MICROGRIDS, MACRO BENEFITS:

How to talk to decision makers about building your own electrical power system

NEMA
National Electrical Manufacturers Association

The electric grid of the future must be resilient, reliable, and local.

This means MICROGRIDS.

College campuses, commercial districts, healthcare facilities, and military bases have already realized the benefits of building a microgrid, but starting a discussion on the elements and benefits of a microgrid project is challenging because each one is unique.

What is a MICROGRID?

The U.S. Department of Energy defines a microgrid as a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or "island mode."

More simply, microgrids put you in control of your energy decisions.

How can microgrids BENEFIT ME?

1 *Flexibility in development*

Microgrids can be built in phases, allowing your electric grid to grow as your business or needs do, potentially minimizing upfront capital costs.

2 *Price stability*

Investing in your own grid can mitigate risk. It acts as an insurance policy against the unknown and potentially high costs for contingency/emergency energy. It also offers protection from changing electricity rates.

3 *Continuous supply*

While many areas in the U.S. have a normally reliable electric grid any outage can be costly and dangerous. Today, the nation's electric grid is under increased threats from extreme weather events, old age, physical attacks, and cyberattacks. By operating in island mode (i.e., isolating itself from the bulk grid while using on-site generation), continuous electric supply can be guaranteed.

4 *Saves money, generates revenue*

Dependent upon local market regulations and programs, your microgrid can decrease your electricity bill and potentially generate revenue by reducing peak load charges, participating in demand response markets, and providing frequency regulation services to the broader grid.

5 *Increased power quality*

Your operations may require a higher quality of power than the electric grid is fit to provide you with. Implementing a microgrid gives you greater control over this metric, which is important to the operation of equipment used in healthcare, advanced manufacturing, laboratories, and other facilities that incorporate sensitive equipment.

How can microgrids BENEFIT SOCIETY?

1 *Increases efficiency, enables renewables*

When electricity is generated a long distance away from where it is consumed, it must travel through a network of wires and equipment. This journey induces losses, making less than 100 percent of the electricity generated available for use. Microgrids enable renewables, such as solar photovoltaic panels, to fulfill your electricity demand. This drastically reduces losses and decreases your carbon footprint.

In addition, energy storage systems enable generation to be decoupled from demand. For example, surplus electricity generated at one point in time can be stored and used later when demand is greater.

2 *Encourages economic growth*

Constructing your own electrical infrastructure helps your local community, regardless of where you are, by creating jobs for the contractors, electricians, and engineers that build your system, as well as the technicians who operate it.

3 *Public safety*

Your microgrid can help ensure power is supplied to critical public services during an outage, helping to keep your employees, tenants, or the general public safe and comfortable. In an urban environment, you can help keep pharmacies, banks/ATMs, heating/cooling centers, and supermarkets open, while also maintaining the availability of phone charging, food preparation, and water services.

How is a microgrid FINANCED and GOVERNED?

1 *Equity financing*

A microgrid project is funded by investors. They earn a return on the profits and increased economic value of the facility.

2 *Debt financing*

A loan or other credit is used to construct the microgrid and is repaid periodically. Bonds may be used to raise funding if a public entity is involved.

Some jurisdictions can empower one or a group of energy users to self-generate and distribute power.

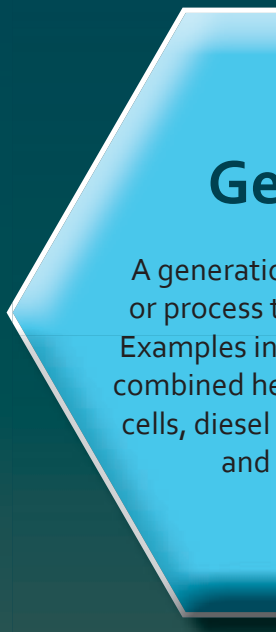
3 *Third-party service model*

A service company builds, owns, and sometimes operates a microgrid site. In return, it is paid for services similar to the operation of a utility.

In federal buildings, Energy Savings Performance Contracts can be arranged to allow third-party services and financing to achieve energy efficiency goals.

4 *Jurisdictional incentives*

States and other jurisdictions are increasingly offering incentives, tax credits, and loan guarantees to develop microgrids.



What elements make up a MICROGRID?

Load

A load is any device or process that consumes electricity. Examples include lighting, heating, cooling, telecommunications, plug loads, and water pumps.

Controller

A microgrid controller regulates electricity production and consumption. It optimizes loads and configures best combination of generation resources and storage.

