

Microgrids: An Old Idea with New Potential

The U.S. Department of Energy defines a microgrid as “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.”

Microgrids themselves are hardly a new concept. Some of the earliest forms of microgrids have been in use for decades. Thomas Edison, who is credited with the invention of the first truly practical incandescent light bulb in 1879, eventually went on to originate the first electric power plant. The precursor to the modern electric utility industry, Edison’s commercial power station was constructed in 1882 on Pearl Street in lower Manhattan. This ground-breaking facility is considered the very first microgrid because a centralized grid did not yet exist. Within four years, Edison’s firm had installed 58 direct current (DC) microgrids.

Not long after this, the electric services industry evolved into a highly regulated market. This market evolution virtually eliminated any incentive to further

advance microgrid technologies because they were inconsistent with emerging utility business models.

Today, however, microgrids are making a resurgence. They remain a practical solution to serve remote communities or facilities that don’t have an economical way to tie into the nearest utility system. At the same time, the function and application of microgrids is rapidly changing and offering new benefits. This white paper will provide an overview of the current state of microgrids and associated technologies.

Applications for Today’s Enhanced Microgrids

The most common uses for microgrids have traditionally included oil refining, mining, lumber, and other businesses that bring generators on site to power remote operations. “Quasi” microgrids can be found at facilities such as hospitals, airports, and businesses with critical processes that depend on uninterrupted energy to operate. Many of these facilities will typically bring in two different utility sources of power to assure that if one fails, the other can serve as a back-up supply. On-site generation is used as an emergency backup in case of a loss of both utility sources.

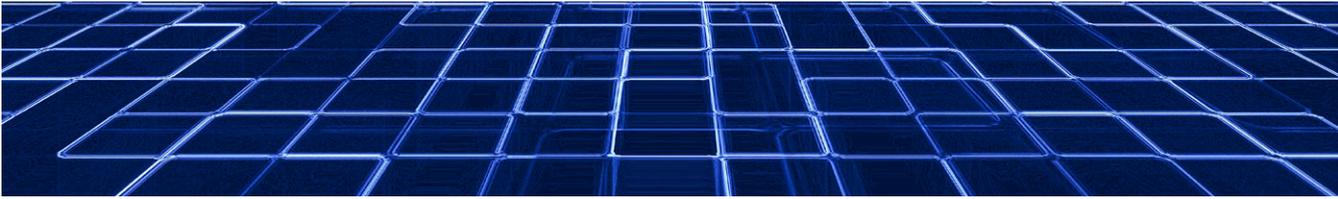


Smart microgrids offer great promise to improve power reliability. They are most commonly found serving industrial and commercial facilities, university and research facilities, military bases, and remote off-grid systems.

White Paper

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Today's enhanced, "smart" microgrids utilize leading-edge technologies to deliver self-healing capabilities and layered communications. These enhanced microgrids are often found filling several applications. Most commonly, these smart microgrids are used at the following locations:

Remote Off-Grid Systems

Microgrids are often the only practical source of electricity for remote areas that are unable to connect to the utility grid. In the past, remote off-grid systems relied primarily on diesel distributed energy generation, but recent advances in solar photovoltaic and wind power systems are now frequently used to supplement generation capacity. Remote off-grid systems may represent the greatest number of microgrids operating today, but they also tend to have the smallest average capacity.

Universities and Research Institutions

Campuses and research institutions are ideal candidates for microgrids because of the common

