Gas Turbine Microgrids:

Reliability and Sustainability through Intelligence

Courtesy Solar Turbines

brought to you by Solar Turbines
A Caterpillar Company

Chapter 1

Overview: How Gas Turbine Microgrids Provide System Intelligence

Movement is afoot worldwide to bring new intelligence to conventional or 'dumb' generation. The gas turbine microgrid is central to this smartening of power generation.

The term dumb generation describes the kind of conventional power plants, wind turbines or solar panels that have been used for decades. They produce megawatts, but do nothing more.

In contrast, intelligent generation systems not only produce megawatts, but also determine how and when to apply the megawatts to achieve a specific effect. The generators gain this intelligence via software controllers.

Such intelligence is at the heart of the contemporary microgrid. It offers a way to derive maximum efficiency and cost savings from energy production while lowering emissions.

In this guide, "The Gas Turbine Microgrid: Reliability and Sustainability through Intelligence," we look at several ways gas turbines contribute to the intelligent functioning of microgrids. We describe how they act as the backbone or anchor for system efficiency, particularly when paired with renewable energy. We feature real-world examples of gas turbine microgrids in North America, Europe and Australia.

When passing clouds halt solar generation or the wind ceases to move wind turbines, gas turbines instantaneously ramp up to keep the electricity flowing.

Why gas turbine microgrids now?

Converging market and societal forces make this the age of the gas turbine microgrid. More than half of the microgrids planned in North America intend to use some form of gas, according to a 3Q2016 microgrid report by GTM Research. Why?

First, natural gas is plentiful and its pricing has remained historically low in the United States, the fastest growing market for microgrids.

Second, gas generation is an effective companion to the growing amount of renewable energy that utilities and others are adding to power grids worldwide. When passing clouds halt solar generation or the wind ceases to move wind turbines, gas turbines instantaneously ramp up to keep the electricity flowing.

Contents

Third, gas offers a sounder environmental choice than coal or oil-fired generation. Natural gas produces less carbon emissions. Biogas is even better from an emissions standpoint. It offers a 100 percent renewable, carbon footprint free fuel that channels landfill and agricultural emissions to good use.

Fourth, natural gas is typically transported below ground making it less vulnerable to storms and supply disruptions due to road closures that are common during major grid interruptions.

The gas turbine is the anchor of many microgrids," said Daniel Fingleton, program manager for strategic growth and special projects at Solar Turbines. "If the plant has the ability to island, which essentially makes it a microgrid, the gas turbine is a critical part. It is key to load control, frequency control, voltage control. It is the heart behind the microgrid. "

Pairing CHP and renewables

Many of these gas turbine microgrids employ combined heat and power (CHP) systems. A highly efficient, clean technology, CHP is especially common in microgrids that serve colleges, hospitals, the military, industrial plants or others that need not only electricity but also large amounts of heat, hot water or steam.

More than half of the CHP plants in the U.S. use gas, according to the U.S. Department of Energy. This may be natural gas or a renewable form of gas, such as digester gas, landfill gas and gasified biomass or municipal solid waste.

Also called cogeneration, CHP is often extolled for its two-for-one fuel advantage. CHP derives twice as much energy from the same amount of fuel as does a conventional power plant. It does this by using the waste heat created in generating electricity. The heat would otherwise be discarded. But instead the waste heat may be used for a variety of purposes, such as heating buildings, warming water, powering industrial processes as steam, or providing air conditioning via an absorption chiller or steam turbine-driven chiller. Electric chillers can be deployed off peak and then the produced chilled water can be stored, allowing a reduction in peak load demand -- and providing a way to balance intermittent wind and solar.

It's particularly interesting to look at how well CHP pairs with renewable energy. The efficiency CHP achieves in this circumstance defies conventional ideas about how gas turbines work.

Typically, a gas turbine—one that's not part of a CHP system—operates at highest efficiency when it is producing the maximum amount of megawatts possible. So, a 15-MW gas turbine, by way of example, most efficiently uses fuel when it produces 15 MW.

But it's different when the turbine is part of a CHP system. The CHP plant can run at a lower production level, generating less than 15 MW, and still achieve very high efficiencies. This is because in a CHP system the fuel isn't just producing electricity; it's also creating usable waste heat that serves buildings within the microgrid's footprint.

