“Advanced Microgrids” Provide Advanced Solutions

Photo credit: Wellspan York Hospital

Wellspan York Hospital, York, PA

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Introduction

Microgrids are sometimes viewed as a form of backup power or a boutique renewable energy project. Both of those views miss the mark and obscure the true benefits and value that can be derived from a microgrid, particularly an “advanced microgrid.”

Advanced microgrids can go beyond backup power and provide essential grid services, offering benefits on both sides of the fence—the customer side and the utility side—while enabling a more economical use of capital that can ultimately lower costs.

A microgrid has the ability to island; that is, it can separate from the local utility grid and continue to operate, even if the grid is out of service, for at least 24 hours.

First, though, it is useful to define a microgrid. As a baseline, a microgrid is an independently operable part of the distribution network, including distributed energy sources, loads and network assets that are controlled within clearly defined geographical boundaries and can operate in grid-connected or islanded mode. There is a lot of information packed into that definition. Looking more closely, one can discern several individual features that define a microgrid. For instance, a microgrid has the ability to island; that is, it can separate from the local utility grid and continue to operate, even if the grid is out of service, for at least 24 hours. A microgrid also has the ability to seamlessly re-integrate or synchronize with the grid.

The ability to island means that a microgrid has control equipment that can coordinate the distributed energy components within the microgrid to operate in an optimal fashion, balancing the needs of the load within the confines of the microgrid and, if warranted, the need for heating or cooling resources, as well as monitoring external conditions and the microgrid’s status with relation to the surrounding grid. Islanding also implies geographic continuity within a microgrid’s footprint, as well as proximity of generation and load within that footprint.

That defines a microgrid, but what distinguishes a microgrid as advanced? An advanced microgrid includes multiple distributed energy resources, such as low emission “always ready generation” coupled with PV charging system battery energy storage (BESS), PV/BESS providing DC power to EV charging stations, or fuel cells providing energy in high electrical price markets with low emission generation backup.

An advanced microgrid can also include features such as a cogeneration plant that provides both electricity and steam for heating or industrial process, or charging stations for electric vehicles. Some microgrids incorporate all of these features.

Just as important as the specific equipment, an advanced microgrid is also defined by the functions and benefits it can provide.

An advanced microgrid provides resiliency, sustainability and commercial viability. Most importantly, an advanced microgrid provides value to both the local utility and to the microgrid customer.

For a full understanding of the benefits an advanced microgrid can provide, it is important to understand the dynamics of the electric power grid. This is key to knowing the commercial viability of a microgrid.

It’s all about the curves

Demand for electric power is not steady. It fluctuates throughout the day and the year, and it varies by season. Those fluctuations can create problems on the grid.

Accumulated demand curve

This can be seen by graphing an accumulated demand curve (ADC). Over a single year, the demand curve is a relatively gentle slope with one exception. When demand is highest, the curve rises exponentially. These spikes are of short duration, but they are very steep. Typically, spikes occur only 40-300 hours per year. Spikes are driven by weather—the hottest afternoons and the coldest mornings—and we have all seen weather extremes intensify.

To use one example, the demand curve for load recorded by PJM ISO shows that the highest demand, nearly 35 gigawatts (GW), is concentrated into about 50 hours per year. Put a different way, nearly 22% of PJM’s load exists for less than 3% of the hours of the year. And, as the amount of renewable energy sources on the grid increases, that concentration of energy demand is going to grow. In effect, what happens on the hottest afternoon when the wind stops blowing or the sun goes behind a cloud?

