MICROGRIDS: WHAT EVERY CITY SHOULD KNOW

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

Doug Vine
Amy Morsch

Center for Climate and Energy Solutions

June 2017

INTRODUCTION

Cities are at the forefront of the national conversation about climate change. Increasingly, elected officials and city residents are finding ways to deploy more clean energy and reduce their carbon footprints. They are also looking for ways to reduce the risks that climate change poses to life and property, both today and into the future.

Microgrids can help cities and businesses increase resilience, reduce emissions, and achieve other policy goals such as brownfield redevelopment or smart city implementation. Private and public entities, including utilities, are taking a fresh look at the role microgrids and other distributed energy resources can play in meeting the energy needs of communities. However, there are challenges, as microgrids are not traditional or typical infrastructure investments for a utility, and the existing regulatory system is not structured to facilitate microgrid development by non-utilities.

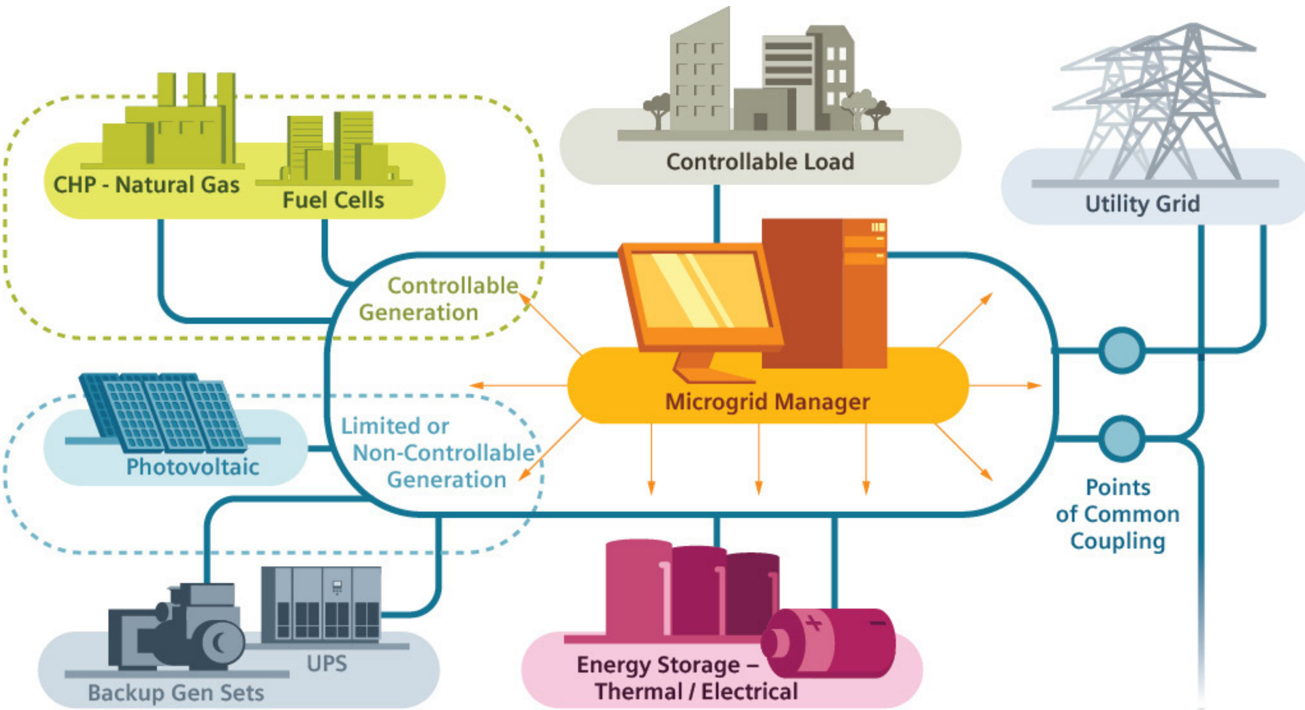
This fact sheet seeks to introduce microgrids as a potential solution to local challenges, describe current financial and legal barriers, and outline the role that local governments can play. A deeper exploration of several of these issues is available in the C2ES report "Microgrid Momentum: Building Efficient, Resilient Power."

