MICROGRID
KNOWLEDGE

Community Microgrids

A Guide for Mayors and City Leaders Seeking Clean, Reliable and Locally Controlled Energy

brought to you by OBG INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Chapter 1

Introduction to Community Microgrids

Why we wrote this guide and what you will learn

U.S. towns and cities are awakening to the importance of local energy; to the value of gaining control over their energy supply, and ensuring that it is clean, efficient and secure.

Recent storms and power outages have accelerated the trend, as has the realization among local officials that developing local energy can help municipalities:

- Keep the lights on when the central grid fails
- Gain more control over energy costs
- Better compete for sought-after industries and jobs
- Improve air quality and achieve climate change goals
- Improve energy efficiency and incorporate solar, wind and other renewable energy

Community microgrids are central pillars of today's local energy revolution. Being developed in municipalities large and small, they are a key feature of the new clean and efficient electrical infrastructure that is beginning to transform America's energy grid into a less centralized and more democratized entity.

Mayors and city leaders are especially tuned into this transformation because of the severe stress that extended power outages create in their communities—from inconveniences that prevent people from completing day-to-day tasks to true threats to health and well-being. Power outages also directly affect commerce and therefore municipal budgets. The U.S. economy pays a high price for power outages—as much $75 billion annually, according to the White House.

Estimated Cost of Weather Related Outages

Year	Billions 2012 $
2012	$27 – $52
2011	$19 – $36
2010	$13 – $25
2009	$8 – $14
2008	$40 – $75
2007	$5 – $10
2006	$23 – $43
2005	$14 – $27
2004	$14 – $27
2003	$14 – $26

Source: "Economic Benefits of Increasing Electric Resilience," Executive Office of the President.

Contents

Voters tend to hold city leaders accountable when prolonged outages occur, although it is private investor-owned utilities—which serve nearly 70 percent of the U.S. electricity customers—that are typically responsible for power restoration. Due to consolidation in the utility industry in recent years, these private utilities may be based in other cities or states, and possibly governed by international parent companies. Contrary to voter perception, municipal officials actually have little control over the timeliness of power restoration.

Community microgrids, however, offer towns and cities a way to keep the lights on even when the central grid fails, and provide basic services to the citizenry.

Credit: Wikimedia Commons

Power outages are one reason that mayors and municipal leaders seek ways to bring energy production closer to home with microgrids. But the value of the microgrid goes deeper; a microgrid may not only deter economic calamity, but also can enhance community prosperity. Microgrids help draw coveted high tech industries to cities and towns by offering the reliable, premium power and cleaner energy services that these businesses require.

In addition, many communities are seeking proven approaches to address climate adaptation; reduce greenhouse gas emissions; and invest in cleaner, more sustainable energy systems. Across the globe, cities large and small are taking initiative to tap local energy resources and build energy infrastructure that will expand their tax base, diversify energy supplies and address the need for expanded services for denser urban populations. Cities are seeing dramatic population growth along with a need for energy master planning and integrated energy systems that optimize efficiency and reduce waste.

As city and town leaders are well aware, electricity is essential to a functioning society, more so now than ever before as almost all aspects of our economy become Internet-based.

Why this guide

While towns and cities show increasing interest in microgrids—and several have projects under development—little easily accessible guidance exists for municipal leaders who are exploring the concept. To help these communities get started, MicrogridKnowledge.com has produced this report, "Community Microgrids: A Guide for Mayors and City Leaders Seeking Clean, Reliable and Locally Controlled Energy," the third in our Think Microgrid series.

In this guide, we describe how microgrids serve communities and explain why states like California, Massachusetts and New York promote their development, and offer substantial incentives to boost the industry.

We also detail the key features of a microgrid, how they work, the value of incorporating both electricity and heat into a project, and why microgrids foster development of renewable energy. We identify steps for cities and towns to take as they begin to develop a project, and discuss various finance options and incentives. Finally, we provide examples of communities that are already benefitting from community microgrids, and others well on their way.

As city and town leaders are well aware, electricity is essential to a functioning society, more so now than ever before as almost all aspects of our economy become Internet-based. We invite you to read on to learn more about how microgrids can protect vital energy supply to your community.

Special thanks to the International District Energy Association (IDEA) and OBG for making this guide possible.

Key Definitions

The U.S. Electric Grid

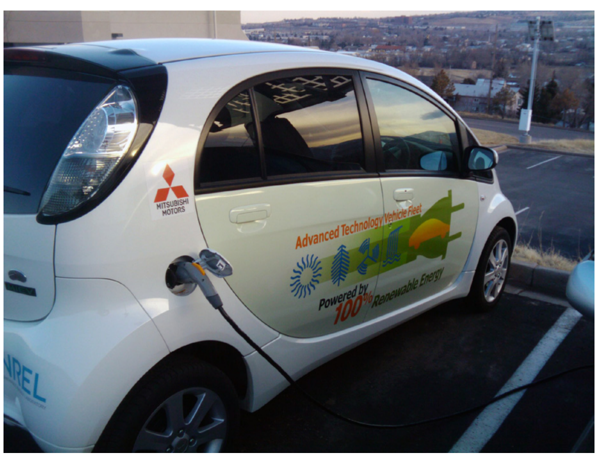
The U.S. electric grid delivers power to more than 140 million customers by way of more than 3,000 electric utilities. The grid encompasses more than 300,000 miles of transmission and distribution lines, and 7,000 power plants [EIA]. About two-thirds of electricity consumers reside within regional transmission organizations, which operate the transmission grid and oversee wholesale power markets.