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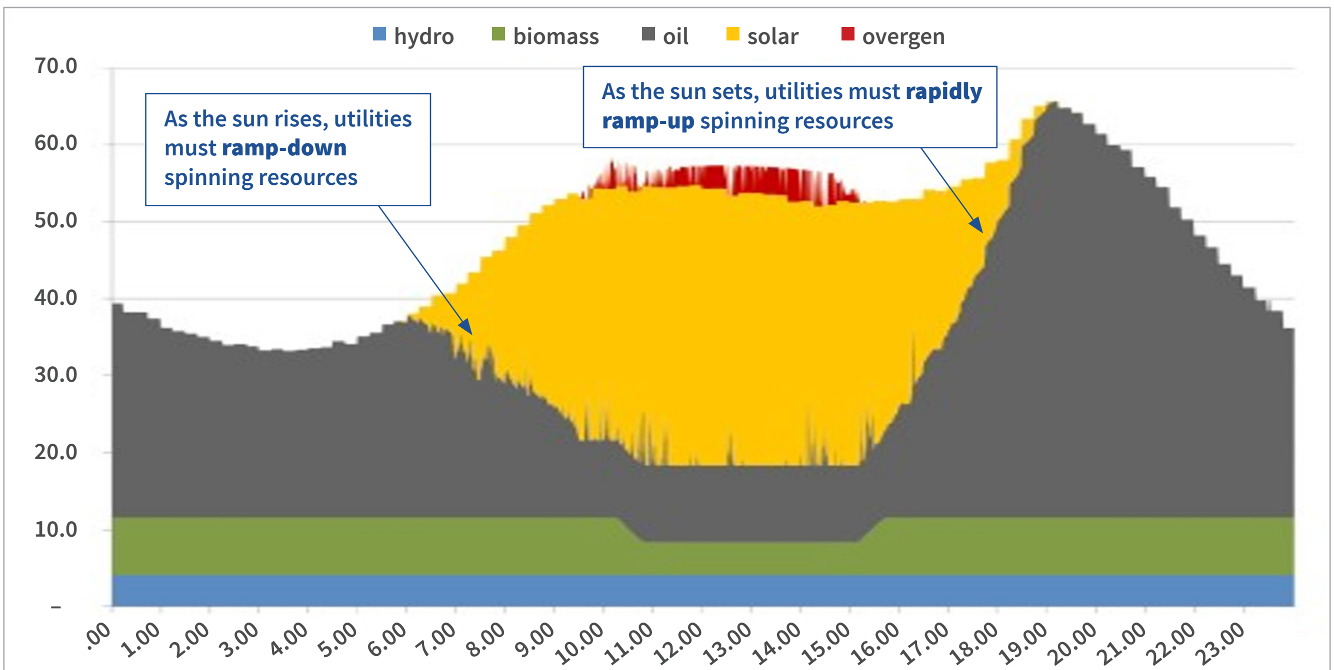
Utilities invest significant resources on the “exponential rise” portion of the ADC. So, those handful of hours represent the highest cost of power to both a utility and to the environment because that load is typically served by less efficient, fossil fueled generation.



Source: PowerSecure

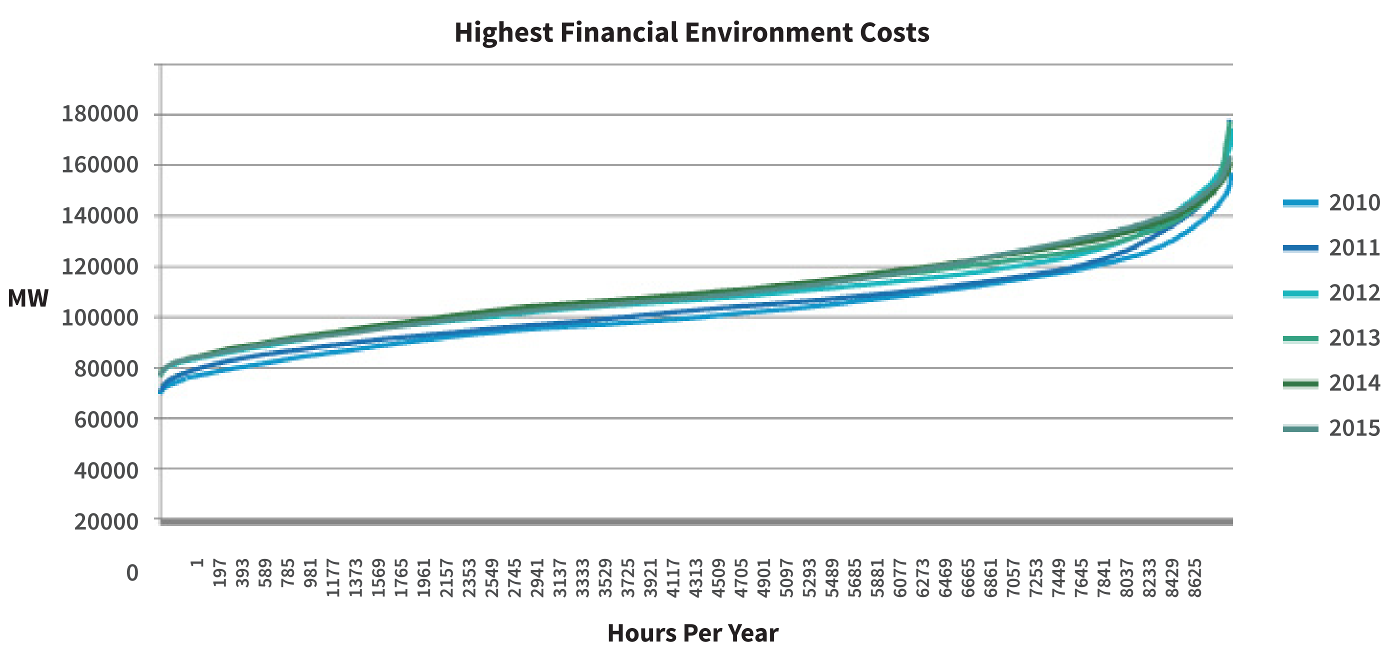
Microgrids are needed to address ramping, frequency/voltage control, non-spinning substitute for spinning reserve and overall power quality for end use customers

