

Microgrids:

What are they? What is their value? Why and where should they be developed?

What is a microgrid?

The U.S. DOE describes a microgrid as “a group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid-connected or island mode”

(definition developed by the Microgrid Exchange Group, comprised of an ad hoc group of individuals working on microgrid research & development)

<http://energy.gov/oe/services/technology-development/smart-grid/role-microgrids-helping-advance-nation-s-energy-system>

What is the value of a microgrid?

The pending review and implementation of the Grid Modernization Plans (GMPs) proposed by the investor owned-utilities in Massachusetts presents significant opportunities and challenges specific to the integration of energy efficiency, demand response and distributed energy resources (DERs) that can support the goals of a modern efficient and resilient power grid.

As a review, the GMP objectives for Massachusetts are:

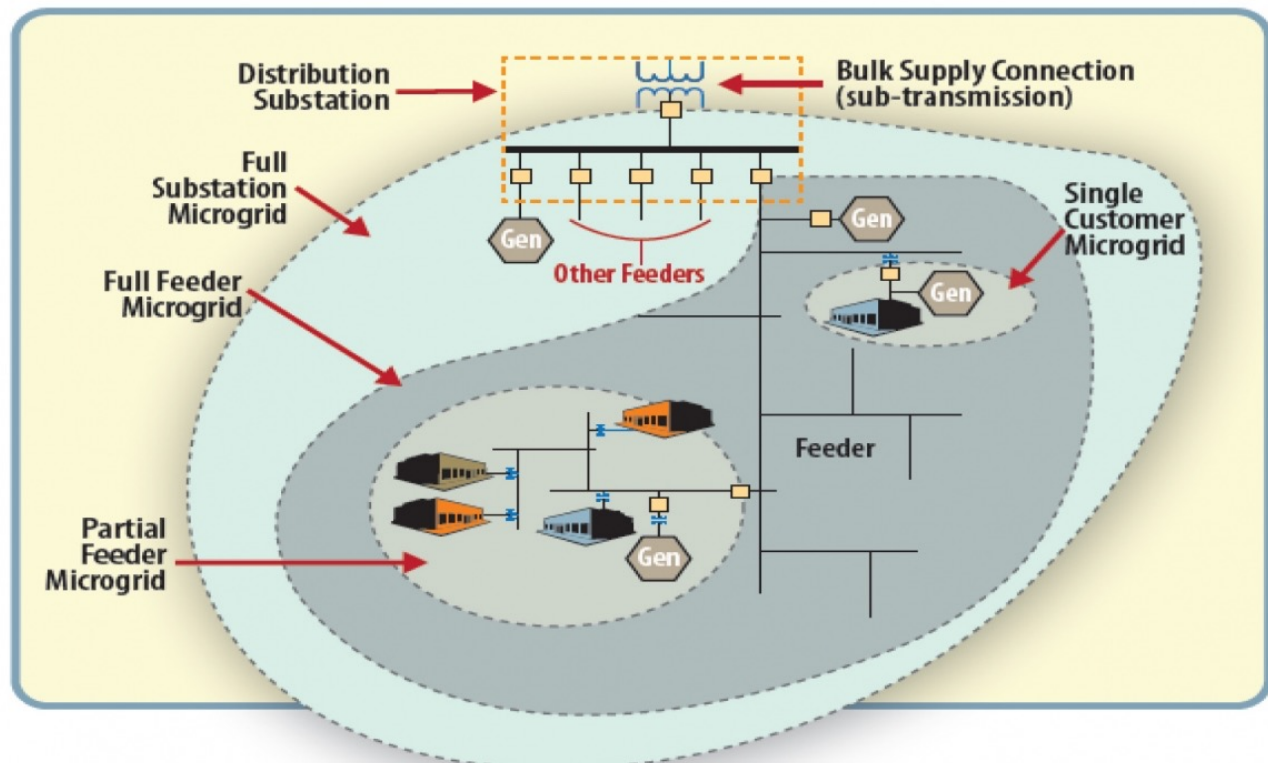
1. reducing the effects of outages;
2. optimizing demand, which includes reducing system and customer costs;
3. integrating distributed resources; and,
4. improving workforce and asset management.

(D.P.U. 12-76-B at 2)

The MA Department of Public Utilities (DPU) stated “Grid modernization is an important means for advancing the statutory requirements and policy goals of further development of energy efficiency, renewable energy resources, demand response, electricity storage, microgrids, and EVs (electric vehicles).” (D.P.U. 12-76-B at 9)

Research and development efforts are underway to advance microgrid demonstration projects across the United States and are designed to meet many of the above GMP objectives. In addition, due to the increasing frequency and intensity of weather-caused grid outages in recent years, the U.S. DOE has placed an added emphasis on R&D to enhance resilience to climate change and extreme weather.

