REPORT

Gas Turbine Market Disruption

PRODUCED FOR:

POWERPHASE® GENERATION SMART®

GALT FOX

Background

Market Operators face Challenges to Optimize Grid Efficiency Every Day

Rapid penetration of renewable energy has become the greatest challenge to managing modern electric power grids in North America. Public opinion supports more renewable resource development and integration into the grid but opposes new transmission investment and construction. Market operators encourage ancillary services and demand response, by creating transparently priced markets for these resources. However, they are still challenged to meet peak demands. As extreme weather has become more common in the past few years, market operators are ever more exacting in their need for fast response, flexible capacity that can meet peak demands in emergencies.

McCOY POWER REPORTS

Market Discovery: Emerging Technologies Discussion

10:30 AM NYC time
15:30 GMT
February 15, 2017

McCOY POWER REPORTS

Contact:
David R. Hetherington
McCoy Power Reports
1910 Byrd Ave, Ste 134, Richmond VA, 23230
p) US: 804 677-8900
w) http://mccoypower.net/
e) davidh@mccoypower.net

Featured Guests:

WÄRTSILÄ

POWERPHASE GENERATION SMART®

Energport

Additional Flexible Generating Capacity is Needed

Many capacity market operators need additional peaking capacity and fast and flexible plant response for seasonal peaks, which are exacerbated by extreme weather events. These operational challenges were brought to light by the 2014 Polar Vortex that hit the Northeast and Mid-Atlantic regions hard. PJM, ISO-NE, and NYISO all struggled to meet power demands as temperatures plummeted. PJM reported it “really exhausted every megawatt we had on the system” to meet record demand.

While the 2014 Polar Vortex highlighted the flexibility crisis, all market operators are juggling policy goals, infrastructure limitations, and market rules to optimize their systems. Generating resources are shifting from centralized nuclear and coal power plants to natural gas power plants, utility-scale wind and solar, as well as distributed solar PV and microgrids. While incorporating more renewables meets policy goals set across the nation, these resources are intermittent. As shown in Figure 1, installing more wind capacity over time does not make it more predictable. Available power output is increasingly volatile as more renewable generating capacity is integrated into the market operator’s transmission network. Given how volatilely intermittent this resource is the market operator, in this case ERCOT, will have challenges ensuring baseload energy demand is fulfilled.

Market operators need a reliable source of power that won’t disappear if a Class 4 hurricane forces a wind farm to temporarily shut down, an eclipse

blocks the sun for several hours as it did in August 2017, or simply to cover the everyday fluctuations in supply that are the new normal in power grids with increasing levels of renewable power

Potential Solutions

Market operators have devised many innovative pricing mechanisms in response to their challenges meeting baseload and peak demands. Among these market innovations are: demand side mechanisms to reduce demand, such as demand response and time-based rates based on real-time capacity prices; and supply side mechanisms to increase available power, such as pay-for-performance, synchronized reserve, black start service, and fast grid regulation. Market operators with a significant amount of renewable generation are subject to minute-by-minute unpredictable intermittency. Imagine a cloudy day where the sun might be blocked by clouds for a few minutes at a time. Ideal technological solutions are those that can respond quickly, at low cost, with minimal need for additional transmission investment. Supply side mechanisms are most capable of providing these solutions, whereas demand side mechanisms require end user consent and approval that delays immediate response and cannot flexibly cycle up and down to compensate for fluctuation in available generating capacity.

FUEL SOURCE AS A PERCENTAGE OF TOTAL GENERATION

ALL FOSSIL FUELS
62.7%

NATURAL GAS
31.7%

COAL
30.1%

NUCLEAR
20%

ALL RENEWABLES
17.1 %

HYDROPOWER
7.5 %

WIND
6.3 %

BIOMASS
1.6 %

SOLAR
1.3 %

GEOTHERMAL
0.4 %

OTHER SOURCES
0.2 %

Fast Response from Generating Technology and Energy Storage

The need for flexible generation intensifies because of renewable resource integration that increases supply volatility and poses a challenge to predictably meeting demand. Market operators need capacity resources that can start fast and ramp fast. Market designs of the past were based on annual commitments to meet demand. Today's resource mix of intermittent renewables necessitates a real-time market of spot energy and operating reserves and 5-minute energy dispatches to satisfy system demand and manage transmission congestion.