Duck curve

There is another curve that has become well known, if not infamous, in the power industry. It is the duck curve, so called because the curve resembles the body, neck and bill of a duck. It demonstrates the growing challenge utilities and grid operators face in the morning and evening when systems with a significant amount of solar power face an increase and rapid decrease in solar generation. In the a.m., utilities need to ramp down traditional generation and, in late afternoon, buy generation that can start or ramp up quickly.

Grid operators who do not appreciate these dynamics can pay a steep price for their lack of understanding. Germany launched its energy transition (Energiewende) in 2000. The program has been successful in promoting renewable energy. In 2000, only 6.6% of Germany's electricity came from renewables. By 2019, renewables' share of electricity production had reached 41.1%. That increase came at a cost, however. The average cost of electricity for German households has doubled since 2000, according to one report.

Germany is also falling behind its own carbon dioxide emissions reduction targets, according to consulting firm McKinsey & Co. And with its last nuclear plant scheduled to be phased out in 2022 and ongoing reductions in coal-fired generation, Germany is likely to face declining, and costly, shortfalls in reserve capacity and "will almost certainly" go from being a net electricity exporter to an importer, especially after 2023, according to McKinsey analysts.



Source: Bryan Knight, director of structured finance, PowerSecure

Creating extraordinary value

Understanding the ADC and duck curves that determine the dynamics of electricity markets is essential to knowing how an advanced microgrid can deliver value. From a utility perspective, an advanced microgrid can provide multiple functions. When renewable resources such as solar power are overproducing, an advanced microgrid can provide load by soaking up excess energy and using it to charge energy storage devices. Conversely, when a utility has a sudden need for energy, an advanced microgrid can provide ramping services in the form of rapid battery discharge or rapid response generation.

> “It has been my experience that in addition to such “duck curve mitigation’ services, an ‘advanced microgrid” can provide a utility with a non-spinning substitute for spinning reserves to provide superior peak load management services, including demand response and autonomous frequency control. These microgrids applied at the meter often result in deferring utility capital expenses for transmission and distribution upgrades.”
>
> - Mark Martyak

For a full view of the advantages of an advanced microgrid, it is important to understand that the benefits a utility can derive from an advanced microgrid can complement and underpin the benefits available to the microgrid customer.

An advanced microgrid is able to provide benefits to two broad classes of stakeholders — utilities and customers — by bridging the gap between their needs. Many microgrid customers have a sporadic, but specific need: providing backup power during an emergency or outage. Utilities have around-the-clock needs that can be costly to meet.

Microgrid Benefits

As discussed, many microgrid customers are looking for any one of three benefits, or some combination of those benefits, namely:

1. Reliability, including loss prevention and business continuity.
2. Sustainability in the form of higher available efficiencies and lower emissions levels.
3. Capital avoidance, for instance, by being able to defer or mitigate more costly utility services.

When utility value and customer value are combined, it creates the extraordinary value of an advanced microgrid. In more concrete terms, the potentially high capital costs of meeting a customer’s need for sporadic and infrequent backup power can be offset by an advanced microgrid available to meet a utility’s 24/7 needs.

An advanced microgrid can fulfill all these needs by using state-of-the-art technologies such as lithium-ion batteries with advanced controls and renewable fuel fired generators that are rated Tier 4 Final under Environmental Protection Agency (EPA) rules, which call for reduced levels of particulate matter and nitrogen oxides.

