

Shift to Decentralized Power Presents Microgrid Opportunities

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A microgrid, as defined by the Consortium for Electric Reliability Technology Solutions (CERTS), is an “aggregate of loads and micro resources operated as a single system providing heat and power and presented as a single controlled unit to the overall grid.” This rather formal definition hides the fact that microgrids will be a crucial component in the trend toward distributed electricity generation that is so central to the Smart Grid concept.

The traditional grid is based on centralized generation with generating units from 10 MW to GW-scale capacity in one location (or a few locations) and distribution through high-voltage (greater than 69 kV) distribution systems. By contrast, distributed generation consists of smaller generating resources (less than 10 MW down to < 10 kW) using medium-voltage (between 1K and 69K) and low voltage (< 1K volt) distribution systems.

Not all distributed generating resources are microgrids. Many are generation resources only and never act as loads on the grid. But all microgrids *are* distributed resources; they are attached to the medium/low voltage distribution network and act both as generating resources and loads.

Microgrid Drivers: Much Needed Functionality and Enabling Technology

The microgrid concept itself is not especially new. However, NanoMarkets/Smart Grid Analysis believes that microgrids present an important new business potential due to the confluence of their ability to supply some of the most prized advantages associated with Smart Grids and the appearance of certain enabling technologies that make microgrids possible. These are identified below.

- As part of a larger grid, the microgrid can “island” itself when the grid becomes unstable, draw current from the grid when grid power is less expensive and provide power to the grid when it’s economical to sell its power to the grid.
- While the costs per kilowatt-hour for centralized generation is increasing (because of feedstock volatility and regulatory issues), the cost per kilowatt-hour of distributed generation utilizing microgrids has been falling (because of lower cost wind and solar, lower cost storage, and low cost sensor networks to enable microgrids). This falling cost has reached the point that it is now an attractive option for many situations, especially in applications where generation source and load are in close proximity and the heat from generation can also be used for space heating. In such cases, overall feedstock efficiencies (heat plus electricity) of greater than 60 percent have been realized in test settings, which is far more efficient than the approximately 30 percent efficiency of centralized generation with up to 10 percent loss of the generated electricity in the distribution network.

The appearance of low-cost computing, sensors and wireless communications networks over the last ten to fifteen years is the key enabler that makes microgrids such an attractive means to increase grid capacity and functionality. This new technology we believe is putting microgrids on a path to become “plug-and-play” elements of the grid within the next few years. Control of local microgrids with low-cost wireless sensors and communications as well as the incorporation of local storage provides the means for high reliability/high quality power solutions that surpass the reliability of the best centralized generation and can approach those of UPS solutions.

This high reliability is due to both the compact size and the local nature of microgrid distribution networks, close proximity between source and load and the inclusion of electrical storage to serve both as a source to level loads and peak shave, but also as a means to smooth any transient instability in the microgrid. These new lower cost electronics also allow “intelligent islanding” of the microgrid to disengage when power quality

is low or prices are high, and to reengage when the “macrogrid” price is low.

As a result of all this, NanoMarkets/Smart Grid Analysis believes that microgrids present major opportunities throughout the world, but these opportunities also seem to vary by geography.

Microgrids, Power Quality and Opportunities in the Developed World

In the established continental grids of North America and Europe, the costs of centralized generation are increasing, microgrid costs are decreasing and the demand for power quality applications that are better served by microgrids is rising. The potential of microgrids in these areas is to increase the use of distributed resources, which will boost capacity, reliability, and security, as well as incorporate renewable resources such as wind and solar into the overall grid. This opportunity is already being pursued in some countries such as Denmark.

Microgrids improve power quality: The main near-term driver for microgrids in regions with established grids is to significantly improve power quality. The increased reliance on electricity for key mission-critical applications is now at a point where the power quality needs for such applications exceed the ability of centralized generation to deliver the required power quality. Power quality has been static for several decades and is predicted by some to even begin deteriorating slightly as demand continues to increase, while supply and distribution remain stagnant.

The traditional centralized generation/distribution strategy maxes out in reliability at between 3- and 4-nines reliability or somewhere on average of about 1–9 hrs of disruption per year. While this has been acceptable for most applications in the past, the increasing reliance on “always on” mission-critical electrical gear and the damage to gear due to power surges/spikes associated with outages make this level of reliability unacceptable for many applications going into the future.

By moving to a microgrid deployment strategy with local generating and distribution resources that can island themselves seamlessly from the greater grid, the reliability can be increased from 3- to 4-nines (1–9 hrs/outage per year) to 6- to 7-nines (3 to 30 seconds/year). With the addition of electrical storage, which is an essential component of most microgrids, the reliability for the most critical applications can be increased further, to up to 9-nines (30 ms/year).

Microgrid deployment in the U.S. and Europe: In the U.S., several large pilot demonstration projects are already underway. The following projects all have active microgrid demonstration programs in place: Chevron Energy, Consolidated Edison (New York), ATK Space Systems, Illinois Institute of Technology, the City of Fort Collins, Colorado, San Diego Gas and Power, and the University of Las Vegas-Nevada. These demonstration projects contain the elements of local generation, intelligent self-islanding, and local storage and demand response capabilities. Depending on the exact goals, they also incorporate high levels of wind and solar and/or combined heat and power.

Europe is also active in microgrid development. Serious work on microgrids in Europe started earlier than in the U.S. for two major reasons:

- First, Europe experienced political pressure to explore power solutions with a lower carbon footprint earlier than North America; thus, microgrids with their ability to integrate high levels of renewables and integrate cogeneration were explored for that reason.
- Second, the EU implemented legislation in the early 2000s, which enabled distributed generators. This legislation reduced the barrier to entry for distributed resources, allowing distributed generation to move into markets that were previously underserved by conventional central generation.

Currently, eleven European countries are operating microgrid projects. But Denmark is the leader in distributed generation. The best known of the true microgrid demonstrations in Denmark is the Bornholm Island microgrid. It serves 28,000 customers, provides over 55 MW of peak

power, and incorporates 30 MW of wind power. The microgrid is connected to a high power node in Sweden and is able to successfully island off from the overall grid when power quality is low.

Island Microgrids

A smaller but high-growth application of microgrids is in true “island” grids, which either do not connect or are designed for sustained periods of independent service. Thus, the U.S. military and many remote industrial and residential areas are relatively small markets, but microgrid growth in these areas is projected to be brisk over the next eight years.

Near term applications for “island microgrids” include:

- Campus applications (hospitals, educational, governmental), which can use both the electricity and heat of CHP-based microgrids
- Premium power applications such as high-quality industrial power parks, data centers and certain gated community applications

A key for all of these applications is the ability to island themselves from the grid within one-quarter cycle to maintain load integrity within the microgrid and provide quality unattainable in traditional grids.

The final area is in remote locations (industrial, remote town, and military), where the falling cost of microgrids and storage capacity, and the emerging ability to seamlessly integrate wind and solar into such grids makes microgrids viable in a way that was not possible even 10 years ago.

Microgrid Opportunities in the Developing World

In less-developed grid regions, political instability and inadequate capital mechanisms have prevented advanced centralized grids from developing. The demand for microgrid is increasing in such areas, enabling electrification where it was not previously possible.

Microgrids in emerging regions seem to be the most economical method available for implementing rural electrification.