

# The Role of Energy Storage in Smart Microgrids

**A**s discussion around development of a smart grid has steadily increased, so too has talk about smart microgrids. A critical ingredient for smart microgrids is energy storage. Energy storage can play a major role in facilitating use of renewable energy resources to power microgrids, while also protecting power stability and reliability within the microgrid. Energy storage technology has advanced significantly in recent years, and the latest technology holds many promising benefits for microgrid applications. In fact, these new energy storage technologies require a complete rethinking of what microgrids are capable of doing.

This paper will review the impact of energy storage on smart microgrids, and will also look at a few real-world applications of energy storage within a microgrid.

## The Challenges in Providing a Reliable Power Supply for Microgrids

The classic definition of a microgrid is a localized grouping of distributed electricity sources, loads, and storage mechanisms which can operate both as part of the central grid or independently as an island. One of the biggest benefits a microgrid can provide, particularly one that can operate either as part of a central grid or as an island, is improved reliability. However, this reliability is predicated on the microgrid's ability to offer a seamless supply of local electricity.

Traditionally, diesel generators have been the power source of choice for powering microgrids. But recent events, such as Hurricane Sandy, have exposed vulnerabilities in relying on diesel generation. Diesel generation can be susceptible to fuel supply disruptions. In the case of Hurricane Sandy, widespread infrastructure damage from the massive storm created extensive fuel shortages, which meant that backup generators could not be easily refueled and operations often had to be curtailed.

In a situation such as this, distributed renewable energy sources, including wind turbines and solar photovoltaic panels, can provide a more reliable source of electrical generation. As renewable resources have become increasingly practical as a distributed energy source, they offer an important alternative that is far less vulnerable to disruption from problems on the grid such as downed power lines, flooded power equipment, or fuel supply disruptions. And with today's growing interest in "green" systems, renewables are fast becoming the preferred choice over diesel generators for powering microgrids.

## Smoothing Power Flow

Yet renewable resources alone provide only a partial solution to the problem of ensuring local generators can meet demand should centralized generating plant supplies be disrupted. The intermittent nature of renewables like wind and solar energy means these resources can't always provide continuous, or sufficient, power generation to support loads. In the case of wind turbines, wind speeds can vary, impacting output. Solar collectors are impacted by cloud cover and can only produce power during daylight hours. Moreover, because of fluctuations in output from both wind turbines and solar systems, they are not always capable of delivering a clean wave form, which can impact power quality.

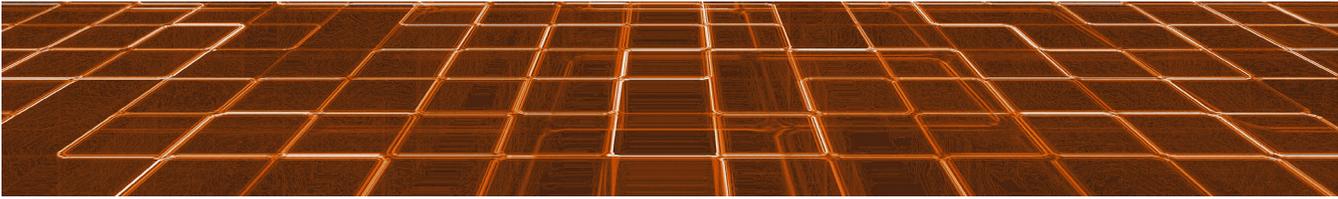
All power systems also require the capability to balance, in real time, differences between load demand and generator output. This balancing capability—which keeps system frequency at the level where it's designed to operate—is critical to ensure the stability and reliability of the overall power system, for both centralized power grids as well as microgrids. In a centralized grid, fossil-fuel-fired generating plants typically will ramp up or down to ensure demand and generation output remains in balance. In a microgrid operating independent of the central grid, however,

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an energy supply that can quickly ramp output up and down is needed to align generation supplies with demand.

Energy storage systems can address these issues. They essentially act as a buffer, either absorbing excess generation, or discharging energy to meet minimum load requirements. In this way, energy storage can be a vital component in helping to maintain the stability of microgrids, as well as the larger grid. Energy storage can provide both frequency regulation and smooth fluctuations in renewable energy output, thereby preventing voltage instability.