WHAT ARE MICROGRIDS?

Microgrids are relatively small, independently controlled power systems that can be operated in concert with, or apart from, the local distribution and transmission system—referred to as the macrogrid in this fact sheet. Microgrids can run on renewables, natural gas-fueled turbines, emerging sources such as fuel cells, or even small modular nuclear reactors when they become commercially available. They can power critical facilities after a weather or security-related outage affects the broader grid. Microgrids can also be the main electricity source for a hospital, university, or neighborhood. While single-user and campus microgrids, such as those that serve an industrial site or military base, have existed for decades, many cities are now interested in systems that can better integrate generation resources and load, serve multiple users, and/or meet environmental or emergency response objectives.

Historically, microgrids generated power using fossil fuel-fired combined heat and power (CHP) and reciprocating engine generators.[1] Today, however, projects are

FIGURE 1: An Example of a Microgrid



Elements of a microgrid could include: controllable generation like natural gas-fueled combined heat and power (CHP) and fuel cells; limited or non-controllable generation like a photovoltaic solar array or wind turbine (not shown); backup generators, uninterruptible power supply (UPS), and energy storage capability. Loads will vary significantly. The microgrid manager (at the center of the diagram) balances generation and load. The microgrid interacts with the macrogrid through the points of common coupling.

Source: Siemens, "Microgrid Solutions" 2016. Available at: https://w3.usa.siemens.com/smartgrid/us/en/microgrid/pages/microgrids.aspx

increasingly leveraging more sustainable resources like solar power and energy storage.[2]

Several variations (and combinations) of microgrids are possible:

- **Number of customers**: Microgrids can serve a single building, multiple customers in a limited geographic area, or customers across an entire community. Microgrids commonly range in size from 100 kilowatts (kW) to mutiple megawatts (MW).
- **Load types and functions**: Microgrids can either serve load for ordinary commercial reasons, (a "general purpose microgrid") or serve a community-oriented function, or both. A general-purpose microgrid provides or supplements the services customers might otherwise receive from the macrogrid. A "community microgrid" serves a public purpose, such as aiding a community during an emergency. For example, a community microgrid might serve critical infrastructure such as police and fire stations, street lights, traffic lights, city water and wastewater facilities, and cell towers, to assure they can operate during blackouts. Community microgrids can also serve general purpose needs by providing power to displace or supplement service from the macrogrid on a day-to-day basis.
- **Connection type**: An off-grid system does not connect to the macrogrid and thus must be a sufficient power source for its customer. A microgrid connected to a macrogrid has greater flexibility since the macrogrid functions as an additional resource.

Microgrids currently provide only a tiny fraction of U.S. electricity. In 2016, the United States had about 1.6 gigawatts (GW) of installed microgrid capacity out of 1,066 GW total capacity.[3,4] Installed microgrid capacity is expected to increase to 4.3 GW by 2020. Most existing microgrid projects are concentrated in seven states: Alaska, California, Georgia, Maryland, New York, Oklahoma, and Texas.

Notably, microgrids appear to be attractive to many large U.S. companies that are committed to working on their own and in partnership with governments to transition to a sustainable low-carbon economy. NRG Energy, one of the country's largest independent power producers, has turned its Princeton, New Jersey headquarters into a fully-islandable microgrid demonstration project laboratory from which the company can test and refine ideas for real-world applications. NRG is also collaborating with grid operator PJM to explore ways that microgrids can help enhance macrogrid operations, findings that will be of interest to utilities across the country.[5]

HOW WOULD A MICROGRID HELP MY CITY?

Microgrids can provide several benefits to the environment, utility operators, and customers. These benefits are particularly important to cities, which strive to create safe, livable communities with thriving economies.