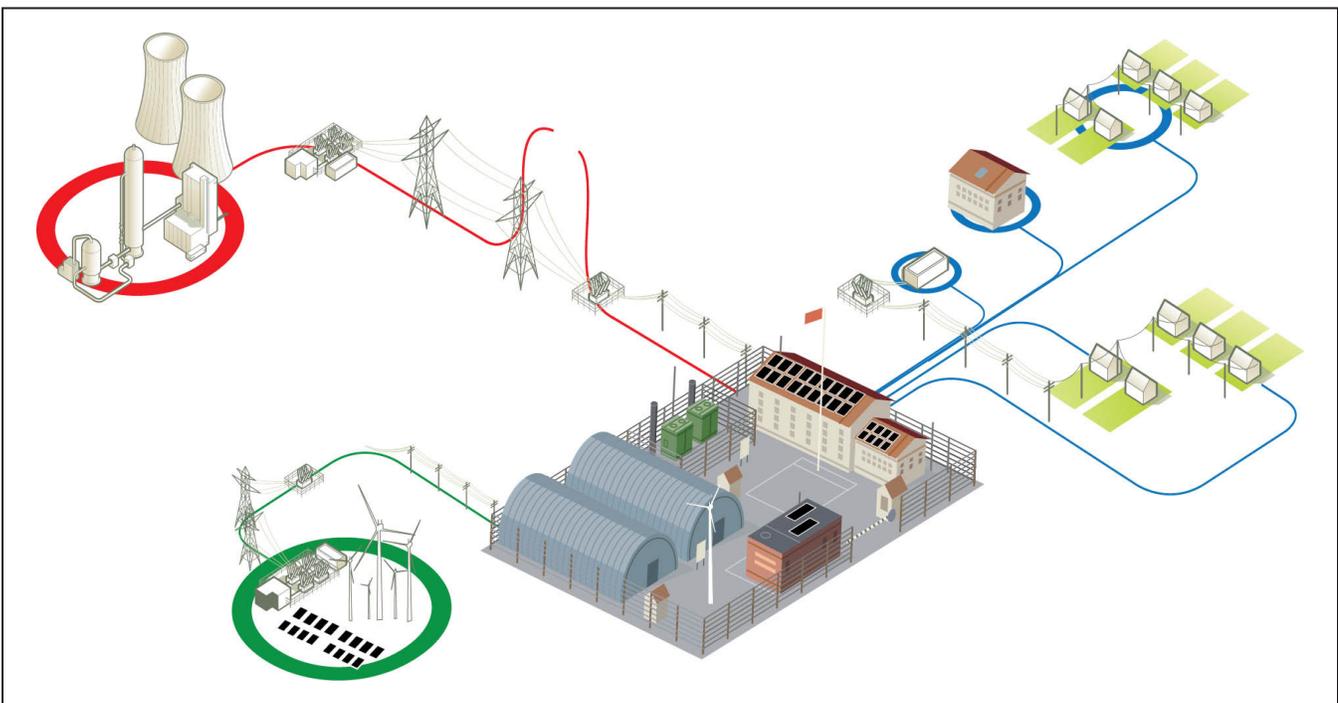
ownership of the facilities. According to Pike Research, 40% of future microgrids will be developed in this market segment, adding 940 MW of new capacity valued at \$2.76 billion by 2015. Such facilities are ideal for sophisticated, state-of-the-art microgrids.

Industrial and Commercial Facilities

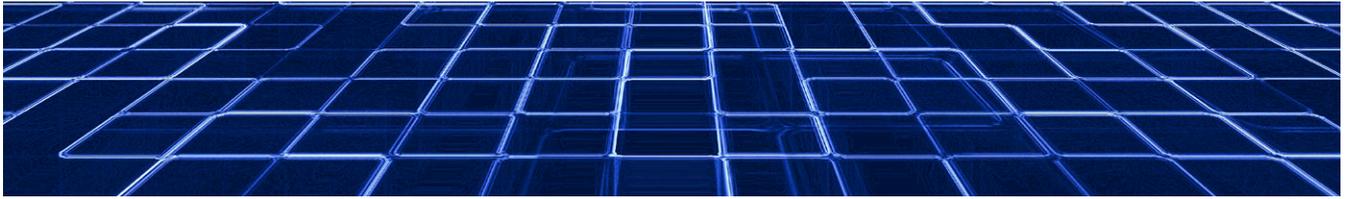
Businesses that require a high degree of uptime, such as data centers, are prime candidates for microgrids. Microgrids provide a measure of redundancy that ensures a constant source of power.

Military

The military's use of microgrids is a small but growing segment of the market, as planners look to ensure a reliable source of energy regardless of a unit's proximity to an available power grid. In particular, the military is looking to achieve net zero energy, where they employ renewable resources such as wind, geothermal, fuel cells, and solar to offset the carbon footprint of power from fossil sources.



"Quasi" microgrids serve loads with critical processes that depend on uninterrupted energy to operate. Local generation is used as a backup in case of a loss of the centralized utility source.



New Standards and Technologies Accelerate Adoption of Microgrids

As the push to create a true smart grid has advanced over the past 10 years, the power industry has worked to develop both new standards and new technologies for delivering clean, reliable and secure electricity. The incorporation of wind, solar, storage, and other distributed energy resources into an interconnected electrical grid has required new standards to ensure reliability and stability. Because microgrids most typically connect to the utility grid, they will now have to comply with these new standards in order to coexist seamlessly. New IEEE standards provide a clearer roadmap on how to connect microgrids to utility power systems, and thus are mitigating a roadblock to microgrid adoption.

In recent years, new technologies have also come to market. These new technologies allow modern “smart” microgrids to provide benefits exceeding those of their predecessors, and are spurring renewed interest in microgrid development. As renewable energy becomes more reliable and the capacity of new battery-based stored energy systems increases, microgrids are

now viewed as a viable way to meet demand when production of intermittent renewable sources like wind and solar energy is low. Such advancements in the efficiency of renewable energy generation and energy storage have made it practical to use these technologies as a back-up or even as a primary source of generation for important loads served by microgrids.