"Most people think that at reduced load a turbine is not efficient. That is a fallacy when it is also serving a thermal load," said Chris Lyons, power generation program manager at Solar Turbines. "Even if you reduce the output of the gas turbine, the overall efficiency of the CHP plant remains very, very high."

Why is this important?

Today's advanced microgrids often include multiple forms of distributed energy. Renewable energy is increasingly one of those forms. When CHP technology is also included in the microgrid, the system becomes highly agile in managing renewable energy intermittency —the problem of a sudden drop off in energy production when the wind doesn't blow or the sun doesn't shine.

CHP is especially good at overcoming intermittency by offering what is called spinning reserve — generation that is not used but ready to go at a moment's notice.

"Consider a scenario where you install a 15-MW gas turbine in a microgrid that also has 4 MW of solar photovoltaics. Say you typically only need 11 MW of generation from the gas turbine. You hold the other 4 MW in reserve as a spinning resource. If a cloud comes over, and your solar panels stop generating, you can instantaneously crank up the gas turbine to make up for the 4 MW loss," Lyons said.

These microgrids are typically designed so that renewable energy is the first fuel. They will use, for example, the maximum amount of solar generation that the system produces before employing other forms of generation. This makes sense since the sun is a free — and an emission free — fuel. But solar generation can't always be counted on, so the gas turbine acts as the backbone of the system, always there and operating and ready to step in to deliver reliable power when the solar energy disappears, due to cloud cover or sunset.

Given the efficiency and versatility CHP provides, it's not surprising that it is used within a large number of grid-connected microgrids. For example, GTM Research says that CHP accounts for 80 percent of operational university microgrid generation.

(For more information on CHP in microgrids, see our earlier white paper, "The Energy Efficient Microgrid.")

The thinking microgrid

This ability to manage renewable variability is one of several ways microgrids bring intelligence to what would otherwise be dumb generation. The intelligence comes by way of software-driven systems known as microgrid controllers.

Controllers vary in their intelligence. Some provide simple functions such as basic dispatch of heat and electricity use within a microgrid. Others offer highly advanced management. Moment by moment these master controllers continuously configure all of the various resources available to the system — possibly natural gas generators, solar, wind, energy storage, thermal energy, diesel engines, grid power, building load. The controller determines what combination of resources to use, and when, to best meet customer goals. The customer might want to achieve best price, low carbon emissions, high electric reliability, renewable portfolio standards, or some other goal.

Adding intelligence allows a microgrid to employ a range of services, among them:

- **Demand response**
- **Frequency control and other ancillary grid services**
- **Management of intermittent resources, such as wind and solar**
- **Price arbitrage**
- **Black start capability**
- **Carbon management**

The controllers also manage the microgrid's islanding function, its ability to detect disruption on the central grid and automatically separate itself, so that its customers do not fall victim to a grid power outage. The microgrid then relies on its on-site generation to keep power flowing to local customers. Advanced controllers do this automatically and autonomously, with no human interaction, and no disruption to the customer's service. The same seamless transition occurs when the microgrid reconnects to the grid after the power outage ends. The customer is unaware of any change.

About this report

We wrote this report to provide real-world insight into how gas turbine microgrids create reliability and sustainability through intelligence. We believe this report will be especially helpful to universities, hospitals, military facilities, manufacturers and others who are considering installing microgrids. It also offers insight for utilities partnering with customers to develop microgrids, or installing microgrids to help integrate renewables and bolster their distribution systems.

The report is a collaboration of Microgrid Knowledge, the leading microgrid news and information site, and turbine manufacturer Solar Turbines, a Caterpillar subsidiary.

Solar Turbines offers a depth of experience in gas turbine and microgrid installation. The California-based company has installed more than 8,000 generation units worldwide, in various environments, many with islanding capability. Solar Turbines has been at the forefront of incorporating intelligent control into gas turbines. The technology can monitor, control and optimize not only the gas turbines within the microgrid, but also its other generators, equipment and load.

Chapter 2

From Electricity to Guinness Stout with a Gas Turbine Microgrid

Environmental futurist Amory Lovins famously said that people don't want kilowatts of electricity; they want the byproducts: a cold beer and a hot shower.

St James's Gate Brewery in Dublin, Ireland, offers an opportunity to see exactly how those kilowatts of electricity become cold beer with the help of an intelligent gas turbine microgrid.