Microgrids can reduce greenhouse gas emissions in two ways:

1. **Offering the opportunity to deploy more zero-emission electricity sources**. The microgrid manager (e.g. local energy management system) can balance generation from intermittent renewable power sources such as solar with distributed, controllable generation and storage (e.g., natural gas-fueled combustion turbines, thermal storage or emerging generation sources such as fuel cells). They can also use energy storage to balance production and usage within the microgrid.
2. **Making use of energy that would otherwise be lost**. When power has to travel long distances (e.g. from a centralized power station), line losses occur, requiring additional generation to ensure that far away demand is met. Since microgrid electricity is generated adjacent to where it will be used, line losses are minimized and less power is required to meet an equivalent level of demand. Additionally, when electricity is generated from certain centralized power sources (e.g., fossil fuels and nuclear power) a great deal of heat energy is created, and typically released—unused—into the atmosphere. When power is generated close to the end users, it becomes economically feasible to use this heat energy productively, such as heating water or space in nearby homes and businesses. Thus, less fuel is combusted overall, resulting in lower greenhouse gas emissions.

When sited strategically within the electricity system, **microgrids can help to lower electricity prices and reduce peak power requirements** by reducing or managing electricity demand and alleviating grid congestion. In this manner, microgrids may support system reliability, improve system efficiency, and help delay or avoid investment in new electric capacity. For example, New York City residents may benefit if a ConEd demand management program, which includes a microgrid project in a low-income community, is able to delay or defer building a $1.2 billion substation in Brooklyn or Queens.[6,7]

In addition, **microgrids can enhance grid resilience to more extreme weather**. When Hurricane Sandy cut off power to millions of homes and businesses in the Northeast, a few areas—mostly parts of universities—kept the lights on using their own power generation systems. Sustaining electricity service during widespread natural disasters is one reason for the growing interest in microgrids—particularly for city governments tasked with maintaining critical public services. The city of Charlotte, North Carolina, is exploring a public safety campus microgrid powered by a solar PV system (an arrangement that combines climate change mitigation and resilience benefits). Microgrids such as this can also help the macrogrid recover from a system outage, either indirectly, by sustaining services needed by restoration crews, or directly, by helping to re-energize the macrogrid.

For cities on the edge of the macrogrid, microgrids can ensure power reliability. For example, in Borrego Springs, California, a mixed-ownership microgrid is providing clean, reliable, and resilient power cost effectively to a hard-to-serve, isolated community.[8]

BOX 1: Microgrids Provide Financial, Resilience, and Social Benefits

The Food and Drug Administration (FDA) Federal Research Center microgrid in White Oak, Maryland, has an inherent resilience value: Money would be lost if scientific experiments were ruined due to loss of power and climate control. While surrounding areas went dark during a 2011 earthquake, 2012 derecho event, Hurricanes Irene and Sandy, and numerous other storms, the FDA center's microgrid remained online. The project prevents about 72,000 metric tons of carbon dioxide equivalent emissions per year. It also provides ancillary services to the existing macrogrid, generating revenue for the project.

WHAT ROLE DOES LOCAL GOVERNMENT PLAY?

Local governments can play a critical role in supporting microgrid technologies. Developers respond to market signals, and local policy can create clarity and communicate priority levels for microgrid developers. In addition, local governments can engage stakeholders around market needs and opportunities, and even set the tone as a microgrid customer. City leaders can consider the following strategies.[9,10]

Set the policy environment:

- Assist would-be developers in determining limits on their potential customer base, e.g. examine franchise agreements that give exclusive rights to the incumbent utility.
- Waive permitting fees and/or expedite the permitting process.
- Grant zoning incentives to projects that include microgrid features such as energy storage, renewable generation or intelligent energy management.
- Ensure zoning codes and homeowners association covenants do not inhibit on-site energy storage and renewable energy generation.
- Require or encourage developers to consider microgrid technologies in permit applications.

Support project development:

- Engage anchor institutions (like hospitals and universities) and developers on community energy use, public purposes and customers the microgrids might serve.
- Identify locations ripe for economic development, or local energy systems that could be expanded.
- Provide information about underground infrastructure to interested developers during project conception.

Participate in and develop projects:

- Establish district energy zones that provide municipal infrastructure that will allow future microgrid development.
- Pursue projects as an anchor customer or supporting partner. Acting as a first mover and demonstrating intent can pave the way for attracting private sector participants.

WHO IS INVOLVED?