In some markets, the controller works with other microgrid components to provide a response to grid operator signals including demand response programs, day-ahead forecasting, and weather models. In hybrid ac/dc architectures, the controller configures best combination of ac/dc supply and consumption.

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on resource is any device
that produces electricity.
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eat and power (CHP), fuel
and natural gas gensets,
small scale wind.

Storag

A storage asset is an
or process that allows
production and consu
be decoupled. Exampl
electrochemical batteries,
compressed air storage
fleet-type electric vehi
thermal storage (e.g.,
and ceramic blo

At 9.2 megawatts (MW), the new CHP system at the Marine Corps Air Ground Combat Center in Twentynine Palms, California, is the largest of its kind in the Marine Corps.

Photo of the 82nd Airborne Cogen Plant at Fort Bragg—one of the generation assets that will be tied into the microgrid.

Benefits, Financing, and Structure of Microgrids in the U.S.

MILITARY INSTALLATIONS

Twentynine Palms Marine Base Facility

Twentynine Palms Marine Base Facility is the world's largest Marine Corps base. In 2009, it upgraded to a microgrid with the help of a $2 million grant from the Department of Defense. The centerpiece of its microgrid is a controller with advanced algorithms and computational design engines located at the base's grid control center.

This installation, in conjunction with renewable energy generation solutions, will improve energy efficiency and sustainability. As with all microgrid systems, the base will have an energy storage system, allowing it to self-sustain in the event of a power interruption to the larger grid. This enables the base to be more secure and better protected in the face of disaster.

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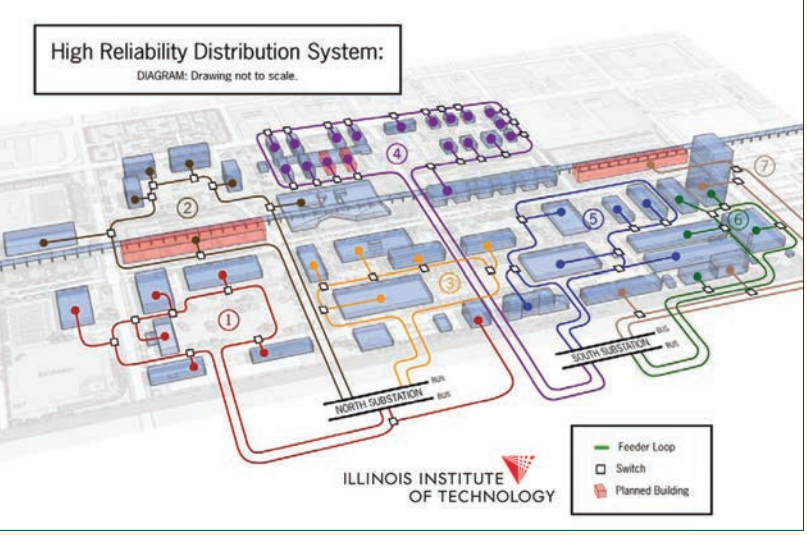
Fort Bragg, North Carolina

Fort Bragg, a 100-square mile U.S. Army post in North Carolina, recently invested in a $3.4 million project to install one of the world's largest microgrids to its facilities. Fort Bragg has an existing backup generation system composed of 15 diesel generators and a 5 kW fuel cell, but the system is limited to supporting only the most critical facilities. With the implementation of a microgrid, reliability will be extended to their entire property.

The project includes a 5 MW gas turbine, a renewable biomass plant, a full and enhanced maintenance system, and a 24/7 monitoring communication system. The installation is set to launch in 2015 and will maximize power reliability and cut energy costs.



Illinois Institute of Technology's High Reliability Distribution System

Solar canopies atop University of California, San Diego's Hopkins Garage includes 1.2MW of solar photovoltaics.

UNIVERSITY CAMPUSES

Illinois Institute of Technology

The Illinois Institute of Technology (IIT) is credited with developing the world's first smart microgrid. The $14 million microgrid project has saved its main campus approximately $1 million annually. IIT implemented several wind turbines and other renewable energy systems to make it more sustainable. In addition, it added energy storage facilities, wiring infrastructure, monitoring systems, and substation upgrades. Not only does IIT have more reliable energy and the capability to island, it also can reduce the main grid's load by up to 12 percent during peak times. Better reliability means fewer blackouts per year; the average number of annual blackouts has dropped over the last few years. IIT's microgrid installation not only cuts the energy costs of the campus, but it also makes it sustainable.

Princeton University

Princeton, a world-renowned research university in New Jersey, is home to approximately 8,000 undergraduate students and many high profile, uninterruptable research operations.