Flexible gas generation and storage can supplement existing capacity. Reciprocating engines, gas turbine combustion upgrades, and energy storage are technologies that can startup and provide power within two to five minutes, and shut down in less than one minute when no longer needed. Their value is in providing fast and flexible response capacity that serves a dual purpose to market operators, and a critical cost management purpose for plant operators. First, for grid scale solar and wind that typically earn less than $20/MWh in long term power purchase agreements, these fast and flexible resources can drive operating costs down and ensure greater reliability. Second, these resources respond in the 5-minute intervals needed for real-time market management for power or grid regulation. Lastly, reciprocating engine-based solutions allow plant operators to quickly cycle power production up and down without additional maintenance to the gas turbine which no longer must completely power off when demand is low; the reciprocating engine can reduce the need for maintenance downtime because the turbine is no longer required to start and stop to meet supply and demand fluctuations. In all, flexible gas generation technology such as reciprocating engines and gas turbine combustion technologies are essential assets because they provide predictable and responsive power to mitigate market volatility induced by high penetration of renewable resources. Reciprocating engines and gas turbine combustion upgrades provide fast, flexible response while minimizing capital and operational costs.

Benefit of Flexible Technology

Technologies that can easily integrate into existing infrastructure are cost effective means for market operators to ensure supply to meet demand. The fast response technologies discussed here – Wartsila's reciprocating engines, Powerphase Turbophase upgrade for gas turbines, Powerphase Fastlight compressed air energy storage to boost available gas turbine combustion air, and Energport AC Container to supplement gas turbines – all offer modular design and flexible sizing. Flexible generation technologies are the

[1]https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

conventional means of meeting real-time need for additional capacity and grid regulation. Until February 15, 2018, it was unclear whether energy storage resources could bid into and provide capacity and ancillary services. In a draft ruling on February 15, the Federal Energy Regulatory Commission (FERC) clarified that electric storage resources can participate in the capacity, energy, and ancillary service markets.
Small and nimble technologies, such as Wartsila Flexicycle, Powerphase Turbophase, Powerphase Fastlight, and Energport AC Container Series L500 L2000, offer modular solutions to meet demand without additional infrastructure investment. These solutions have a small footprint and are easily installed where needed, whether at an existing power plant (Turbophase and FastLight) or on a standard utility distribution circuit (AC Container Series L500 L2000). All these solutions can be scaled to meet capacity needs. The Flexicycle solution is comprised of a mix and match of reciprocating engines and gas turbines of varying capacity, that can be individually cycled and dispatched to flexibly meet demand.

Turbophase is a scalable solution that tailors its gas turbine boosting system to fit plant operator goals, and Fastlight increases overall power plant and grid efficiency because the turbine keeps operating at low power during off-peak periods to compress air that will be used to boost its responsiveness and capacity during peak periods. AC Container Series L500 L2000 offers 500 kWh to 3000 MWh per module, that enables flexible grid operation by charging during off-peak periods and dispatching during peak periods or for system regulation.

Ratepayer Value

The energy generation and storage solutions discussed here can help utilities and market operators meet energy demands while stabilizing ratepayer costs and meeting public policy goals of incorporating more renewable generating capacity and minimizing new transmission investments. Considering the capital cost of a conventional natural gas peaking plant, reciprocating engines and energy storage enable greater grid efficiency, faster development timeframes, and ease of integration that provides a winning solution for ratepayers.

Maximizing Grid Efficiency

Utilities can create better value for their customers, or ratepayers, by investing in fast and flexible generation today, to enable renewable generating capacity in the future. Fast response, small, and modular technologies provide a cost-effective means to develop a flexible, yet stable power market and grid. By upgrading their existing generation with reciprocating engines or energy storage, plant operators can improve grid efficiency and responsiveness. More renewable generating capacity becomes a dispatchable resource with reciprocating engines or energy storage to optimize its operations, minimizing the intermittency of renewable resources. Reciprocating engines and energy storage also optimize gas turbine operations. Reciprocating engines boost gas turbine output during peak periods. During off-peak periods, gas turbines no longer cycle down or completely turn off if they have energy storage. The gas turbines can continue operating, storing the excess power in energy storage, and no longer being subject to frequent start conditions that can wear on the turbine's parts.

Enhancing grid efficiency today with flexible resources is a proactive measure to mitigate renewable resource intermittency and prepare power grids for the renewable energy future. By maximizing grid efficiency and optimizing performance today with fast and flexible resources, utilities can ensure the ability to quickly respond to volatile renewable generation power output. With a considerable built in buffer against volatility, utilities can invest in and deploy significantly sized wind and solar installations. In the long run utilities can pass significant operational savings, due to investing in and operating renewable generating capacity, on to ratepayers. Levelized costs of electricity generated by wind and solar continue fall due to material improvements, production tax credits, and nonexistent fuel costs.

Support Policy Goals

Regulators across the U.S., reflecting ratepayer opinion, are calling for utility investments that enable a resilient, reliable, lower cost, and clean energy future. Today's investments can create a platform to support the integration of more renewable resources. Reciprocating engines, gas turbine optimization and energy storage help utilities meet these goals as a cornerstone of fast and flexible power generation. They flexibly scale and ramp to compensate for renewable resource intermittency and consequential fluctuation in power supply to meet market demand. And finally, they can be installed wherever they are needed in a utility network, to provide power where needed or to provide ancillary services to manage distributed energy resources. Utilities can use these technologies as a cost-effective means of meeting long-term policy goals and serving their customers.

