Understanding Microgrids

With the increased focus on renewable energy, efficiency and the need to make the business case for the smart grid, a growing number of stakeholders are focusing on smart microgrids as a viable approach to grid modernization at the local level. Developed for a community, office park, university, military base or other entity, smart microgrids incorporate local distributed energy supplies that meet the exact needs of the constituents being served while networking with the larger grid. They feature the range of smart technology in a single location, which maximizes service quality, savings and entrepreneurial job creation potential and thus helps produce a viable business case. Through smart microgrids, the economic benefits to consumers of the smart grid transformation are maximized and are a significant multiple of the cost. They also provide local choice regarding the electricity generation source and supply, such as locally distributed renewable energy sources. More commonplace in Europe and Japan, smart microgrids face some policy and regulatory barriers here that are being challenged as the reliability, quality and environmental benefits they offer become clearer.

What is a smart microgrid?

Microgrids are modern, small-scale versions of the centralized electricity system. They achieve specific local goals, such as reliability, carbon emission reduction, diversification of energy sources and cost reduction, established by the community being served. Like the bulk power grid, smart microgrids generate, distribute and regulate the flow of electricity to consumers, but do so locally. Smart microgrids leverage the bulk power system to take advantage of lower cost baseload power and remote renewable resources.

Smart microgrids connect with the larger grid and provide valuable services benefiting both utilities and their customers. They operate in coordination with the utility to improve customer service, but the infrastructure is controlled either in part (as with a community) or wholly (as with a university) by the local entity. Universities such as Princeton and Harvard own and operate their own microgrids, as do communities like Naperville, Ill., and military bases such as Fort Bragg, N.C. Controlling the infrastructure on the local level allows for private investment in the system and, when combined with their relatively small size, makes microgrids hotbeds for entrepreneurial innovation.

What are the benefits of the smart microgrid approach?

Accelerates improvement — The term "microgrid" reflects a new way of thinking about designing and building smart grids. The microgrid approach focuses on creating a design and plan for local energy delivery that meets the exact needs of the constituents being served, whether a city, university, neighborhood, business park, or major mixed use development. At the local level, smart microgrids most efficiently and economically integrate consumers and buildings with electricity distribution and generation. Through smart microgrids, the economic and environmental benefits to consumers of the smart grid transformation are maximized, and are a significant multiple of the implementation costs, as described below.

Increases reliability — Smart microgrids increase reliability locally through the establishment of a specific reliability improvement plan that integrates redundant distribution, smart switches, automation, power generation, power storage and other smart technologies. Local power generation and storage allow portions of the grid and critical facilities to operate independent of the larger grid when necessary and thus eliminate blackouts. Technologies such as smart switches and sensors automatically fix — and even anticipate — power disturbances, unlike today's system where switches have to be reset manually in case of an outage. Redundant sources ensure that power continues to flow when storms, ice or squirrels cause interruptions in the power system. Microgrids also back up the bulk power grid when power demand and cost are highest by supplying electricity ancillary services.

Helps consumers save money — Consumers and businesses in the U.S. pay at least $150 billion per year in costs due to power outages. Smart microgrids' reliability significantly reduces these costs. Microgrids allow consumers to procure power in real-time at significantly lower costs, while using local generation to hedge peak power costs. In addition, the microgrid model usually includes third-party financing and long-term modernization plans, which diminish the infrastructure improvement costs that are typically passed on to ratepayers. Similarly, local power generation is typically more efficient and reduces the distance energy must travel and thus passes on fewer costs from transmission losses, congestion pricing and customer service overhead, particularly when power costs are at their highest.

Generates revenue — Consumers and businesses can supply valuable services to the grid in return for payments from the serving utility or independent system operator. This includes demand response, real-time price response, day-ahead price response, voltage support, capacity support, and spinning reserve to name a few. These smart microgrids also set the stage for additional consumer revenues from distributed power generation, plug-in electric vehicles and carbon credits.