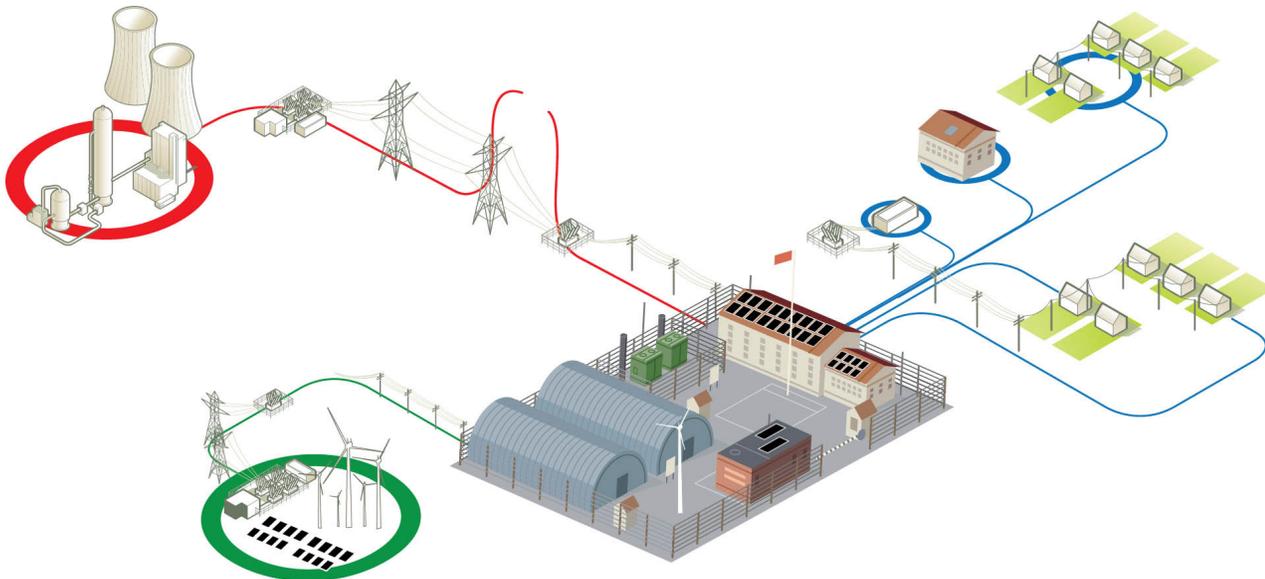
Energy storage can also provide a power supply during outages that last for an extended period of time, as batteries can be recharged when renewable generation is at its peak. This type of backup power supply can be particularly valuable during severe disruptions to the central grid where an outage might last for days, as was the case with Hurricane Sandy.

The versatility of energy storage systems has begun to make it more practical to use renewables to power microgrids as a primary source of power in situations where there is either limited or no connection to a utility source, such as in remote business operations or communities, or within some developing nations.

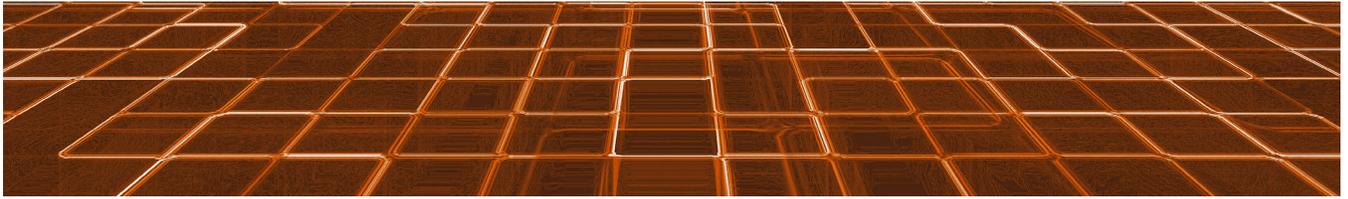
## Energy Storage Enables Seamless Transition to Backup Generation

Even in cases where diesel generators are used as the source of backup power generation, energy storage can prove vital to ensure continuous power for the most critical electric loads. When a microgrid disconnects from the central grid and switches to a backup power source, there is typically a five to 15 second lag as diesel generators spin up. For certain critical systems, such as hospitals or data centers that require an uninterruptable source, even the shortest disruption while a backup generator is spinning up after disconnecting from the central grid are unacceptable. Energy storage systems, when applied as part of an advanced uninterruptible power supply, can bridge this gap. Energy storage can allow loads to be maintained during the period while the microgrid transitions to its alternate energy source.

Energy storage can take several forms. Generally, storage systems consist of batteries that retain energy until needed, but these systems could also include mechanical systems such as flywheels. Flywheels store rotational power through a spinning mass that discharges a short-term burst of energy as torque is applied to the mass, causing it to decrease its rotational speed. The stored energy of a flywheel



Energy storage systems can provide a back-up power supply in the event loads are disconnected from the central power grid. They can also make renewable power generation a practical power supply for islanded loads.



might only provide 15 to 20 seconds of power, so its applications would be limited to those scenarios where the backup sources of electrical generation come online quickly.