What does a Microgrid look like? (from U.S. DOE Microgrid Initiative)



As shown above, a microgrid may be as small as a **Single Customer Microgrid**, or include a **Partial Feeder Microgrid**, or a **Full Feeder Microgrid** or a **Full Substation Microgrid**. Components of the microgrid include: generating resources (Gen), storage devices and loads including controlled loads.

Generating resources cover all sources possible at the scales and within the context of the microgrid, e.g. fossil or biomass-fired small-scale combined heat and power (CHP), photovoltaic modules (PV), small wind turbines, mini-hydro and micro-turbines, plug-in electric vehicles, for example.

Storage devices includes all of electrical, pressure, gravitational, flywheel and heat storage technologies. While the microgrid concept focuses on a power system, heat storage can be relevant to its operation whenever its existence affects the operation of the microgrid. For example, the availability of heat storage will alter the desirable operating schedule of a CHP system as the electrical and heat loads are decoupled. Similarly, the pre-cooling or heating of buildings will alter the load shape of heating ventilation and air conditioning (HVAC) systems, and therefore the requirement faced by electricity supply resources. Battery storage devices can also manage resource needs in combination with intermittent resources such as PV.

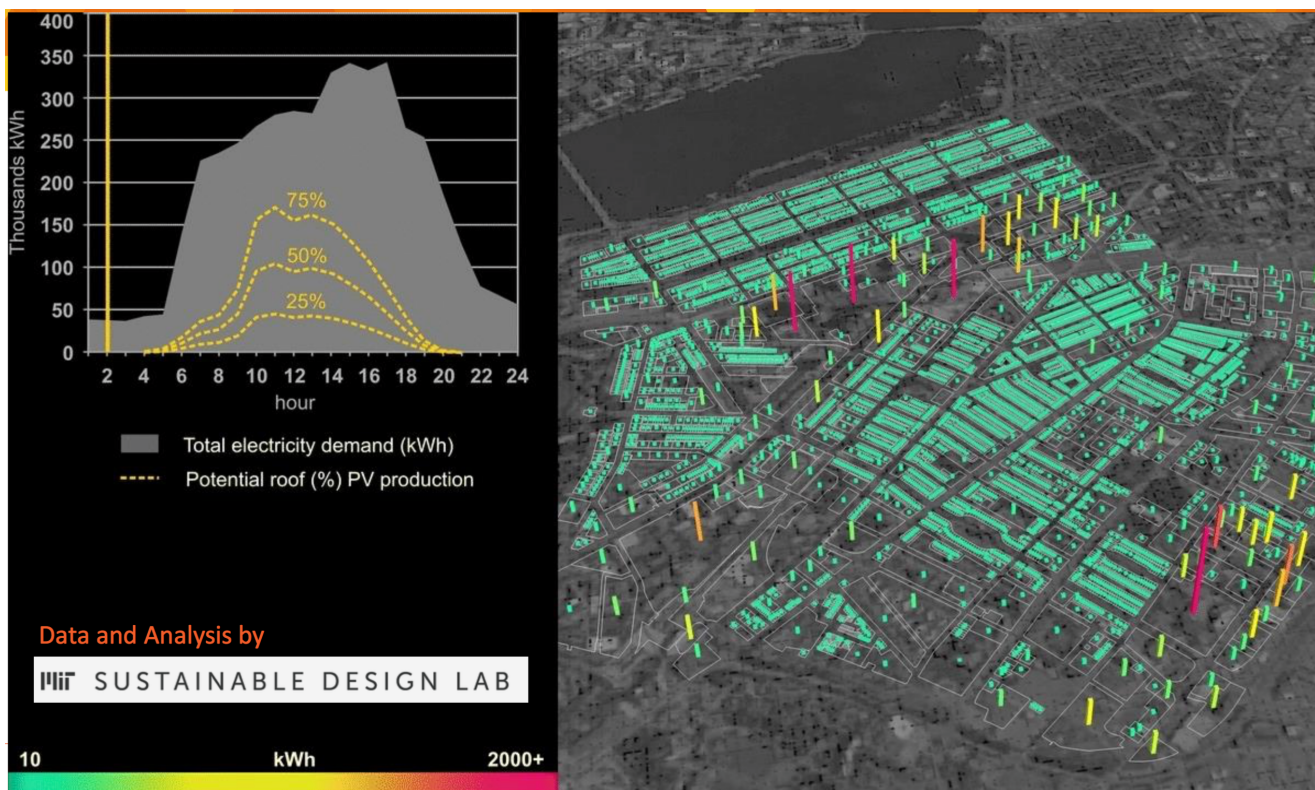
Controlled loads, such as automatically dimmable lighting or delayed pumping, are particularly important to microgrids simply by virtue of their scale. In small power systems, load variability becomes more significant than in large utility-scale systems. The corollary is that load control, load shedding and demand response can make a particularly valuable contribution to the microgrid.