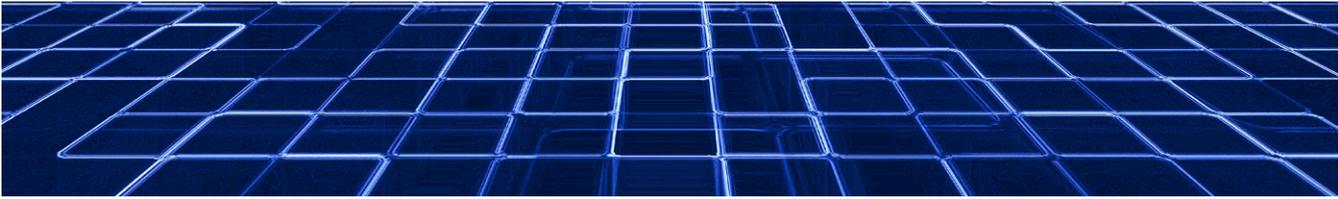
Some experts believe microgrids are better suited for integrating renewables because, by definition, they encompass a finite area, making it easier to control the impact of these energy supplies, as well as a finite number of loads to power, which reduces the burden on the grid. A smaller system is simply easier to manage.

Smart microgrids offer important advantages beyond making it easier to integrate renewable energy sources. They offer greater reliability in the event of a utility grid outage; increased efficiency through the elimination of electricity lost in transmission and distribution; and improved ability to maintain security due to the limited scope and location of the microgrid.



Energy storage solutions—such as this installation in Presidio, Texas—can serve as a back-up power supply and also allow use of renewable energy sources in smart microgrids.

These benefits have sparked a surge of interest in microgrids. Pike Research projects that more than 3.1 gigawatts (GW) of new microgrid capacity will come online worldwide by 2015. This new capacity represents an overall market value of \$7.8 billion. North America alone is expected to capture 74% of this market. As the current microgrid capacity leader, the U.S. had approximately 626 megawatts (MW) operating in 2010 with a projected increase to 2,352 MW by 2015.



Achieving the Smart Microgrid

Though interest in microgrids is strong, ensuring reliable delivery of power within the microgrid and integration to larger, centralized power systems is not a simple task. Effective system architecture at the local level is key to achieving a smart microgrid, one that successfully augments the centralized grid with alternative and renewable power generation. In order to be truly effective at providing a reliable power supply, a microgrid should have the proper level of control and automation in place to make it self-healing.

With intelligent controls, a smart microgrid has the ability to recognize a problem occurring within the system and then reconfigure itself without intervention by a centralized controller. This automation capability enables the microgrid to provide the high level of service reliability required by today's power consumers.

Working in conjunction with bulk power utilities, smart local power distribution systems should be flexible enough to respond to specific user needs, while complementing the capacity of the grid at large.

Modern Microgrids Hold Tremendous Promise

Modern microgrids can provide additional functionality with significant benefits: they can dynamically "island" loads. Islanding occurs when a microgrid's load or group of electric loads is electrically separated from the central utility grid (for instance, when switches have opened). In this scenario, the loads run solely off a local, distributed generation source instead of a bulk power utility source.

By islanding, smart microgrids can anticipate and instantly correct system disturbances, and ensure that end user's mission-critical functions will be uninterrupted, even when their primary utility supply is disrupted. Dynamic islanding allows loads to be transferred in smaller increments between distributed and centralized generation sources, which can help maximize the availability of supplies to meet electricity demand from the most critical loads. This increased level of reliability can help attract high-value, digital-based businesses and industries to an area, such as data centers.

By providing greater local control, smart microgrids also enable more effective distributed power generation and storage. With such control, it is possible to more accurately determine how and when such renewable energy sources should be implemented. By maximizing efficiencies, smart microgrids can help to expedite the incorporation of alternative energy supplies.

In addition to enhancing power reliability and enabling the increased use of renewable energy resources, smart microgrids offer improved security by reducing the grid's vulnerability to natural disasters or attacks against the power system. When configured with the right technology, a smart microgrid is less susceptible to power interruptions caused by a single point of failure at the transmission line, centralized control systems, or substation level, and loads are also better protected against wider disruptions where a central utility generating plant goes offline.

Microgrids also offer another approach to help meet peak demand. In such applications, the microgrid helps optimize utilization of utility assets and can reduce the need for underutilized reserve capacity, ultimately reducing overall costs.

Conclusion

With an increased focus on reliability and a desire to reduce environmental impacts, the energy industry is beginning to explore the advantages of advanced microgrids as a complement to centralized power distribution. Smart microgrids that rely on centralized generation as their primary source, and use distributed energy resources to provide back-up power, can intelligently add and/or shave load from the distributed resource to maintain continuous power.

By providing a more reliable source of electricity, smart microgrids offer an opportunity to improve customer satisfaction and reduce carbon emissions, which are critical industry objectives.