Microgrid

Exactly what constitutes a microgrid remains somewhat open to debate. But they can be broadly divided into two main types: the remote microgrid and the grid-connected microgrid.

Remote microgrids are typically found on islands or other places too distant to connect easily to the U.S.' central grid. They are independent, stand-alone energy systems.

This guide focuses on grid-connected microgrids, since U.S. cities and towns are far more likely to pursue their development.



Credit: National Renewable Energy Laboratory

Generally a grid-connected microgrid functions somewhat like the large electric grid, but serves a much smaller footprint. It provides energy for one or more customers within a contained boundary, and it typically operates multiple sources of power generation and possibly heating and cooling, and includes the wires and pipes to deliver the energy. It also may include energy storage and electric vehicles.

A grid-connected microgrid is distinguished by its ability to operate connected to the grid (in parallel) or in stand-alone fashion (islanding mode). Today's microgrids also use sophisticated controllers and software for smart energy management.

Sometimes microgrids are confused with emergency back-up generation. Microgrids are in fact more complex. Supplying back-up power is an important microgrid function, but they also provide a host of other services to maximize efficiency and minimize energy costs—not only for customers within the microgrid but to the larger grid as well.

Community Microgrid

Early microgrids tended to serve one customer or energy user, such as a university or hospital. The emerging community microgrid, however, often provides energy for multiple customers.

Most important, a community microgrid typically focuses on ensuring that the citizenry receives critical services during a grid outage. So community microgrids may include police and fire stations, hospitals, waste water treatment plans, schools, emergency shelters, grocery stores, gas stations, communications centers or similar facilities. Some community microgrids extend their reach further, even incorporating homes and businesses.

Chapter 2

Evolution of the Microgrid

Origin, components and basic tasks of microgrids

Microgrids have received heightened attention in recent years from government, industry and the media. So it's easy to get the impression that they are a new technology. In truth, simple microgrids have been around since the time of Thomas Edison.

More importantly, several colleges and universities have been operating microgrids for decades. These institutions demonstrate that microgrids can function compatibly with the local utility grid, and indeed benefit not only energy customers within the microgrid, but also those served by the larger grid.

The Princeton University microgrid was widely recognized for its continuous operation during SuperStorm Sandy while over 8.1 million electricity customers were without power from New York to Michigan.

SuperStorm Sandy, with its crushing destruction of the Northeast's electric system, raised awareness about the value of microgrids. In fact, the Princeton University microgrid was widely recognized for its continuous operation during Sandy while more than 8.1 million electricity customers were without power from New York to Michigan. But microgrids actually began gaining traction several years earlier as governments and energy experts identified needs they fill within a modern grid.

In Europe, microgrids are part of a broader smart city trend. Smart cities use advanced technology and communications to create urban environments that are more livable, efficient and eco-friendly.

In the U.S., today's keen interest in microgrids can be traced directly to grid modernization legislation passed by Congress eight years ago. The Energy Independence and Security Act of 2007 acknowledged that the U.S. grid was aging and would benefit from replacement and updating. The law brought about a collaboration of federal agencies and research institutions, which fostered policy for smart grids and microgrids. The Department of Energy subsequently identified advanced microgrids as being an essential part of the modern electrical grid. Since then, the DOE has made development of next generation microgrids a high priority.

Navigant Research predicts the worldwide market for what it calls 'community resiliency microgrids' will expand from $162.9 million in 2015 to $1.4 billion by 2024. For the broader microgrid market, revenue may reach $40 billion by 2020, with much of the activity centered in the U.S.

Now, industry analysts are forecasting significant microgrid growth in the coming years. Navigant Research predicts the worldwide market for what it calls 'community resiliency microgrids' will expand from $162.9 million in 2015 to $1.4 billion by 2024. For the broader microgrid market, revenue may reach $40 billion by 2020, with much of the activity centered in the U.S. That would mean five-fold growth in microgrid installations, from 866 MW in 2014 to 4,100 MW by 2020, according to Navigant.