Why Would a Community Choose to Implement a Microgrid?

Depending on the generating resources available, type of load(s) and interconnection location to the local distribution company, a microgrid can provide all requirements or some of the requirements for power by the community. A microgrid not only provides local power but may do so more cost-effectively, more reliably than traditional grid sources. In addition, a microgrid allows communities to be more energy independent and, depending on the mix of renewable sources, can be more environmentally friendly. In short, the benefits can be economic, environmental and reliability/resiliency.

The **City of Boston** convened the Pace University Energy and Climate Center, facilitated by Dr. Jonathan Raab, Raab Associated, Ltd., in a microgrid workshop series held in 2014 included stakeholder representatives from the MA DPU, City of Boston, electric distribution companies (EDCs), distributed generation and microgrid developers and customers. The workshops included legal and economic analysis; identification of benefits, costs, deal-makers and deal-breakers; and the development of a straw proposal for a multi-user microgrid that could be used as a template for pilot projects in Massachusetts.

In addition, as part of energy system planning, Boston undertook a Community Energy Study. This study was commissioned by the Boston Redevelopment Authority in August of 2014, funded by a grant from the Mass Clean Energy Center for microgrid planning with additional funding from the Department of Homeland Security (Science and Technology). Project partners were: MIT Sustainable Design Lab, MIT Lincoln Laboratories and Eversource. This project used advanced modeling and energy data to establish city-wide consumption patterns (see below) and identified localized generation and distribution scenarios to be used as foundational data to explore the viability of advanced energy systems, including microgrids.

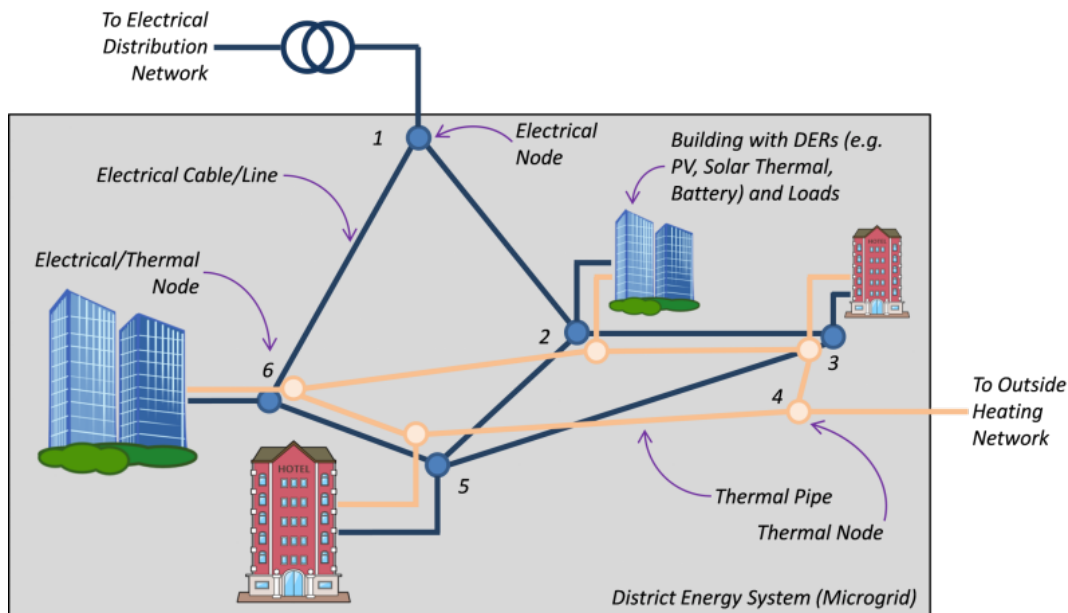


Where Should a Community Choose to Locate a Microgrid?

The location of a microgrid involves a number of factors, mentioned earlier, and communities with funding through DOE/LBNL are, in California (CA), working with the CA Public Utilities Commission, Investor Owned Utilities and other stakeholders to develop an optimization platform, hosted online, to be able to identify meaningful behind-the-meter DER adoption patterns, potential microgrid sites and demand resources. This optimization platform would evaluate the impacts of high renewable penetration feeders on the distribution and transmission grid, all in support of statewide goals in California to integrate 15 GW of distributed energy resources, including 12 GW of renewable energy on distribution systems.

Here on Cape Cod and Martha’s Vineyard, the Cape Light Compact and the Cape & Vineyard Electric Cooperative are in the unique position to be able to assemble many of the components (PV resources, energy efficiency/demand reductions, geographic end-use load profiles, electricity pricing and other relevant price information, for example) that would go into the development of a local siting and optimization tool that could, like California, evaluate the the impacts of and best choice for microgrids.

