch and operates based on differences of speed. When the device connected to the output shaft of the clutch — in this case the compressor — is moving faster than the input side (engine), the clutch disengages. When power is applied to the input side, however, and its speed matches or tries to overtake the speed of the output side, then the clutch engages.

The disadvantages of the dual-drive approach include:

• *Initial Costs:* The implementation of a dual-drive approach adds to initial costs because two drivers are purchased and installed, not one. However, the return on investment can be rapid where electric price volatility is present or peak rates make operation uneconomic at certain times. The operator avoids being locked into a single energy source. Daily or hourly fluctuations are responded to by activating the clutch to move from one driver to another. Adding an engine-motor to a gas engine–based compressor to create a dual-drive system in the 2000- to 5000-hp (1492- to 3730-kW) range costs 25% to 30% more than an engine-only train.

• *Emissions Violations:* In areas where emissions regulations are tight, the system would need to be set up to run most of the time on electricity. It would switch to gas only when prices are high or when the grid goes down. The operator would need to set enforceable runtime limits to ensure emissions targets are met.

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