So, while an advanced microgrid is serving as a customer’s standby generator, it does not need to sit idle. It can be doing duty by providing grid services — autonomous frequency control or demand response services for the local utility.

Practical applications

Described in broad strokes, these descriptions may seem academic, but, over the years, PowerSecure has deployed several advanced microgrids that illustrate the practical application of these ideas and principles.

Neighborhood of the Future

Photo courtesy of Southern Company

In Alabama, PowerSecure deployed a project known as Neighborhood of the Future. It includes 400 kilowatts (kW) of natural gas-fired generation for always-available standby power, 330 kW of photovoltaic solar panels, and 360 kW, 825 kilowatt hours (kWh) of battery energy storage.

The project provides a neighborhood in the Birmingham suburb of Hoover with 100% resiliency and uninterruptable power in most grid situations. It also provides a compelling utility solution to residential resiliency without the need for individual generators or home battery storage systems, especially in lower economic neighborhoods where people cannot afford high-cost individual solutions.

Marine Corps Air Station

Photo courtesy of PowerSecure

In the Southwest, PowerSecure built a microgrid for Arizona Public Service to serve the Marine Corps Air Station (MCAS) in Yuma, Arizona. It provides 25 MW of clean, Tier 4 Final generation to back up this essential air base. The system was also designed to accommodate 25 MW of BESS, as well as 13 MW of solar power that is already underway.

The microgrid provides 100% resiliency to the base and has five operating modes. It can provide black start services if the air base or the surrounding grid goes down. The microgrid can island, that is, operate independently from the surrounding grid. The system can also export power and provide load management to Arizona Public Service, and, through Autonomous Frequency Response, the system can automatically adjust to frequency levels on the California Independent System Operator (CAISO) when there are undervoltage conditions at the base, such as when the sun goes behind a cloud and solar generation dips. The microgrid is also capable of operating in test mode without disruption to power supplies at the air base.

Because of the benefits the advanced MCAS Yuma microgrid provides to Arizona Public Service—including frequency control, peak load management and avoidance of capital expenditures for transmission and distribution upgrades in the Yuma area—the system was offered to the MCAS at zero capital costs.

Wellspan York Hospital

In York, Pennsylvania, PowerSecure provided a solution to Wellspan York Hospital, a Level 1 trauma center. Over the years, the hospital had accumulated a variety of backup generators of varying voltages as the facility underwent a series of expansions.

In its original attempt to enhance the hospital's reliability—its chilling and imaging functions had never been connected to backup generation—as well as modernize and unify its electric system, Wellspan would have had to make expensive investments in equipment such as distribution panels and wiring.

PowerSecure, however, was able to provide what a Wellspan administrator refers to as an "elegant connection." Instead of an expensive retrofit, PowerSecure was able to serve the entire hospital—including backup to imaging and chilled water operations for the first time—by building a microgrid that uses the hospital's normal distribution system.

> "PowerSecure's microgrid approach to hospital standby power generation enabled York Hospital to install 100% backup power, N+2 Redundancy and save over $2 million compared to bids we received on traditional standby power systems."
>
> – George Baker, director of engineering, WellSpan York Hospital

The microgrid added 7.5 MW of EPA Tier 4 Final clean diesel generation, 12.47 kilovolts of microgrid switchgear equipment, and a utility interconnection to Commonwealth Edison. The result is 12 generators that run on a common bus with double-ended substations, 100% standby power resiliency, including increased capacity to cover chilling and imaging, 24/7 remote monitoring and the ability to cut or defray costs by earning revenue from participating in the PJM Interconnection's demand response program.

Conclusion

All three examples illustrate and underscore that it is possible to find common ground between an end user and a utility when it comes to designing, building and deploying an advanced microgrid.

The key is understanding the dynamics of the modern power grid and how it is evolving.

Customers are looking for resiliency, sustainability and cost savings. Attempting solutions that are too narrow could mean that resources sit idle. Such underutilization erodes capital efficiency. Alternatively, those same assets could be used to provide valuable utility services, improving the economics of the grid while helping to support a cleaner environment for everybody.

Ultimately, both parties — customer and utility — are pursuing the same goals: higher reliability, higher resiliency and more environmentally beneficial operations. Advanced microgrids are a key part of reaching those goals.