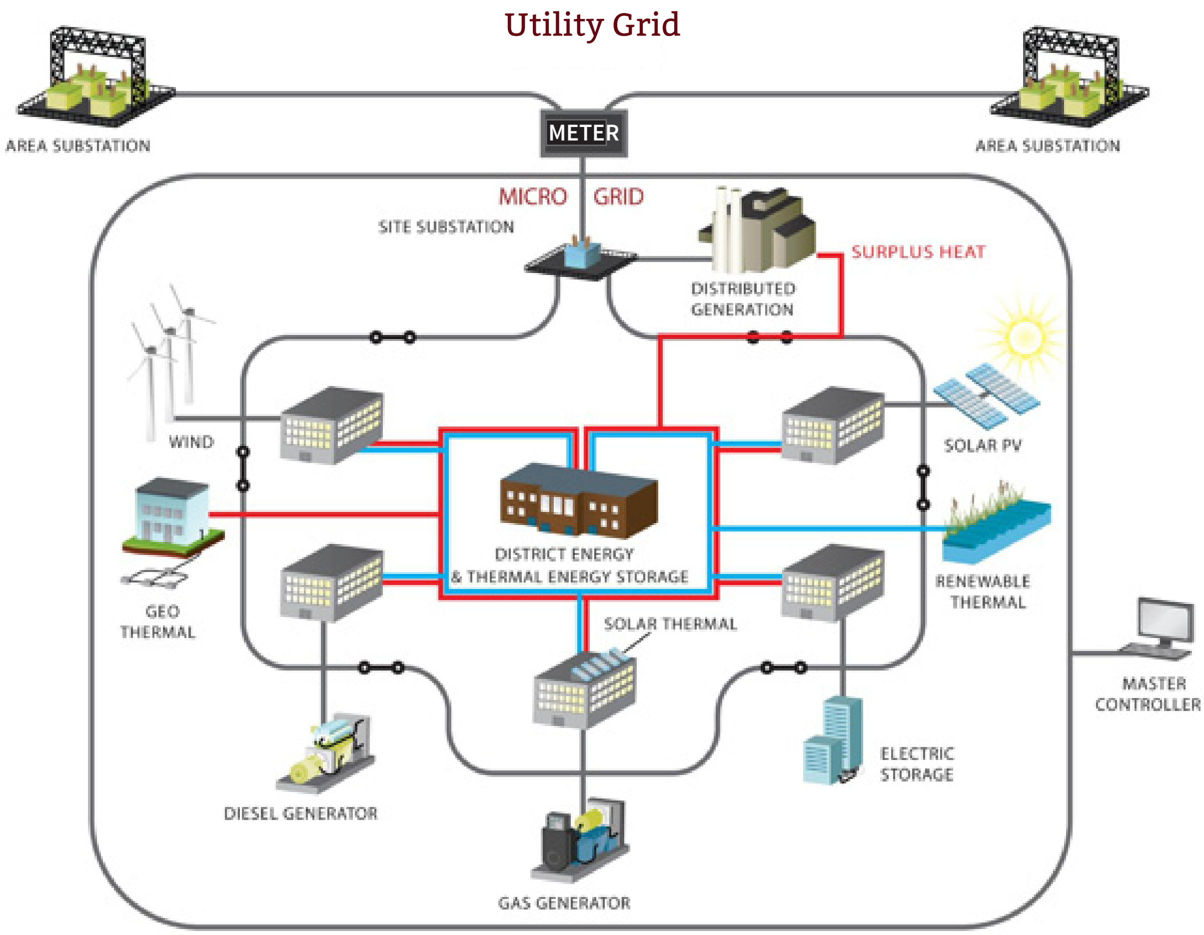
What's in a microgrid?

So what are these new, advanced microgrids exactly?

There is no one type of microgrid. This is not a plug-and-play technology; it is customized to solve a particular community energy or grid problem.

A form of distributed energy, microgrids often are described as mini versions of the larger electric grid because they can mimic, on a much smaller scale, the grid's primary function: energy production by more than one source and its coordinated distribution through wires and pipes to one or more customers.

There is no one type of microgrid. This is not a plug-and-play technology; it is customized to solve a particular community energy or grid problem.



Credit: "NY Prize, Building Community Microgrids in New York," Pace Energy and Climate Center, Lauren Baron

An advanced microgrid will always include at least one form of power production. The power often is produced by natural gas, diesel, renewable energy or fuel cells.

To achieve high efficiencies, many microgrids incorporate combined heat and power (CHP), and might include related district energy.

Also called cogeneration, CHP is often extolled for its two-for-one advantage. CHP derives twice as much energy from the same amount of fuel as does a conventional power plant. So if you spend one dollar on fuel to operate a conventional power plant, you derive a certain amount of electricity. If you spend the same dollar to operate a CHP plant, you derive the same amount of electricity, plus heat energy that you can use to heat or cool buildings, manufacture products, or use in some other heat-intensive process. CHP makes use of the heat created in the process of generating power. Conventional power plants, in contrast, simply discard the heat.

District energy, often coupled with CHP, also is a part of some microgrids. A district energy system supplies steam or hot water for space heating and chilled water for air conditioning through an underground piping network, enabling connected customer buildings to avoid installation of boilers, chillers and cooling towers. The thermal grid creates an economy of scale that facilitates deployment of CHP and other highly efficient or renewable technologies. Very often, thermal energy storage provides additional benefits in optimizing production during off-peak hours and displacing peak demand during more expensive daytime periods.

For more details about microgrids that include CHP and district energy, see our earlier Think Microgrid guide: "The Energy Efficient Microgrid: What Combined Heat & Power and District Energy Bring to the Microgrid Revolution."

> *The microgrid looks at electricity prices minutes or days ahead and also considers weather and other variables in its decision-making. The most advanced controllers manage the microgrid autonomously—without human intervention.*

Advanced intelligence

The advanced microgrid is most distinguished by its increasingly sophisticated software and controllers. Several master microgrid controllers are in development or have been released in recent months. Some of them are offered by energy industry giants who are vying to capture the growing microgrid controller market.