### **Energy Storage Helps Build the Business Case for Microgrids**

For microgrids utilizing renewables, it may be possible to sell excess power back to the utility. Having the ability to generate revenues from excess power capacity enhances the economic justification for a microgrid solution. It is also worth noting that when energy storage is utilized as part of a microgrid connected to a central grid, the storage system can provide vital support for other critical grid goals, including peak shaving and volt/VAR optimization. This flexible capability further supports the business case for an investment in stored energy resources, and smart microgrids in general.

### **Microgrids and Energy Storage: A Few Real World Applications**

Energy storage systems are already serving as a vital component of smart microgrid projects. Following are a few real-world examples of how these systems are making a difference on a daily basis.

In Presidio, Texas—one of the oldest cities in the state—frequent electrical storms have a major impact on power reliability. Residents rely on a single, aging transmission line to connect them to centralized utility generators, and this line is difficult to access and repair because it's located in a remote area covering rugged terrain. As a result, the city has been vulnerable to frequent, extended power outages.

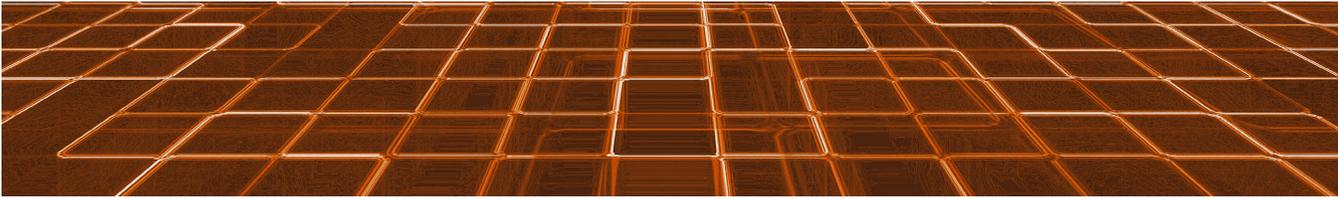
Listed as one of the hottest places in the nation, Presidio residents swelter when their aging transmission line fails, leaving them in the dark. In addition to the loss of air conditioning and lights, computer systems must reset each time power goes off and comes back on. This is of particular concern for law enforcement authorities in a town with an active border crossing with Mexico.

To address this problem, local utility Electric Transmission Texas installed a 4-megawatt sodium-sulfur battery system as a backup power source to mitigate voltage fluctuations and short-term utility outages. The battery system is controlled through an S&C PureWave® SMS Storage Management System, which responds rapidly to changing power system conditions. The PureWave SMS is an automatic power converter and controller that manages the battery charging process, then discharges the stored energy into the electrical grid when needed. Now, when the grid is challenged to meet peak demand, such as when air conditioning usage spikes during a heat wave, the backup storage system immediately kicks in, relieving strain on the utility grid. In the case of an outage, the energy storage can support the entire town's load for up to six hours, providing much-needed time to fix the problem or secure centralized generation from across the border in Mexico—a process that can take several hours.



**In Presidio, Texas, an energy storage system is capable of providing power to the entire town.**

The Presidio battery backup system and its intelligent controls are improving power reliability for residents of the city and surrounding areas, enabling them to keep their lights, air conditioners and computers running. The ability of this energy storage system to reduce power outages and shave peak demand makes a compelling business case for the technology.



In another application, Catalina Island, located 22 miles off the coast of Southern California, utilizes diesel generators to provide electricity for the 3,000 year-round island residents, as well as thousands of tourists. This unique microgrid system is unable to tap into Southern California Edison's central grid, leaving the diesel system to manage fluctuating power demands—and also emitting higher-than-desired greenhouse gas emissions during periods of peak demand.

To reduce these greenhouse gas emissions and help the diesel generators function more efficiently, Southern California Edison decided to use an energy storage system with sodium-sulfur batteries. S&C's PureWave SMS was employed to control charging and discharging of the batteries. This system helps meet peak demand and smooths fluctuations in demand throughout the day, reducing the need for diesel generators to adjust output beyond an optimal level. This, in turn, reduces the production of greenhouse gas emissions.

Since installing a comprehensive energy storage system, Southern California Edison is now able to maintain a more efficient, stable microgrid that ensures consistent service on Catalina Island, while reducing greenhouse gas emissions.

### **Energy Storage Makes Smart Microgrids Tick**

The benefits of having a smart microgrid supported by an energy storage system can be far reaching, with benefits for end users ranging from the military, to remote communities, to data centers and universities. Today's advanced energy storage solutions make it practical to incorporate clean renewable energy resources into a smart microgrid. Energy storage systems also play a critical role in protecting power reliability for the most critical loads. As more users recognize the benefits of applying energy storage in microgrids, such applications—and the associated benefits—will continue to grow.



**On Catalina Island in California, an energy storage solution allows diesel generators to operate more efficiently, reducing greenhouse gas emissions.**

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