Founded in 1759 by Arthur Guinness, the brewery has produced Guinness stout for more than 250 years. It is now run by Diageo Ireland, a prominent Irish food and beverage company, with annual exports of more than $835 million.

When the 15-MW microgrid senses a disruption on the grid, it not only separates the brewery from the grid, but also begins serving two nearby businesses: Digital Hub, which is the largest cluster of digital companies in Ireland, and the Guinness Store House, one of Ireland's most popular tourist attractions.

The brewery receives 100 percent of its electricity and steam via a gas turbine microgrid that incorporates a combined heat and power system (CHP). The microgrid runs connected—"in parallel"—to the grid. It exports about 40 percent of its power to the grid, and can also take up to 5 MW from the grid.

Fueled with natural gas, the facility provides several examples of multi-tasking microgrid intelligence. During outages it goes into island mode to keep the electricity flowing. The microgrid uses CHP to increase system efficiency, and has remote monitoring as a double layer of protection to signal system trouble.

When the 15-MW microgrid senses a disruption on the grid, it not only separates the brewery from the grid, but also begins serving two nearby businesses: Digital Hub, which is the largest cluster of digital companies in Ireland, and the Guinness Store House, one of Ireland's most popular tourist attractions.

By islanding the brewery and businesses, it protects them from experiencing the grid outage. Instead, they

The gas turbine microgrid is crucial to the operation of the brewery given the high production loss the brewery faces from power outages. If the brewery goes down, it takes 12-24 hours to get the manufacturing process fully operational again.

rely on the microgrid's generators until grid power is restored. The microgrid uses three advanced Taurus™ 60 gas turbines, each 4.8 MW.

"If there is grid disturbance the whole brewery and CHP go into island mode. In that mode, the turbines go into frequency control or speed control and match the site load exactly. That happens four or five times a year," said Ronan Nevin, CHP plant manager for Gatepower, a subsidiary of Veolia Alternative, which owns and manages the energy center at the brewery.

The gas turbine microgrid is crucial to the operation of the brewery given the high production loss the brewery faces from power outages. If the brewery goes down, it takes 12-24 hours to get the manufacturing process fully operational again.

"As the site is located in the center of Dublin city, the risk of accidental damage to the electrical grid due to road works etc. is higher than, for example, a new industrial estate on the outskirts of town," Nevin said.

Relying solely on the CHP plant has proven to be a good bet for the brewery. The plant has run continuously with no unplanned shutdown since it was installed in 1997.

The brewery requires roughly 5 to 8 MW to operate during normal operations. Typically, two turbines operate, while a third is on hot standby, said Nevin. If the system trips, the third turbine starts up automatically to keep power flowing reliably.

A remote monitoring system warns the plant operators of any disruption so that they can respond quickly. A manager in the Netherlands provides remote monitoring and tracks the alarms and notifies Gatepower so that they can work out any issues. The microgrid also has on-site engineers tracking reliability, so the remote monitoring system serves as a double safeguard.

The microgrid's electric reliability is only half of the equation. The brewery also relies on the CHP system for 100 percent of the steam heat used to brew the beer. The temperature of each brew must be carefully controlled. An interruption in steam pressure could mean loss of the batch of beer being processed. The CHP system, which includes three 27-tons/hour steam boilers, has proved reliable, and no back-up steam source has been necessary.

Because of its high efficiency, the gas turbine microgrid helps Ireland meet the European Energy Efficiency directive, a set of binding measures to help the EU reach its 20 percent energy efficiency target by 2020. (The EU is considering increasing it to 30 percent.)

"The Guinness brewery is an excellent example of the value that this kind of microgrid intelligence brings to an industrial operation," said Chris Lyons, power generation program manager at Solar Turbines. "The brewery and neighboring businesses gain energy reliability, while the grid receives additional electric capacity. Everyone gains from the plant's high efficiency because it results in lower carbon output and greater sustainability."

Chapter 3

Gas Turbine Microgrids on Two Continents: Mirror Images of Reliability

One of the benefits of a microgrid is the ability to 'island' electrical operations from the surrounding grid.

In Sitka, Alaska, the grid is always islanded. The city is the grid, and the city—the largest in the United States in terms of area—occupies most of Baranof Island.