An advanced controller manages the microgrid's resources. It can choose to serve customers with various configurations of the microgrid's onsite power or rely on grid power, depending on what offers the greatest price and operational value. The microgrid looks at electricity prices minutes or days ahead and also considers weather and other variables in its decision-making. The most advanced controllers manage the microgrid autonomously—without human intervention.

Microgrids' advanced controllers, software, switches and sensors make them advanced energy managers.

Microgrids also may include other resources. For example, many now use energy storage, particularly batteries. Batteries are falling in price and can gain additional cost advantage for the microgrid in certain wholesale energy markets.

Similarly, electric vehicle charging stations are sometimes incorporated into a microgrid. Demand for EV charging stations remains small today. But it is expected to grow. EVs, which operate with batteries, may eventually act as widespread energy storage devices for microgrids and the larger grid.

Complex relationship with utility

Last, customers are an important part of any microgrid. The customer, or 'load', may include buildings, homes, data centers, research facilities, manufacturers or other energy users. The load is a resource that is managed on the microgrid, as is generation. Consumption is configured for maximum efficiency. For example, the microgrid's customers may take their power from the grid during periods when demand is minimal and grid prices are low. But when the grid becomes strained or prices rise, the microgrid may serve its customers with its own on-site power plants.

The local utility also is a customer of the microgrid, in the sense that microgrid can provide it with power supply and other energy services. Conversely, the microgrid is a customer of the utility, since it takes power supply from the utility when it makes economic sense to do so. So the relationship between utilities and microgrids can be mutually beneficial, even symbiotic at times.

Advanced microgrids have several abilities that make them valuable to customers and the grid. The microgrid can run in parallel to the grid or can partition from the grid ("island"), as circumstances dictate. In island mode, the microgrid stops taking service from the grid and acts as a standalone source of power supply for its customers. This can be particularly valuable to mission-critical facilities housing surgical centers or research, since it reduces the urgency for grid service resumption.

Advanced microgrids also have black-start capabilities, which allow generators to start up cold. Ideally, the generator supplies power without the customer experiencing any interruption. This function, when fully in place, makes it so that customers are unaware that the microgrid shifted between grid power and self-supply. IEEE has created standards and best practices for safe microgrid islanding, black-start operations, and grid-reconnection, known as IEEE 1547.4.

Now you know the origins of today's microgrids and their basic features and relationship to the grid. So should your community pursue microgrid development? Consider the four main benefits of microgrids that we explain in Chapter 3.

Chapter 3

Four Good Reasons for Community Microgrids

Electric reliability, a strong grid, economic development, efficient and green energy supply

It is clear why city leaders are turning their attention to microgrids. Energy is the lifeblood of any contemporary community, and severe storms in recent years have revealed the vulnerability of the central grid. The American electorate knows this and is concerned. In a March 2015 Gallup poll 88 percent of those surveyed described themselves as worried about energy availability and affordability; 63 percent said that their concern ranges from a fair amount to a great deal.

Moreover, microgrids help address three of the major challenges faced by cities that U.S. mayors cited in a separate survey: infrastructure, finance and economic development. A highly functioning electric grid is one of the most crucial forms of infrastructure in any modern town or city, and it is one that can ease the cost of other services and spur economic development.

Taking into account the priorities of city leaders, and the concerns of the electorate, here are four good reasons for cities and towns to pursue microgrids.

1 Microgrids keep the lights on in a crisis

Microgrids are characterized by their ability to separate or island from the central grid. They can halt their flow of power to the grid, or from the grid at any time. This spares the microgrid and its customers from also becoming victim to a power failure moving along the grid.

When it islands, the microgrid turns on its on-site generation to send power to its customers. In community microgrids, customers are likely to be critical service facilities; possibly police, fire, hospitals, grocery stores, or gas stations.

Community members who have lost power know that they can travel inside the microgrid's borders for medical care, shelter, food. During a power outage in 2013, San Diego Gas & Electric contacted customers who had medical conditions and invited them to go to a cool zone, set up at a resort in Borrego Springs, the site of a microgrid that serves 2,800 customers.

Sometimes the microgrid's services are less tangible, but equally important in a crisis. A Whole Foods in Brooklyn designed a microgrid as a place of refuge for people to gather, exchange information, charge phones and get in touch with distant family members, who may be worried about their well-being.

2 Microgrids can strengthen the central grid

Microgrids offer benefits beyond keeping the lights on during power outages. They can help the central grid function better.

For example, during extreme hot and cold weather, the central grid sometimes becomes overtaxed. The microgrid can 'shed load' during these periods to ease strain on the central grid. This means that the central grid stops transmitting power to certain facilities and the microgrid takes over.

Depending on where in the U.S. it is located, a microgrid may be allowed to provide other "ancillary" services for the central grid, such as helping to maintain the grid's ideal frequency.

Or a microgrid may participate in a demand response program, where utilities or grid operators call upon the microgrid (and other participating customers) to temporarily reduce their energy consumption. This occurs when short-term power prices spike or a power outage appears imminent. Microgrids receive financial compensation for these grid services.