Microgrid developers must work with the finance community, advisors, partners, customers, regulatory agencies, government officials, and other stakeholders.

- **Developers/Owners**: Builders or project managers of microgrids
- **Investors**: Financial backers of projects
- **Advisors**: Companies or individuals that provide technical design support, and/or help prepare and communicate the financial case for the project to investors
- **Partners**: Companies that help to develop the project including utilities or government entities in the case of a public-private partnership
- **Customers**: Consumers of the microgrid's power, thermal energy, and other services
- **Regulatory Agencies**: Public utility commissions and their like
- **Government Officials**: State and city officials
- **Other Stakeholders**: Community representatives and others who might be affected by the microgrid development

Cities are pursuing microgrids to ensure reliable power to critical infrastructure during grid outages. Portions of the city under microgrid control continue to function during a widespread outage.

WHO OWNS AND PAYS FOR A MICROGRID?

While each project is unique, here are three common ownership models:

- **Utility-owned microgrids** can often be funded by including the capital cost in the utility's rate-base, provided the utility can demonstrate the need for and cost-effectiveness of the microgrid to its regulators.[11] These microgrids simply offer a different technological approach to delivery of traditional services by established service providers.
- **Privately-owned microgrids** can be much more challenging. They may compete with electric service delivered through existing infrastructure, and face legal and administrative challenges that limit their deployment.
- **Community-owned grids** are often funded by government sources (state and federal) through bonds, tax credits, grants, loans, tax deductions, and credit enhancements. However, these microgrids face financing challenges even in states that have encouraged such projects.[12]

Long-term public-private ownership microgrids are gaining popularity because they allow for flexible sharing of project risks and management. Mixed-ownership microgrid projects were nearly nonexistent in 2013, but were projected to make up 38 percent of the market in 2016. One example of this is in Maryland, where Schneider Electric, Duke Energy, and the Montgomery County government are collaborating on two microgrids to power county facilities. Ratepayers won't have to pay any extra costs, and the government will get more resilient and affordable power with environmental benefits.[13]

Developers seeking financing should first explore state funding opportunities. In 2014, Massachusetts gave $18.4 million to cities and towns for energy resilience projects, including microgrids.[14] Connecticut has allotted $20 million to microgrid projects, with most of the funding going to municipal projects.[15] California funded $27.3 million for 10 microgrid and electric vehicle charging projects.[16] States including California, Connecticut, and New York have developed clean energy banks (CEBs or green banks), which leverage both public and private dollars to fund clean energy, including some types of microgrids.[17]

DO MICROGRIDS MAKE FINANCIAL SENSE?

A financial feasibility study can help quantify and reduce microgrid development risk. This standard industry practice includes calculating the project's start-up costs, identifying the sources of funding, and calculating the

TABLE 1: Sources of Microgrid Finance

PUBLIC FINANCE (FEDERAL, STATE AND MUNICIPAL)	PRIVATE FINANCE
• Tax-exempt bonds • Tax credits • Grants • Loans • Tax deductions • Credit enhancements • Clean Energy Banks • Commercial property assessed clean energy (PACE) • Resilience bonds • Power purchase agreements (PPAs)	• Equity financing • Debt financing, loans • Corporate bonds • Energy saving performance contracts (ESPCs)—Energy service companies (ESCOs) • Power purchase agreements (PPAs) • Third-party model

project's likely returns. Each project's starting point is likely to be unique. Existing electrical infrastructure or generation assets can help mitigate the cost of constructing the system. Buying electric generation equipment typically accounts for the largest share of the development and construction cost.[18] Other costs to consider are infrastructure build-out and microgrid control systems. Development and construction costs can escalate depending on the location of the microgrid, its degree of sophistication, and whether the project is designed to be scalable.[19]

Microgrids generate revenue in several ways:

- **Providing metered electricity to consumers** within the microgrid network. This provides a steady stream of income. Investors will consider the basis on which these sales are made, including the duration of their commitment as well as the creditworthiness of the customers.
- **Providing metered thermal energy**. A microgrid can provide hot water, steam, or chilled water – offerings most electric utilities do not provide.
- **Ensuring reliable and resilient systems**. A microgrid may attract a premium tariff from customers that require a higher level of service and have a low tolerance for disruptions. For example, a grocery store may be willing to pay a higher electricity price for a guaranteed uninterruptible power supply to keep valuable refrigerated and frozen food from perishing in the event of a grid outage. A data center or other service provider that cannot afford to be offline even for an instant might be willing to sign a contract for a premium service.
- **Generating Renewable Energy Credits**. A microgrid may be eligible to generate renewable energy credits (RECs). While some owners will retire these RECs to assure their claim to "green" power, others may sell them, creating yet another revenue stream.
- **Selling excess power back to the larger grid**.
- **Providing macrogrid services**. Participating in demand response markets or providing frequency regulation services can provide another revenue stream.[20]

This revenue will be offset by operating costs, including fuel, labor, security, and administrative costs, as any utility service provider will incur. Also, participation in markets to sell macrogrid services (e.g., demand response, frequency regulation) has a cost, as the microgrid owner will need to become a market participant or contract with a marketer able to make the transactions. In addition, the microgrid owner may need to purchase power from the macrogrid owner or the wholesale market. Like any business, meeting such obligations means the microgrid will have working capital requirements, which also need to be considered when arranging financing.

WHAT ARE THE LEGAL CONSIDERATIONS?

Microgrid investors will be concerned with the legal environment in which the project will operate, and should consider relevant statutes, regulations, market rules, local ordinances, tariffed rates, terms and conditions (including interconnection rules and fees and stand-by power charges), and even electrical codes. While risk related to future changes in law is unavoidable for any investment, the legal framework for microgrids is particularly undeveloped and contributes to greater risk. This risk is based on an expectation that the legal void will be filled soon, although the contours of new laws are unknown.

Microgrids confined to a single site and a single owner, such as within an industrial complex or a building, are generally the easiest type of project to assess. No state prohibits an entity from self-supplying its electrical needs, although the law may or may not be hospitable to such arrangements and may limit the use of leasing arrangements or other third-party services.

Microgrids that serve multiple customers, however, face challenges from a legal framework that fails to define the rights and obligations of the microgrid owner with respect to its customers and the macrogrid operator. In addition, state franchise rights and rights-of-way laws granted to utilities may limit microgrid developers' access to customers. Connecticut was the first state to develop a legal definition of a microgrid to promote community microgrids for resilience in the wake of Hurricane Sandy.[21] However, the Connecticut law is not designed to provide a complete framework for the development, connection, and integration of microgrids, including those that serve other purposes. Other states are even further behind in providing legal certainty. Addressing these legal barriers is essential to the wider deployment of microgrids.

CONCLUSION

Microgrids can deliver benefits to the environment, the power system, and energy customers by enabling deployment of greater quantities of low-emission energy sources, creating opportunities for greater efficiencies, and ensuring system reliability. These benefits will be felt by the customers and their surrounding communities, which is a major reason microgrids are being considered across the United States. Although there is growing interest in related "smart city" investments, renewable energy, and resilience measures, greater awareness is needed about microgrids' potential and how they fit into the electricity grid of the future. Local governments can support increased awareness and decision-making by first understanding the variety of microgrid types and ownership models discussed here, as well as the emerging policy needs associated with microgrid technologies. While project developers and partners must navigate legal uncertainties and establish financing plans, municipalities have the unique capability to support the technology by creating development incentives, removing policy hurdles, and even pursuing their own microgrid projects.

ENDNOTES

1 Wood, Elisa, "US Microgrid Market Growing Faster than Previously Thought: New GTM Research." Greentech Media. August 29, 2016. https://microgridknowledge.com/us-microgrid-market-gtm.

2 Ibid.

3 Wood, Elisa, "US Microgrid Market Growing Faster than Previously Thought: New GTM Research." Greentech Media. August 2016. https://microgridknowledge.com/us-microgrid-market-gtm.

4 U.S. Energy Information Administration, "Electric Power Monthly: Table 6.2A." Accessed on July 5, 2016. http://205.254.135.7/electricity/monthly/index.cfm.