Baranof Island is not electrically connected to the mainland, so all the power for Sitka's roughly 9,000 inhabitants is produced locally. The power comes from two hydroelectric plants, which give this city on Alaska's pristine Panhandle the distinction of deriving nearly 100 percent of its energy from renewable resources.

Hydropower may be the most reliable and least intermittent of renewable resources, but no power source is perfect. And on an island grid that is an important consideration.

Occasionally a tree or a tree limb falls on an electrical wire and trips off one of Sitka's two hydropower plants. When that happens—and it is not an infrequent occurrence—Sitka's gas-fired turbine kicks in.

Sitka ordered the gas turbine from Solar Turbines, a Titan™ 130 modular power plant, back in 2013 when it was facing a growing need for electric power. Back then, oil prices were on the rise, and customers were switching from fuel oil to electric heat. To meet that demand, the city embarked on a project to raise the height of its Blue Lake Dam by 83 feet to impound more water and to raise the electrical capacity of the hydropower plant by a little over 50 percent. The city added three hydropower generators, increasing Blue Lake's capacity by about 16 MW.

While the Blue Lake expansion project was under way, Sitka used the gas turbine to fill in as a power source. Because of its high inertia, a gas turbine is capable of adapting to large on-load and off-loads. That enabled Sitka's gas turbine to provide reliable, stable, and continuous power while the hydroelectric plant was upgraded. When the expansion was completed, the gas turbine shifted into a back-up mode, providing electricity during power outages and emergency situations.

Since it was installed, the gas plant has logged about 100 hours of operation. The plant can provide up to 13 MW of electric power to Sitka and its residents, but more importantly, it provides black-start capability. When an unexpected event—such as a downed power line—trips one of Sitka's hydropower plants offline, the gas turbine turns on and provides frequency regulation and voltage control to stabilize the grid, which would otherwise be in danger of collapse.

In addition to providing critical back-up and black-start capability, the plant also is a good fit environmentally. Sitka is in the Tongass National Forest, the largest temperate rain forest in the world, and exhaust emissions are a critical concern.

The Solar Turbines plant uses a lean premix combustion system, SoLoNOx, for its turbines, in which the fuel is burned with a surplus of air, producing less nitrogen oxide. That also helps reduce the plant's footprint because it eliminates the need for selective catalytic reduction (SCR)emission control technology.

Mirror image in Australia

On the other side of the globe, the City of Esperance, Australia, also operates in isolation. It is not on an island, but it might as well be. The city sits on the south coast of Western Australia State, but is not connected to the grid.

Esperance is also the home of Australia's first wind farm. The Salmon Beach Wind Farm began operating in 1987, but was decommissioned 15 years later because of urban encroachment. It was replaced by the Ten Mile Lagoon and Nine Mile Beach wind farms. Together they can provide nearly 25 percent of Esperance's electricity.

Unlike hydropower, however, wind power is not reliable. The primary source of power in the region, an area that extends about 80 miles from the city, comes from gas turbines, the 38.5-MW Esperance Power Station.

Unlike hydropower, however, wind power is not reliable. The primary source of power in the region, an area that extends about 80 miles from the city, comes from gas turbines, the 38.5-MW Esperance Power Station.

The Esperance Power Station comprises seven Solar Turbines Taurus™ 60 gas turbines generators.

"We operate 24/7," says station manager Craig Bowen. "We run a minimum of two and up to six units in the summer," he says. "On a typical day, we run two sets overnight and then, to cope with the peak loads, one or two additional generators will start, depending on the wind output."

The gas turbines are the "backbone" of the Esperance grid, says Bowen. They also are a mirror image of the role the gas turbine plays in Sitka, which runs only when needed.

In Esperance, the gas turbines are baseload and play a supporting role for renewable power. "The wind farm is set up to run uninhibited at all times to get the most out of the wind," but it is always backed up by a gas turbine, says Bowen. And, as he notes, the wind power lowers overall system costs by reducing the amount of gas needed to run the turbines.

Chapter 4

Microgrid Gas Turbines: A Prescription for Sustainable Energy

When Seton Healthcare Family was planning the Dell's Children Medical Center in Austin, Texas, reliability was an imperative, but they did not want it to come at the cost of their sustainability goals.

In a medical care facility, both objectives are primary. Losing electrical power for critical services or during an operation is not an option. But holding down costs and providing a healthy environment for patients, staff and visitors is also important.