Last, but certainly equally crucial, a microgrid offers grid security in the face of a growing number of cyberattacks. Homeland Security has reported that foreign hackers are targeting the U.S. energy infrastructure. This is one of the reasons the military has been at the forefront of microgrid development.

The U.S. grid is particularly vulnerable because much of it is interconnected, like one large machine. Damage can cascade for miles, knocking out power to not just city-after city, but also state-after-state. The U.S. experienced such an event in August 2003, when 55 million people in the Northeast, Midwest and Canada lost power. Unfortunately, few microgrids existed then.

3 Microgrids can enhance community economics

Microgrids can strengthen community economics several ways—from attracting new businesses to reducing electricity rates.

Energy is a main input in pricing of most goods and services. Microgrids offer a means to help keep electricity rates in check through better grid management. This occurs in several ways.

First, good development practice dictates that buildings within a microgrid undergo cost-effective energy efficiency improvements. This reduces the need for power within the microgrid, so it cuts back on fuel and other generation-related costs.

Second, some microgrids are designed to serve areas of the grid experiencing an overload. The microgrid may offer a less costly solution than construction of new substations or transmission and distribution lines. Several of these 'non-wire alternative' microgrids are now being planned in New York.

In addition, advanced controllers and software allow microgrids to operate in a highly efficient—and therefore cost-effective manner. Many microgrids also make use of valuable heat discarded and wasted in conventional power plants, which improves their economics and bankability.

Last, by easing energy costs, microgrids offer cities and towns competitive advantage in attracting industry and jobs.

It's important to note that the presence and proximity of a microgrid also can help draw industries that are sensitive to power outages, such as data centers, research facilities, pharmaceutical manufacturers and other high tech industries. These industries seek what is known as five 'nines' electricity, meaning that power is available 99.999 percent of the time. Cities and towns that offer that level of reliability will find themselves better positioned to compete when these highly sought-after businesses are seeking a new location.

4 Microgrids improve the environment

Foster renewable energy

Many cities are attempting to incorporate renewable energy into their energy mix. Some have set specific goals. Phoenix, for example, intends to make renewable energy 15 percent of its mix by 2025. Some are even striving to become 100 percent renewable—and succeeding. The town of Greensburg, Kansas, now gets all of its electricity from renewables after being rebuilt following its almost total destruction from a tornado in 2007.

Microgrids can help these cities more easily incorporate renewable energy in two ways.

First, many microgrids include renewables, in particular solar, which has become increasingly appealing because of its falling costs and low carbon footprint.

Credit: National Renewable Energy Laboratory

There is a downside to solar and other forms of renewable energy; they can't always be counted on to produce energy. The sun doesn't always shine and the wind doesn't always blow. But microgrids with advanced controllers and more than one generation source can accommodate this variability; they are able to select the best mix of resources—without human intervention. Based on weather forecasting and other factors, the microgrid selects and uses the mix of generation that works best at any given time.

Microgrids also can play a role in assisting the larger grid with its integration of renewable generation. The microgrid can act as a backup resource on the grid when solar and wind farms do not produce power. And as demonstrated at the Princeton University microgrid, a natural gas turbine generator can react and respond quickly to an unforeseen voltage sag caused by a dense cloud passing over a 4.5 MW solar farm.

Help cities meet climate goals

Climate change is a growing concern among municipal leaders, especially those who are along the coasts or who have experienced recent severe weather. Some cities have set greenhouse gas reduction goals.

Boston, for example, is striving to reduce greenhouse gas emissions 25 percent by 2020 and 80 percent by 2050, mirroring a mandate the state of Massachusetts has set for itself. As part of its plan, the city is encouraging development of more microgrids that use CHP and district energy. These would add to the city's district energy networks operated by Veolia, which serve about 250 commercial and government buildings, hospitals, universities and other institutions. The network spans 45 million square feet in Boston and the Longwood Medical Area as well as the biotechnology corridor of Cambridge.

Credit: Veolia North America

More cities are expected to do the same, as a way to help their states develop strategies that will be required under the Environmental Protection Agency's pending Clean Power Plan.

Interestingly, in trying to achieve these goals, cities may also reduce their electric rates, if they pursue a systems approach that incorporates CHP connected to microgrids. That's one idea explored in a new report, "Smart Tools in a 111(d) Toolbox: Combined Heat and Power (CHP) and District Energy."

"District energy and CHP, coupled together, offer buildings an incredibly flexible and cost-effective local solution to meet onsite energy needs, while also providing considerable emissions reduction benefits," said report author, Anna Chittum, Manager, Strategic Initiatives at the International District Energy Association (IDEA).

As the reports notes, CHP and DE could be excellent compliance options for states.

"CHP systems have always offered a way to do more with a single fuel input, offering a greater 'bang for the buck' while simultaneously reducing emissions intensity. They utilize much more of the useful energy of their fuels, often more than twice as much. In other words, they burn far less fuel to supply the same amount of energy, making their energy inherently less emissions-intensive."

Given these four good reasons to build microgrids—electric reliability, grid strengthening, economic advantage, and environmental improvement—we're likely to soon see many more microgrids in U.S. cities and towns. But how will communities pay for these microgrids? We survey the options in Chapter 4.