5 NRG, "Sustainable Headquarters." Accessed on May 8, 2017. http://www.nrg.com/news/sustainable-headquarters.

6 Bade, Gavin, "ConEd Brooklyn-Queens non-wire alternative project installs first microgrid." December 14, 2016. http://www.utilitydive.com/news/coned-brooklyn-queens-non-wire-alternative-project-installs-first-microgrid/432380.

7 Tweed, Katherine, "Con Edison Unveils Auction Numbers for Its Pioneering Demand Management Program in New York." Greentech Media. August 5, 2016. http://www.greentechmedia.com/articles/read/The-Numbers-Are-In-for-Con-Edisons-Demand-Management-Program.

8 Anderson, Erik, "Microgrids power desert community and urban campus." Inside Energy. December 21, 2016. http://insideenergy.org/2016/12/21/microgrids-power-desert-community-and-urban-campus.

9 Bourgeois, Thomas, et al., "Community Microgrids: Smarter, Cleaner, Greener." Pace Energy and Climate Center. Accessed on April 26, 2017. http://energy.pace.edu/publications/community-microgrids-smarter-cleaner-greener.

10 Pace Energy and Climate Center. "Microgrids & District Energy: Pathways to Sustainable Urban Development." Accessed on April 26, 2017. http://energy.pace.edu/publications/microgrids-district-energy-pathways-sustainable-urban-development.

11 See, *infra*, discussion at n. 51.

12 Wood, Elisa, "Connecticut Figures Out Microgrids (And Helps the Rest of Us) Part 2." April 7, 2015. http://microgridknowledge.com/connecticut-figures-out-microgrids-and-helps-the-rest-of-us.

13 Spector, Julian, "Microgrids on the March: Utilities Are Building Out New Business Models to Make Islanding Work." Greentech Media, February 7, 2017. https://www.greentechmedia.com/articles/read/distributech-roundup-microgrids-on-the-march.

14 Wood, Elisa, "Massachusetts Awards $18.4M for Microgrids and other Energy Resiliency Projects." Microgrid Knowledge, Dec. 29, 2014. http://microgridknowledge.com/massachusetts-awards-18-4m-microgrids-energy-resiliency-projects.

15 Wood, Elisa, "Connecticut Figures Out Microgrids (And Helps the Rest of Us) Part 2." Microgrid Knowledge, April 7, 2015. http://microgridknowledge.com/connecticut-figures-out-microgrids-and-helps-the-rest-of-us.

16 Wood, Elisa, "California Awards $27.3M for Microgrids and EV Charging Projects." Microgrid Knowledge, Feb. 4, 2015. http://microgridknowledge.com/california-awards-27-3m-microgrids-ev-charging-projects.

17 Wood, Elisa, "Green Banks to Finance Microgrids?" Microgrid Knowledge (Nov. 2, 2015). http://microgridknowledge.com/green-banks-to-finance-microgrids.

18 Wood, Elisa, "What Does a Microgrid Cost?" Microgrid Knowledge, April 26, 2016. https://microgridknowledge.com/microgrid-cost.

19 Wood, Elisa, "What Does a Microgrid Cost?" Microgrid Knowledge, April 26, 2016. https://microgridknowledge.com/microgrid-cost.

20 National Electrical Manufacturers Association, "Microgrids, Macro-Benefits: How to talk to decision makers about building your own electric power system." 2014. https://www.nema.org/Communications/Documents/Microgrids-Macro-Benefits.pdf.

21 As defined by Connecticut, "'[m]icrogrid' means 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 and that connects and disconnects from such grid to enable it to operate in both grid-connected or island mode." Conn. Gen. Stat. §16-243y.

CENTER FOR CLIMATE
AND ENERGY SOLUTIONS

The Center for Climate and Energy Solutions (C2ES) is an independent, nonpartisan, nonprofit organization working to forge practical solutions to climate change. Our mission is to advance strong policy and action to reduce greenhouse gas emissions, promote clean energy, and strengthen resilience to climate impacts.

2101 WILSON BLVD. SUITE 550 ARLINGTON, VA 22201 703-516-4146 **C2ES.ORG**