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DOE's Quadrennial Energy Review Stakeholder Meeting
Natural Gas Transmission, Storage & Distribution
Pittsburgh, PA – July 21, 2014

Thank you for the opportunity to describe our experience and a strategy for utilizing our nation's natural gas pipeline infrastructure more effectively.

History

Ormat Technologies, Inc. began focusing on the benefits of clean, reliable energy almost five decades ago. In the early 1970s, Ormat commercialized the Organic Rankine Cycle (ORC) technology for the application of remote power solutions, manufacturing small (by today's standards) power units in Massachusetts. This technology was adapted and well received by the then-booming oil pipeline industry in North America. This industry was using the technology for reliable remote operation of gate-valves in very remote areas and under extreme environmental conditions. In the early 1980s, Ormat ventured into geothermal, commercializing low-temperature geothermal resources with its ORC technology to generate electricity in the U.S. The first installation of the Ormat Energy Converter (OEC) in 1984, at the Wabuska facility outside of Yerington, Nevada, and is still in operation today, proving the reliability and dependability of Ormat's technology. As low-temperature geothermal power generation began to grow in the U.S. in the early 1990s and Ormat's technology was proving to be the primary choice. Ormat began to expand the application of its OEC to offshore platforms and waste-heat recovery installations. In the late 1990s, Ormat expanded to owning and operating geothermal and Recovered Energy Generation (REG) projects that generate revenue through electricity sales. Ormat's stance as an independent power producer and the major supplier of ORC technology grew quickly in the new century. Today, with over 626 MW of geothermal and REG power plants, and with over 1,750 MW of installed OEC capacity worldwide, Ormat has firmly planted itself in the development and support of clean energy, and has been able to prove, where many have failed, that there is a long-term, reliable solution for the world's energy crisis.

Fuel-Free Energy

Fifteen years ago, Ormat installed its first REG power plant, generating electricity from the wasted heat of a gas compressor station. This compressor station, located on the Transcanada gas pipeline in northern Alberta, Canada, converts the waste heat from a Rolls Royce RB211 gas turbine into 6,500 kW of electricity (the equivalent of 6,500 homes).

Today, about 100 MW (the equivalent of 100,000 homes) is being supplied to local grids in Canada and the US directly from the waste heat generated in the gas transmission process. This 100 MW is distributed amongst 19 projects, located in 6 states (Montana, North Dakota, South Dakota, Minnesota, Colorado, and Nevada) and 3 provinces (Saskatchewan, Alberta, and British Columbia).

The Gas Transmission Process

Every natural gas pipeline uses compressor stations to pressurize and move product from production to distribution or processing. These compressor stations mainly use natural gas from the pipeline as fuel for the compressors, which are mostly gas turbines or gas engines. The waste heat from these compressors (exhaust from the gas turbines or gas engines) holds the potential for electricity generation.

There are over 1,400 compressor stations in the US today (as provided by the EIA). These are installed amongst approximately 220,000 miles of gas pipelines throughout the country. With an average electricity production potential of 4 MW each, these compressor stations could produce over 5.6 GW of clean, fuel-free electricity (5,600,000 homes).

In Pennsylvania, new pipeline projects (in early stage development) represent 15% of all pipeline projects in the US, and since 2010, 22% of pipeline projects in the US were completed in Pennsylvania. This represents a tremendous opportunity in growth of the pipeline network, which is dependent upon compressor stations.

Generating Electricity

Converting this waste heat to electricity is performed with a simple, commercial, and proven process. The technology is based on the Organic Rankine Cycle, a thermodynamic process of converting (relatively) low temperature heat into work (electricity).

Compressor stations (gas turbines) exhaust heat at about 900°F. This heat is concentrated through a waste heat oil heater to a thermal oil (used commonly in this application) which is delivered to the REG power plant. Inside the power plant, the heat is transferred to a working fluid in a closed loop process, which is vaporized. This vapor drives a turbine and, hence, an electrical generator which exports power to the local grid. The working fluid is then condensed and then recirculated back through the process.

The REG power plant is unique from other, more commonly used, power generation cycles in that it is closed loop, air cooled, and inherently easier to operate and maintain. REG's are closed loop, meaning all of the process is kept inside pipe and not exposed or emitted to the environment. Ormat's REGs are normally air cooled, meaning it does not require the use of valuable water resources to operate (unlike more common power generation cycles), and does not require expensive and time consuming maintenance, such as steam turbine refurbishment and high pressure boiler certification. Additionally, because of the low-cost maintenance, Ormat operates REG power plants remotely, simplifying operation and allowing for large scale development of power generation along gas pipelines.

The business arrangement between REG and the pipeline is a symbiotic one. A typical REG power plant includes an agreement between the pipeline owner and the REG owner. The pipeline owner receives a royalty for the usage of its waste heat – heat which otherwise has no value to the pipeline. The operations and safety at the compressor station are not impacted by the REG

facility. In some cases, the pipeline owner has retained ownership of the REG power plant and the energy it produces.

Reliable, Resilient

Today, REG power plants have proven to be reliable and resilient. Through 30 years of product development and evolution, matched by a large installed capacity, these power plants have shown higher availability than today's largest (and most depended on) power plants. Coal, gas, and nuclear plants today only provide availability of 90-95% at most, while Ormat power plants have consistently provided availabilities up to 99%. This high level of reliability is today's best-of-breed base load energy supply.

These power plants have been installed and operated, over the past 30 years, in 26 different countries, and almost every environment imaginable. From the arctic of northern Canada to the high desert of Nevada, to the heat of Africa, the technology has proven to be resilient to environmental conditions time and time again. Ormat has also developed the power plants to operate as dispatch and island mode (available power on demand), conditions that very little power generation technologies can effectively provide today.

Clean Energy, Clean Jobs

This generation of electricity does not require any additional fuel consumption, and is generated from a waste heat stream that would/is otherwise wasted. Comparably, the electricity generated offsets approximately 1 ton of CO₂, 1.25 kg of NO_x, and 4.5 kg of SO₂ for each MWh generated. On an annual scale, as 6 MW REG power plant will save approximately 48,000 tons of CO₂, 66 tons of NO_x, and 240 tons of SO₂ which would be generated by the same power from a coal based facility.

Additionally, operation of REG power plants brings good, clean jobs wherever these pipelines are located. A single REG facility can generate 84 new construction jobs, 6 new operation jobs, and generate approximately \$8,000,000 in local revenues, including \$100,000 annually in property taxes.

REG is also attracting large technology firms as a reliable, clean, energy source. In 2013, Ormat entered into a joint development with eBay to construct REG power plant for their Salt Lake City data center, which already utilizes fuel cell technology for power.

Wherever There are Gas Pipelines...

The best quality of REG power plants is that they can be installed anywhere. With existing gas pipelines or new pipelines. Today, with new growth in natural gas production (such as Pennsylvania), new gas pipelines and hence compressor stations will be built. Each compressor station has potential to generate clean, fuel-free, electricity, jobs, and revenue for the local community. With minimal investment, Ormat (and other developers) can create new reliable and resilient power generation infrastructure.

Recovered Energy Generation represents an excellent ancillary service to the gas transmission infrastructure, by supplying local electrical generation without any additional fuel (gas) consumption. REG also effectively reduces the life cycle climate impact of natural gas transmission projects by supplying electricity to local sources without increasing fuel consumption.

Lastly, LNG, which is a growing topic of interest in the US today, either importing or exporting, is also an excellent source for additional power generation, and offer further improvement to the climate impact of natural gas transmission.