As an example, the Multi-Location DER-CAM (Distributed Energy Resources-Customer Adoption Model, in development since 2000 by Berkeley Lab), enhanced modeling capabilities for microgrids is illustrated below for a District Energy System. The objective of the DER-CAM model is to minimize the cost of operating on-site generation and CHP systems, either for individual customer sites or a microgrid.



Microgrids Enhancing the Resiliency of Distribution Systems

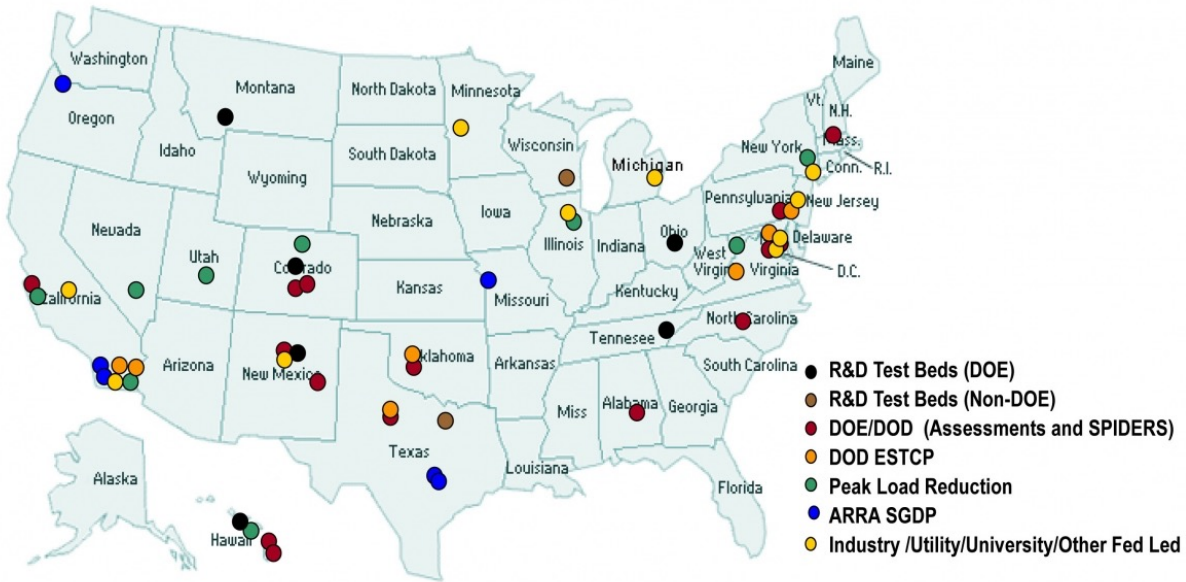
Pacific Northwest National Laboratory and Washington State University are working together to examine the use of microgrids as a resiliency resource. Modeling is being done to examine use of generating resources that may serve loads within, as well as outside, the boundaries of the microgrid. In addition, DOE awarded more than \$8 million to seven microgrid demonstration projects to help communities better prepare for extreme weather events and electric grid disruptions. These projects will bring together communities, technology developers and providers, and utilities to develop advanced microgrid controllers and system designs for microgrids under 10 mW in capacity.

Microgrids are key building block for a Smart Grid

The DOE Smart Grid R&D Program has launched a national effort on electric distribution grid resilience that considers microgrids a key building block. This effort not only responds to the increasing vulnerability of grid outages due to climate change and extreme weather events but also supports Executive Order 12653 “Preparing the United States for the Impacts of Climate Change” and the goal of “building stronger and safer communities and infrastructure” in accordance with “The President’s Climate Action Plan”. The Smart Grid R&D Program resides within the DOE Office of Electricity Delivery and Energy Reliability (OE) and has the program objectives of:

- ✦ modernizing the electric distribution grid through adaptation and integration of advanced technologies (information, communications and automation) and new operational paradigms (microgrids and transactive controls, such as smart meters with two-way communications capability that can allow time-varying prices to trigger load changes at a price-responsive device or overall building/facility level (e.g. signals to programmable communicating thermostats (PCTs)) that turn-up the set point on air-conditioning systems)).
- ✦ supporting the increasing demand for renewable energy integration and grid reliability and resiliency at the state and local levels.

These ongoing microgrid demonstration projects (see map below) consist of renewable and distributed systems integration (RDSI) projects designed for peak load reduction. In 2008, 9 RDSI projects were selected via competitive DOE solicitation with the primary goals to (1) demonstrate at least 15 percent peak demand reduction on the distribution feeder or substation level through integrating DER, and (2) demonstrate microgrids that can operate in both grid parallel and islanded modes. This integrated approach has the potential to allow more power to be delivered through existing infrastructure, thereby deferring transmission and distribution investment, and to increase the reliability of the grid.



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