Chapter 4

Incentives and Financing for Community Microgrids

From government funding to private financing

Financing microgrids for cities and towns may require piecing together funding from a variety of potential sources. Each project requires a customized approach, and an evaluation of not only costs, but also potential revenue sources.

When you first seek out financing for a municipal microgrid, your team should assess your organization's credit quality, the sponsor's capital resources, and your preferred ownership structure. Based on these considerations, your team may choose to use equity financing, debt financing, government funding, leasing, or third-party services.

Although much of the early financing for microgrids has come from government agencies, a private financing market is emerging through large companies such as Siemens and Schneider Electric. Local banks and utilities can also play a role.

Microgrid financing often must cover various components of the project, such as power and energy generation systems, energy efficiency retrofits, and distribution systems and connections. Microgrids are likely to improve their bankability if they increase their value by offering thermal energy as well as electricity.

State funding

So far, much of the funding cities and towns have tapped for microgrids comes from government sources. These may include energy bonds, tax credits, grants, loans, tax deductions, and credit enhancements from federal organizations. It is not unusual for governments to provide early funding for energy technologies that they see as promising but in need of an initial boost to create demonstration projects.

Some states also offer incentives for microgrids, or for components of the project, such as combined heat and power. In Chapter 6 we profile several of these projects.

Most notable among state programs is the NY Prize, a $40 million grant program to create model community microgrids. New York has already begun awarding $100,000 prizes to cities for feasibility studies in the first stage of what will be a three-stage grant process.

Massachusetts in 2014 granted $18.4 million to cities and towns for energy resiliency projects, including microgrids. Connecticut has allotted $23 million to microgrid projects through two competitive solicitations, with most of the funding going to municipal projects. The New England state at this writing was planning a third round of microgrid funding. California funded $27.3 million for 10 microgrid and electric vehicle charging projects, including several that will benefit municipalities.

In addition, New Jersey has created a $200 million resilience bank for the development of distributed energy resources at critical facilities. Other states, including California, Connecticut and New York, have developed Green Banks, which use public funding to leverage private capital; the funds may cover components of microgrids, such as solar energy.

But most notable among state programs is the NY Prize, a $40 million grant program to create model community microgrids. New York has already begun awarding $100,000 prizes to cities for feasibility studies in the first stage of what will be a three-stage grant process. Money is available for local governments, community organizations, non-profit entities, for-profit companies and municipally-owned utilities. More details about NY Prize are here.

Several state incentive programs also exist that can help fund the generation portion of the microgrid, particularly combined heat & power and solar.

Other government financing

In addition, energy bonds such as qualified energy conservation bonds (QECBs), taxable bonds, and tax-exempt bonds may assist municipal microgrid developers. Agencies can issue tax-exempt bonds to access lower interest rates than banks provide.

Several federal tax credits are available for the generation portion of a microgrid. However, municipalities generally must partner with a private entity for the project to reap the tax benefits.

Federal tax benefits can be grouped into two types: investment tax credits (ITCs) and production tax credits (PTCs). ITCs cover the capital costs of renewable energy sources and cogeneration. PTCs cover large-scale wind power, biomass energy, and other renewable energy sources.

Specific federal tax credits cover qualified fuel cells, solar power, wind power, microturbines, biomass, geothermal energy, CHP, thermal pumps, marine power, hydropower, and energy from municipal solid waste. These tax credits are usually 30 percent, but some are only 10 percent. Some of these credits are no longer available, since they required construction to begin before 2014. The remaining credits will expire at the end of 2016 unless new legislation changes the picture.

Tax credits benefits do not offer any direct value to municipalities or tax-exempt organizations. However, municipalities can partner with private entities that can use the tax credits. This kind of partnership can lead to more favorable project economics.

Credit enhancements allow borrowers to ask third parties to commit to pay their debts in case of default. The third parties' credit ratings help to lower costs for the borrowers. Credit enhancements are available from the United States Department of Agriculture, the United States Department of Energy, and other funders.

Tax deductions for cities and towns developing microgrids may include the commercial energy efficiency deduction on capital costs, accelerated depreciation on the capital cost of energy projects, and sales or property tax exemptions.

Private financing

Cities and towns can access private financing through partnerships with public benefit corporations, energy service companies, private investors, banks and utilities. Private equity firms are beginning to offer financing specifically for community microgrids.

Credit: Veolia North America

Public benefit corporations can issue tax-exempt leases to nonprofits for energy efficiency and cogeneration equipment in some cases.

Energy service companies can own and operate microgrids for municipal customers. Customers pay these companies in the same way as they would pay utilities.

Private investors support equity financing by contributing to projects and then receiving shares of the returns. There are two methods of using shared savings to finance microgrids. In one approach, the developer provides the capital and shares more of the savings. In a second approach, the sponsor plays that role.

Banks provide debt financing with the expectation of being repaid through principal and interest payments. Credit ratings and credit enhancements determine the interest that the debt financiers assess.

Many utilities offer incentive programs that provide rebates and rewards to cities and towns.