Encourages economic growth — More and more communities and nations are finding that microgrids can jump-start economies through new job creation at the local level and new business opportunities for stakeholders. Microgrids increase local investment through community on-bill financing of energy efficiency, local spending on grid improvements and integration of distributed energy and other smart technologies. By fostering the development of microgrids, some of these countries are establishing a new electricity business model that is more efficient, environmentally responsible, compatible with future technologies and likely to spur continuous innovation. Japan and Denmark are leaders in implementing the microgrid approach; most recently, Japan's energy agency, NEDO, partnered with the state of New Mexico to co-fund and develop microgrid projects for several communities.

Makes the grid "futureproof" — One of the greatest benefits of smart microgrids is that they are much better positioned than the centralized grid to meet the known and unknown needs of the future. They allow local communities and commercial campuses to increase the overall electricity supply quickly and efficiently through relatively small local generators, solar cells, wind turbines and other means, rather than having to wait for power companies to build centralized power plants that are costly and take much longer to come online. Smart microgrid technology empowers consumers, stimulates future electricity innovations and activates entrepreneurial free-market funding. In addition, smart microgrids' energy management technology enables plug-in electric vehicles to be connected to the electricity system as smart power storage resources rather than simply another electricity user.

Reduces carbon footprint — The most significant environmental benefit of a smart microgrid is its ability to use local generation and the resulting "waste" heat to displace coal-fired generation. A local power generator can be renewable- or natural gas-fueled. The smart microgrid can reuse the energy that is produced during electricity generation for heating buildings, hot water, sterilization, cooling and even refrigeration (through absorption chilling). Smart microgrids also make it possible to get the most from clean, renewable energy because they have the flexibility needed to use a wider range of energy sources, including those that present a challenge for the current centralized system such as wind and solar. Microgrids enable consumers to meet some or all of their electricity needs by generating their own power, whether it is through sources like wind, solar, geothermal, microturbines and so on. This "bottom-up" consumer approach can reduce reliance on fossil fuels and lower greenhouse gas emissions based on open market economic value.

What types of technologies are used within a smart microgrid?

At home:

- **Smart meters** that allow for the two-way exchange of pricing, usage data and electricity.
- **Programmable smart appliances** and devices that come on when the price of power reaches consumer's desired price point.
- **User-friendly home energy control systems** that allow customers to interface with the smart microgrid to automatically control every aspect of a home's power usage.
- **Energy efficiency improvements** that help consumers use less energy and ultimately save money on monthly electricity bills.

In addition to home technologies, at work:

- **Advanced energy control systems** to make commercial buildings "smart."
- **Advanced lighting technology** with digitally programmable controls that are responsive to the cost of power, the number of occupants in a building and where occupants are located.
- **New heating and air conditioning technology** that automatically adjusts building ventilation rates in real time based on occupancy, air quality, the cost of power or any other factors a manager chooses.
- **New electricity generation systems** that can provide power to individual buildings and supply power to the entire grid.

Within the electricity distribution system:

- **"Smart" switches, relays and sensors** that replace their outdated and inefficient predecessors to allow the smart microgrid to manage and distribute power more efficiently and reliably.
- **Redundant designs** that provide a second source of power when recurring storms, ice and squirrels interrupt power.
- **Protected infrastructure** installed underground or within structures.
- **Computerized controls** that constantly scan for, and even anticipate, potential instabilities to correct problems before users experience any disruption in service.

What are some examples of smart microgrids?

U.S. Army Fort Bragg

Fort Bragg, North Carolina

To enhance power reliability while reducing costs, Fort Bragg, a U.S. Army base near Fayetteville, N.C., elected to build one of the world's largest microgrids. With guidance from Honeywell, Fort Bragg integrated a variety of distributed generation technologies that work in conjunction with the military base's utility infrastructure. Covering more than 100 square miles, Fort Bragg owns its own electric distribution network and is able to monitor various generations from a central energy management center. Despite its size, the various generation technologies are fully integrated with the post's distribution network, information technology and communications infrastructure. As a result of its smart microgrid distribution system, Fort Bragg has enhanced its energy reliability and reduced overall energy costs.