Technology Specifications

Wartsila Flexicycle Power Plants

Wartsila's reciprocating engines provide flexible solutions to managing and dispatching power. A Wartsila Flexicycle power plant is based on gas or multi-fuel internal combustion engines (ICEs) and a steam turbine combined cycle. It has two operation modes: dynamic simple cycle that has more than 50% electrical efficiency, and highly efficient combined cycle of more than 54% electrical efficiency. The Flexicycle power plant solution's two-in-one characteristic makes it a very competitive solution for taking care of a grid system's intermediate load. The Flexicycle power plant can provide baseload generation and can ramp up in less than 5 minutes to provide fast synchronization. With the flexibility of multiple independent units, it can power up or down one or several at a time, to meet daily load fluctuations in electricity markets that have significant renewable generation capacity or other non-dispatchable power.

Powerphase Turbophase

Turbophase boosts gas turbine performance because it is 30% more efficient than traditional axial flow compressors at compressing ambient air. Turbophase uses a natural gas or diesel reciprocating engine to drive a two-step process to perfectly prep air for a gas turbine combustor. The reciprocating engine drives four to five stages of centrifugal compression to cool the air, which then passes through a heat exchanger that heats it with the engine's waste heat. Prepping air for the gas turbine combustor is critical to optimizing system performance. Traditional gas turbine systems lose efficiency at high elevation and on hot days because the ambient air gets thinner under these conditions. The traditional axial flow compressor can't compress thin air to meet optimal temperature and pressure feed to the combustor unit, so the amount of power produced by the generator decreases. Turbophase restores system performance because it can compress thin ambient air to meet system needs and maintain generator output. A Turbophase system aggregates compressed air from 1-10 Turbophase compressor modules and feeds it via a stainless-steel header pipe to the gas turbine combustion wrapper. The modules are 32'L x 8'W x 18' tall with water or air cooling components that are stacked on top, and fully integrated to receive fuel diesel or gas and cooling water from the plant. Auxiliary power load for a Turbophase module is small; 35 kW for each water-cooled compressor module and 135 kW for each air-cooled module. The modules are installed on a concrete foundation, located up to 1 km from the power plant. Turbophase systems include a Turbophase control system enclosed in a 20'L shipping container. The Turbophase control system consists of the Turbophase Master Controller (TPMC), which manages each module's controller and integrates with remote HMIs in the plant control room. Because Turbophase systems are powered by reciprocating engines, they can come on in less than 5 minutes from a cold start or in seconds if they are powered up and venting the air to atmosphere. This makes the Turbophase system ideal for filling in gaps when renewable energy drops off, optimizing power grids with fast responding flexible gas generation at combined cycle heat rates.

Powerphase FastLight

FastLight is a compressed air energy storage system (CAES) that deploys compressed air to add power to a gas turbine. It optimizes the efficiency of its compression process by using the gas turbine power to compress air when demand is low. The compressed air is stored in above ground tanks and dispatched to the gas turbine as needed to support renewables or take advantage of price anomalies. Fastlight benefits the gas turbine by allowing it to reduce its minimum load, thus supporting renewable integration and related market volatility. With Fastlight, gas turbines can quickly ramp from minimum load to dispatch power to the grid and quickly ramp down when no longer needed, using their excess power to compress air to be used when the gas turbine is dispatched to the grid again. This cycle – of ramping the gas turbine up and down, using excess power during system off-peak periods to compress air, and then using the air for power generation – increases gas turbine efficiency and market efficiency. FastLight systems have a 30-year useful life, further lowering life cycle costs and environmental impact compared to batteries that need to be replaced and disposed of every 7-10 years.

Energport

AC Container Series L500 L2000 is a utility scale energy storage system that provides a plug-and-play, single container, highly integrated AC block of lithium iron phosphate (LFP) cells. The containers are 40'L x 8'W x 9.5' tall, and scalable from 500 kWh to 3 MWh. The containers are easily integrable into a standard utility distribution connection at 60 Hz, with a no-screw connection for high reliability and low connection resistance, as well as a web-based real-time power monitor. With an aluminum package and aluminum silicate fiber cotton separator, the containers have low arc hazard risk. The AC Container Series L500 L2000 has a 15-year design life and 10-year warranty. These containers enable utilities and market operators to load shift at specific times, reduce peak demand, and establish a reliable back-up system for mission critical energy demands.

POWERPHASE®
GENERATION SMART

info@powerphase.com

Produced by **Peter Perri**
Senior Partner
peter.perri@galtfox.com

GALT FOX
Growth through Digital Advantage®