To meet both needs, Seton chose to power their new facility with a combined heat and power (CHP) plant that would not only provide power, but also capture waste heat from the combustion process to provide district heating.

Seton Healthcare Family chose to power their new facility with a combined heat and power (CHP) plant that would not only provide power, but also capture waste heat from the combustion process to provide district heating.

The CHP plant, known as the Mueller Energy Center, is owned and operated by Austin Energy, the local municipal utility. It was built on a 3-acre brownfield site, an old municipal airport, and scaled to meet Dell's energy needs.

At the heart of the CHP plant is a Solar Turbines 4.6-MW Mercury™ 50 gas turbine generator. The waste heat from the turbine is recycled in a heat recovery steam generator to produce 22,000 pounds per hour of steam and chilled water from a 900-ton Trane two-stage absorption chiller. Adjacent to the CHP system are two centrifugal chiller plants, standby steam boilers, and a thermal energy storage tank. The energy center also includes a 1.5-MW backup diesel generator with black-start capability.

If there is an outage or an interruption in grid electrical service, the gas turbine microgrid can continue to run, providing all of the hospital's needs for power, steam and cooling, an important consideration in July and August in Austin.

The ability to island its electrical service was an important consideration for Seton. It allows the hospital to continue to operate if there is a grid failure. During a disaster, the hospital becomes a place of refuge and a center for medical care.

According to one study, the probability of failure for a traditional hospital grid-plus-backup system is 67%. Having the Mueller Energy Center flips that equation for Seton.

The gas turbine microgrid, in fact, provides more energy than the medical center needs. "We actually export power," said Barrett Story, a supervisor at Austin Energy and the operator of the Mueller Energy Center.

"The gas turbine is the primary source of power for the hospital, but it doesn't run by itself," Story added.

The hospital is backed up by two electric feeds from different substations in the surrounding power grid. Excess electricity from the energy center is exported back to Austin Energy's grid, and excess chilled water is distributed to a half-dozen other nearby facilities.

With such a robust gas turbine microgrid able to meet such a range of needs, it might be easy to lose sight of Seton's other goal. But the use of a CHP facility was critical for meeting Seton's sustainability goals.

The rationale of a CHP plant is that it derives maximum efficiency from a single fuel. It burns gas to make steam to turn a turbine and run a generator and, rather than exhausting the steam, captures it for use as steam—for sterilization in the hospital for instance—or to produce more electricity.

"Designed by Austin Energy, the CHP facility provides power and thermal energy for the hospital. For the larger community, the microgrid assures medical services will be in place during a crisis. And all of this comes from a sustainable, clean energy source."

– Daniel Fingleton, Solar Turbines

The gas turbine at the heart of the system is the key to meeting those goals. It is highly efficient, with a heat rate of 6,700 British Thermal Units per kWh. According to the Department of Energy the average heat rate for a gas turbine fired by natural gas in 2015 was 11,302 BTU/kWh. The gas turbine also has low emissions, less than 5 parts per million for nitrogen oxides, without the need for exhaust flue injections, according to Story.

Compared with Austin's overall fleet average, the CHP unit reduces CO_2 emissions by 47 percent. Compared with a typical coal plant, it cuts carbon dioxide by 72 percent and can reduce sulfur dioxide emissions by as much as 99 percent.

The emissions profile of the gas turbine at the center of the CHP plant was one of the reasons cited for achieving the maximum 10 points allowable under a U.S. Green Building Council credit system for green buildings, which in turn allowed the Dell Children's Medical Center to become the first hospital in the world to win a Leadership in Energy & Environmental Design (LEED) platinum certificate.

"This is an excellent example of how a utility, Austin Energy, can partner with a customer to capture multiple benefits from a gas turbine microgrid," said Daniel Fingleton, program manager for strategic growth and special projects at Solar Turbines. "Designed by Austin Energy, the CHP facility provides power and thermal energy for the hospital. For the larger community, the microgrid assures medical services will be in place during a crisis. And all of this comes from a sustainable, clean energy source."

Chapter 5

Modeling Efficient Energy Management for the Next Generation

The University of Missouri (Mizzou) has been able to reduce its coal consumption by 73 percent through use of highly efficient and sustainable microgrid technologies—moving it significantly toward its carbon reduction goals.