Conclusion

As you draw up the blueprint for financing a municipal microgrid, consider the factors outlined above. Bring together a knowledgeable team of stakeholders with experience in microgrid financing. Evaluate the many sources of capital that can be used to support the physical components of your project. As you map out your options, inquire about each funding source to see what opportunities will work best for your town or city. Your job can be made easier by working with an experienced energy development team—particularly one knowledgeable about microgrids, CHP and district energy.

So far we've provided a basic overview of the microgrid and its components. And we've discussed microgrid benefits and how communities can pay for projects. Now we will look at next steps to develop a microgrid, and how you can serve as a leader in bringing this technology to other communities.

Chapter 5

First Steps and Future Promise

The value of a microgrid lies in its sophisticated ability to offer cost-effective solutions customized to a community's energy needs. So while the technology is proven, it is not as simple to develop as say, installing back-up diesel generators or solar panels.

Therefore, it is important that municipal leaders engage energy experts early in the planning process, so that they can configure a microgrid that cost-effectively meets the community's unique energy requirements.

Microgrids are suited to today's constrained municipal budgets, in that microgrids are modular so can be developed incrementally. A community may begin small with minimal investment and then gradually expand, adding more generators, an expanded thermal grid, and customers over time.

Credit: Wikimedia Commons

Communities sometimes build all new infrastructure for a microgrid. But it may be easier and more cost-effective to configure a microgrid around existing energy facilities, such as a CHP plant that may already serve a local hospital or college.

MICROGRID KNOWLEDGE

Where to Start

In its report, "Community Microgrids: Smarter, Cleaner, Greener," the Pace Energy and Climate Center outlines the following eight steps to follow in developing a microgrid.

1. **Set project goals.** Is the goal to maximize reliability? Cost savings? Business growth? Should the project be built in phases?
2. **Organize, educate core stakeholders.** Who are the potential champions, stakeholders and authorities who will have a say in this process? Should a steering committee be appointed? How can these parties be educated and organized?
3. **Identify project site.** Where are reasonably large pockets of consistent energy demand? Are there large energy users in these pockets who can anchor a project?
4. **Conduct 1st level screening study.** Is this project technically feasible? Is this site appropriate?
5. **Conduct 2nd level screening study.** What are the project site's daily and sub-hourly energy demands? What will be the capital costs and returns on investment?
6. **Conduct audit grade study.** What will the business model, ownership structure, tax treatment, and payback period of this project look like? How thoroughly must the technical viability of the project be demonstrated in order to attract financing?
7. **Acquire financing.** Will bonds, equity, leasing, third party ownership or some other type of financing work best for the project?
8. **Acquire necessary approvals and construct.** Will this project require zoning variances? Building permits? Revocable consents? Excavation permits?

It's also helpful for city leaders to gain a basic understanding of how electric competition works, especially in the organized power markets that serve about two-thirds of the U.S. population. Rules vary within these markets and some make it easier than others for microgrids to earn revenue by selling ancillary services to the grid.

Future promise

Microgrids are a niche technology. But energy experts increasingly envision a future where microgrids and other forms of distributed energy come to dominate the U.S. grid. They see such a grid as more nimble, competitive, price-responsive and safe from physical or cyberattack. This model puts control of energy more in the hands of consumers and communities.

Before microgrids can achieve this promise, state regulation and policy will need to catch up with new energy technology. This lag in government policy creates challenges to microgrid advancement. As a result, community leaders may find themselves grappling with some of the following issues as they develop microgrids.

Key challenges

1 How to compensate microgrids fairly

Microgrids create a new exchange of value on the grid that has yet to be monetized. It's agreed that power outages are costly to society. Microgrids help avert outages and create oases of electricity and shelter during a crisis. How should a microgrid owner be compensated for this service to society?

Kenneth Horne, associate director at Navigant Research, summed up the issue this way, in a presentation he made at the Third National Conference on Microgrids in Dallas, Texas in April 2015:

"If you are a Walmart or a Walgreens or a gas station at the time when the grid is out, you are doing more than simply selling things to customers for a profit. You are providing essential community services for citizens who have no place else to go—whether you are providing milk for a mother who has to feed her young child, or you are providing food (something most of us take for granted on a day-to-day basis) or other kinds of supply, material, perhaps shelter, perhaps warmth. The basic essential needs that we all have as human beings—that we are blessed not to have to think about on a daily basis—suddenly become the center of our lives."

2 How to manage the utility relationship

Forward-thinking utilities support the idea of microgrids and some are developing microgrids of their own. But others see microgrids as competitors. Your utility's pre-disposition makes a difference since it can affect the ease with which your project becomes interconnected with the grid during development.

Three main points of contention sometimes occur between utilities and microgrids.

1. **Who will pay what in the exchange of services?**
   As the exchange of services become more complex between utilities and microgrids, it is inevitable that issues will arise about payment fairness. Standby rates already sometimes serve as a point of friction between utilities and microgrids. Utilities charge standby rates for being at the ready to supply power to distributed energy generators. The rates vary nationwide, some high and some low.
2. **Where can a microgrid operate?**
   Utility franchise rights are at the heart of this issue. In many states a microgrid cannot string its wires across a utility right-of-way without utility or municipal permission. This can preclude the microgrid from serving customers that are across the street. Some states, among them Connecticut, Massachusetts and New York, are working on ways to resolve this issue and make it easier for microgrids to encompass multiple customers.
3. **Are utilities competitors or partners?**
   How this issue plays out is likely to vary depending on whether or not your community is in a state where electric retail markets are regulated or deregulated, and whether or not that state is creating rules that provide incentive for utilities to support microgrids.