During Superstorm Sandy in 2012, Princeton's microgrid allowed the campus to disconnect from the faulty main power grid and run on its own using 11 MW of local generation. It allowed the school to preserve and protect many research operations and better ensured student safety during a time of unplanned disaster. Costing between $6 and $8 million to build, the microgrid improves energy efficiency from 40 percent to 80 percent, and gives the university the ability to monitor utility facilities closely, which maximizes safety, reliability, efficiency, and sustainability when it is needed most.

The University of California, San Diego

Considered one of the most advanced microgrids in the world, the University of California, San Diego microgrid serves a campus community of more than 45,000 students, faculty, staff, and visitors. It generates 92 percent of the electricity used on campus annually. The microgrid also saves the campus more than $8 million a year in power costs. The microgrid's ability to island helps ensure grid reliability and energy independence, helping to protect critical equipment from interruptions in power supply. For a university that does approximately $1 billion of research per year, this is no small achievement.

Aerial photo of the University of the Virgin Islands campus on St. Thomas and St. Croix

Aerial view of the Federal Research Center at White Oak, the new U.S. Food and Drug Administration headquarters located in Silver Spring, Maryland.

The University of the Virgin Islands

The University of the Virgin Islands (UVI), with a student body of 2,500 undergraduate and graduate students and campuses on the islands of St. Thomas and St. Croix, recently signed a power purchase agreement to develop a solar project and thus begin to develop a true microgrid. Along with this, a grant from the U.S. Department of Agriculture High Energy Cost Grant Program will allow for the implementation of thermal energy storage on both campuses.

The 3-MW solar project will provide about half of UVI's energy needs. This is projected to save the University between $1 and $1.3 million annually. Energy costs are four times higher in the U.S. Virgin Islands than the average continental U.S. costs. The microgrid will serve as a foundation for UVI to become completely energy independent.

CORRECTIONAL FACILITY

Santa Rita Jail, a 113-acre county jail that houses up to 4,000 inmates and 500 personnel in 18 different housing units, requires 3 MW of reliable and secure electricity 24 hours a day. Santa Rita's $14 million microgrid project, which was completed in 2011, includes a 1.2 MW rooftop solar photovoltaic system, a 1 MW fuel cell power plant for heating, five 2.3 kW wind turbines, a 2 MW advanced energy storage system, a 12 kV sub-cycle disconnect switch, and islanding capability. All of these installation projects and upgrades were funded by the U.S. Department of Energy, Public Utilities Commission of California, and private partnerships.

The implementation of microgrid monitoring and maintenance systems has allowed the jail to self-generate during power outages and lower its energy costs. Upgrades to the facility's electrical infrastructure have allowed it to maximize security, reliability, and sustainability.

Neal Bartek (left), San Diego Gas & Electric (SDG&E) smart grid projects manager, and Gil Montes (right), who serves as a project manager with the company, inspect the controls unit for on-site generation at the Borrego Springs microgrid operated by SDG&E.

FEDERAL BUILDING

White Oak, the headquarters of the U.S. Food and Drug Administration (FDA), is a 3.9 million square-foot research and development institution in Maryland that employs approximately 9,000 workers. Since 2002, FDA has been upgrading electrical infrastructure and implementing a microgrid. Some of these projects include installing photovoltaic systems, adding a turbine generator, chiller, and additional solar panels. These projects are predicted to save the government $70 million over the next 23 years. The installation of several independent power generators and turbines make generation capabilities up to 55 MW.

The microgrid at White Oak accounts for a 30 percent reduction in energy savings and a 72,000 metric ton reduction in CO_2 emissions. Since its installation, FDA has implemented island mode 70 times in 36 months and averaged a 99.999 percent uptime over a 12-month period. The proven maximization in reliability and other benefits are priceless if research and critical projects are protected with an extra level of energy insurance.

RESIDENTIAL COMMUNITY

Borrego Springs is a desert community in San Diego County with its own microgrid. In September 2013, a severe storm knocked out power to the only transmission line serving the community. This outage affected 3,000 of the utility's customers. The community's microgrid uses local power generation, local energy storage, and automated switches, and was able to island from the main grid. As soon as the storm passed, the microgrid restored power to 1,200 customers immediately by switching to onsite power; it also pinpointed the exact locations of power failure. The onsite power provided electricity to a designated "cool zone," a vital public section of the community.

This cool zone kept residents safe from the dangerous heat until power was restored. Through the microgrid's monitoring and maintenance systems, power was restored to all 3,000 customers within 24 hours of the disaster and the residents of Borrego Springs were kept safe.