The college's efficiency achievements are in keeping with its long history of energy innovation.

Mizzou's full service energy center has evolved since the late 1800s when Thomas Edison donated one of his earliest steam turbine driven electric dynamos (DC generator). When MU illuminated Academic Hall in 1883, it was one of the first demonstrations of incandescent light west of the Mississippi.

Today, the large and complex microgrid serves a 15-million square-foot campus in Columbia, MO with a campus population of more than 34,000 students.

The 66-MW energy center employs four coal-fired boilers, a 100-percent biomass-fired boiler, four steam turbine generators, a dual-fuel oil and gas-fired boiler, and two Solar Titan gas turbines with heat recovery steam generators and sophisticated controls. The power plant campus experienced a summer peak electric load of about 50 MW and has a winter peak steam demand of about 330,000 lbs/hour.

The microgrid is interconnected with the local municipal utility through a 69-kV tie line, and leverages favorable wholesale market prices through MISO when possible. When grid prices are high, the university relies more on its on-site power generation. This interconnection also allows MU to contract for renewable energy generated off site such as wind and solar.

Evolving microgrid

As the plant was gradually modernized over the years, it gained various microgrid capabilities. "We didn't one day sit down decide to become a microgrid; we evolved into a microgrid," said Harry Frank, managing engineer of power plant operations, energy management.

Two pivotal additions over the last 15 years significantly increased its efficiency, intelligence, response time and environmental footprint.

First, the campus installed two 12.7-MW Solar Titan gas-fired turbines in 2002, which included controls that allow for islanding during disruptions on the central grid.

The gas turbines allow quick load following dispatch—the generators can be brought on line within a matter of minutes when a need arises, Frank said. The turbines' software intelligence allows for frequency control of the on-site generation fleet when the system goes into island mode.

Highly efficient use of fuel

The natural gas turbines offer an example of highly efficient use of fuel. They not only generate 12.7 MW each, but also produce high-temperature exhaust gas that is channeled into waste heat boilers. That high pressure steam (900 psig) supplements the other boilers that produce steam to drive the steam turbine generators, producing additional power. This means more electricity from less fuel, the hallmark of energy system efficiency.

The university extracts low pressure steam (60 psig) from the steam turbines and delivers this thermal energy to campus for heating campus buildings, producing domestic hot water, chilled water production for air conditioning, and various campus operations. These include the university health center, athletic facilities, student recreation center, research reactor and food service.

The second major upgrade to Mizzou's plant occurred in 2013, when it added the biomass combined heat and power unit. The unit not only offers the customary efficiency of CHP—making the most of fuel by co-generating both electric and steam—but also offers the opportunity to leverage the benefits of renewable energy. The campus now receives more than one-third of its energy from renewables, primarily from the biomass plant along with a wind power purchase agreement.

The sophisticated campus microgrid can leverage fuel prices for best economics. But given the current small variation in biomass, coal and natural gas prices, the college is maximizing use of biomass to reduce carbon emissions. And it may expand the biomass use in the future to continue to further drive down emissions.

Sustainability is a priority for Mizzou. The university has signed on to American College and University Presidents' Climate Commitment, and is working toward achieving climate neutral¬ity by 2050. It has already cut a greenhouse gases by 51 percent over a 2008 baseline with the help of the campus microgrid.

An Education Tool

Because of its sophistication, Mizzou's microgrid has gained a national—even international reputation. Hundreds of visitors from around the world visit the campus to learn about how the energy center functions.

Even more importantly, the energy center acts as an educational tool for Mizzou engineering students. Reliability, efficiency and sustainability are the energy center's three tenants—but always in the context of the university's main mission—educating the next generation.

"Universities have been leaders in adopting gas turbine microgrid technology. And the University of Missouri stands out as a model among them demonstrating for engineering students—and everyone else—how this technology can help us move from less carbon-intense generation," said Chris Lyons, power generation program manager at Solar Turbines.

Chapter 6

What's next for gas turbine microgrids?

Gas turbine microgrids are growing in sophistication as microgrid controllers become more advanced.

Control technology featured in this report tends to accomplish such functions as islanding and frequency control.

Microgrids are rarely developed in a plug-and-play fashion. Instead, they often require a great deal of pre-installation study by an experienced and knowledgeable energy company.