Beach Cities Microgrid Project

San Diego, California

The Beach Cities Microgrid Project in San Diego has brought together some of the nation's biggest names in the energy industry to learn more about how a smart microgrid in the San Diego area would work under real-world conditions and ultimately reduce peak loads by more than 15 percent. This effort is led by San Diego Gas and Electric in partnership with Horizon Energy Group, Advance Control Systems, Motorola, IBM, Lockheed Martin, Pacific Northwest National Laboratory and the University of San Diego. Together, they developed a system that incorporates multiple distributed generation systems, such as solar power in homes and businesses, biodiesel-fueled generators, distributed energy storage devices and demand response technologies such as smart meters.

Perfect Power at Illinois Institute of Technology (IIT)

Chicago, Illinois

IIT has partnered with the Galvin Electricity Initiative and the United States Department of Energy (DOE) to develop a Perfect Power System — a smart microgrid for the IIT main campus. In collaboration with S&C Electric, Endurant Energy and ComEd, the university is building an electricity system of interconnected smart microgrids in a loop configuration with a redundant electricity supply. Construction on this system is under way, and it will offer IIT the opportunity to eliminate costly outages, minimize power disturbances, moderate an ever-growing demand and curb greenhouse gas emissions. It is estimated that the system will pay for itself as it is built over the next five years.

What regulatory barriers are blocking implementation of smart microgrids?

For smart microgrids to happen in communities across the country, we need a fundamental change from the electric utility industry's traditional focus on supply-side technology and infrastructure, which ends at the meter, to one that embraces the numerous individualized service and supply opportunities on the consumer and business side of the meter. Most communities and retail consumers are powerless in a system in which federal and state regulation, under the guise of "protecting ratepayers," discourages innovation, consumer action and consumer economic benefits.

Regulatory policies are needed, at the state level and via federal mandates, to create a more consumer driven electricity system — one that holds the state regulatory process accountable to the consumer and creates a truly sustainable economic stimulus based on entrepreneurial innovation. Policy changes that are driven by consumer needs, as described in the Galvin Electricity Initiative's Electricity Consumer Principles, need to be implemented in order to accelerate innovation in the electricity system while protecting consumers through standards and market boundaries. As an example of a policy barrier, in many states, utilities have the exclusive right to run power lines across public streets, which in effect prohibits communities from making infrastructure improvements of any significance. A renewed state regulatory structure would unlock the benefits of smart microgrids and invite innovation and investment — which can put states at a significant competitive advantage.

Perfect Power—the ultimate smart microgrid

The Perfect Power System is a model of the power system of the future and demonstrates that focusing on consumer needs can maximize consumer value. Designed in keeping with Six Sigma quality methods, the Perfect Power System is the "ultimate" smart microgrid, designed to perfectly meet the power needs of the end-user, both in quantity and in quality. Although the requirements of Perfect Power vary by consumer, the key components of a Perfect Power System — such as smart technology, redundancy, distributed generation and storage, cogeneration or combined heat and power, and consumer control — work together with the bulk power grid or system as an integrated whole to provide its consumers with maximum economic and environmental benefits, reliability and efficiency.

The Galvin Electricity Initiative, launched by former Motorola CEO Robert W. Galvin, has brought together many of the nation's leading electricity experts to reinvent our electric power system into one that is fundamentally more affordable, reliable and energy-efficient. The Initiative has created innovative business and technology blueprints for the ultimate smart grid — the Perfect Power System. The system is a smart microgrid that meets the needs of 21st century consumers and provides reliable, secure electricity regardless of nature's wrath or security threats. To pave the way for Perfect Power and system transformation as a whole, the Initiative is advocating for new policies that reflect a set of guiding Principles — the electricity consumer's Bill of Rights — in Illinois and other key states. For more information, visit *www.galvinpower.org*.