More advanced controls—including those being developed by Solar Turbines—offer the ability to automatically leverage energy prices. They can calculate best pricing among on-site resources at any given moment or between the grid and the microgrid.

New advanced controllers also may leverage resources for lowest emissions, greatest use of renewables, reduction of grid congestion or system demand, or other variables.

The bottom line is that an advanced microgrid is ultimately a technology tailored to solve a customer problem. As a result, microgrids are rarely developed in a plug-and-play fashion. Instead, they often require a great deal of pre-installation study by an experienced and knowledgeable energy company.

"Microgrid control is a question of operating philosophy," explained Herman Snodgrass, Solar Turbines design engineer for microgrid control systems. "The more complex the system, the more we need a clear definition of the customer's control philosophy. Everybody does things a little bit differently."

Customer base changing and growing

Gas turbine microgrids are not only growing more sophisticated, but they also are finding a wider customer base. Early microgrid customers tended to be universities and hospitals. Today microgrids are increasingly being installed by cities and towns, data centers, manufacturers, business parks, stores and in a few instances, residential housing developments.

Electric utilities also are increasingly pursuing microgrids, either on behalf of their customers or to bolster their grid. AEP, Duke Energy, Exelon, National Grid and Pacific Gas & Electric are among the utility giants with microgrid development plans.

While utilities offer a large potential market of gas turbine microgrids, hurdles remain to their full market participation.

"A key problem is lack of regulatory clarity when it comes to utilities. Microgrids are not clearly defined in regulation," Lyons said. "Some policymakers describe them as generation, others as distribution or reliability assets."

As a result, it is unclear whether or not utilities can recover microgrid investments in their rates, especially in restructured states. "Until public utility commissions define microgrids and resolve this problem, many utilities may move slowly on microgrid investments," he added.

Other less conventional markets also offer promise for microgrid technology—these include ships, planes, offshore rigs and mines.

For example, an offshore oil rig that experiences a generation shortfall or disruption, might use microgrid controls to shed loads, so that its critical needs are met. The controller will turn off power to some lights or unnecessary living quarter services, so that it can keep load pumps functioning.

If the platform goes totally black, it faces a time-consuming restart process.

"You have to go start your diesel generators. You have to slowly bring everything back up. So, if they have an outage, it is huge. The first time our system spares them an outage, it pays for itself," Snodgrass said.

Gas turbine as microgrid backbone

The microgrid industry's growth depends on education, Lyons said. Many energy customers still do not understand the full capabilities of an advanced gas turbine microgrid, especially one that uses CHP.

For example, many are unaware of a CHP plant's spinning reserve capability when the unit is operating at partial load.

"They are still very efficient but also have the ability to provide quick dispatching power to offset the arrival of cloud cover over a PV plant, or other interruptions in renewable power supplies. At the same time, they provide valuable VARs (Volt Amperes Reactive), supporting the distribution system," he said.

Such quick response makes gas turbines a central part —a backbone—of today's advanced microgrid, added Daniel Fingleton, program manager for strategic growth and special projects at Solar Turbines. "They offer a bridge to more renewable energy and lower carbon emissions."

Microgrids are gaining traction worldwide. And as they do, expect to see growing use of gas turbines to serve them.

About Solar Turbines

Headquartered in San Diego, California, USA, Solar Turbines Incorporated, a subsidiary of Caterpillar Inc., is one of the world's leading manufacturers of industrial gas turbines, with more than 15,000 units including over 8,000 generator sets and over 2 billion operating hours in 100 countries. Products from Solar Turbines play a key role in a clean future and fulfilling our customers' needs for sustainable energy solutions.

Solar has a dedicated Power Generation product line focused to meet customer specific needs since 1960. These products are designed to provide ultra-high efficient energy exceeding 85%, in combined heat and power applications while ensuring a reliable and resilient power source with or without a utility grid.

Our Power Generation products serve a wide customer base. Applications range from high heat and power demands needed by universities and district heating systems, to those that have an intense need for reliable power like hospitals and emergency response centers.

Solar's foundation is people and Solar's culture is one where individual contributions are valued, diversity in the workplace is encouraged, and safety is emphasized in all aspects of the business. Solar Turbines is comprised of a dedicated and multi-talented workforce of more than 7,000 employees with decades of experience working as a global team.