Utilities earn revenue by selling kWh of electricity. As a result any entity that reduces those utility sales—as a microgrid would—can be viewed as a competitive threat. As an alternative, some states have implemented "de-coupling" that shifts revenue risks somewhat and creates incentives for utility performance and efficiency in exchange for anticipated reduction in simple volumetric electricity sales.

Utilities in deregulated states cannot own power plants for the most part. So from that perspective it is easier for communities and private companies to develop microgrids in deregulated states. However, issues still may arise about ownership of distribution lines that carry the power from generators to customers and equitable cost-recovery methodologies that allow accessibility to the wires under reasonable price signals.

Model for the future

Microgrids are an established technology. But they interact in new ways in energy markets and provide services not before quantified. Given the value of these services, several states are trying to determine how to resolve these challenges and smooth the way for development of more microgrids and other forms of distributed energy.

It's important for mayors and city leaders to participate because they can play an instrumental role in shaping rules that foster community microgrids. A mayor seeking an economic development advantage by offering a more resilient, clean energy microgrid to attract a high value pharmaceutical research/manufacturing campus will want regulators to enable reasonable rules for microgrid deployment and optimization.

State public utility commissions seek input on these changes. It's important for mayors and city leaders to participate because they can play an instrumental role in shaping rules that foster community microgrids. A mayor seeking an economic development advantage by offering a more resilient, clean energy microgrid to attract a high value pharmaceutical research/manufacturing campus will want regulators to enable reasonable rules for microgrid deployment and optimization.

California, Connecticut, Maryland and Massachusetts are among those that are exploring various innovations. But New York is the most closely watched because it is proposing an entire remaking of electric markets and rules that is expected to lead to significant development of microgrids and other forms of distributed energy.

Called Reforming the Energy Vision, or REV, New York's approach does more than just address the problems that can stymie microgrid development. Instead, it remakes the utility's entire role.

REV attempts to animate markets that foster distributed energy. The utility becomes a new entity, the distributed system platform, a kind of impartial distributed grid manager that ensures use of the most efficient and cost-effective mix of retail energy. In this new role, utilities no longer depend on kWh sales for revenue, but are paid for their services in managing the platform. Unable to own microgrids, except under limited circumstances, the utility does not directly compete with the private or public entities that develop microgrids.

New York has already taken steps toward putting REV in place, but many rules are still being developed. The proceeding is ongoing before the New York Public Service Commission, Docket 14-M-0101.

State rules are likely to evolve for years to come as energy consumers increasingly turn to microgrids and distributed energy. In place for over a century, the structure for energy delivery is radically changing in the U.S. The consumer and community no longer need to be passive recipients of energy, but can be active players who manage how much and what kind of energy they use. Communities do not have to wait for a final resolution of government policy to become part of this change. Indeed, many towns and cities are already moving forward with microgrids.

In the next chapter, we profile several examples of community microgrids under development or already operating.

Chapter 6

Community Microgrids in U.S. Cities and Towns

Profiles of microgrids in operation and planning

NY community leverages existing power and district energy assets for new microgrid

Jamestown, New York, offers a good example of a community microgrid design that begins by incorporating existing energy facilities, a strategy that can decrease project complexity and cost.

Rather than building all new infrastructure, the city has proposed a microgrid that will use an existing natural gas-fired power plant and district energy system.

"Jamestown has a municipal utility with a long history of employing local energy. By intelligently leveraging these assets—both power and thermal energy—the city is now just a few short steps away from establishing a community microgrid. We have seen many concepts, but this community is within striking distance," said Darek Letkiewicz of OBG, whose engineering team assisted the Jamestown Board of Public Utilities (JBPU) in applying for NY Prize funds to develop the project.

Established in 1923, JBPU is one of the oldest municipal power systems in the United States and one of the largest municipal utilities in New York.

Credit: Veolia North America

A focal point of the system is the Carlson Station, a natural gas-fired power plant that is over 100 years old and has been expanded and upgraded several times. Key features of the facility are:

- A 43-MW simple cycle unit and two 22-MW steam turbine generators at Carlson Station
- Two natural gas-fired hot water thermal energy generators at Carlson Station that provide steam to 73 downtown buildings
- A 50 MVA substation on Dow Street which serves 55 percent of the municipal utility's customers

A microgrid is especially important to the city, given that it is in western New York, where severe winter storms are not unusual. JBPU customers have experienced several outages caused by failures on a National Grid 115-kV electrical transmission system that connects to the municipal utility.

The Jamestown Microgrid will use the power generation equipment located at the Carlson Station, along with an onsite 35kV/15kV electrical distribution substation. The equipment will power underground electrical distribution circuitry.

"The system will ensure a high level of utility service reliability in the core area of downtown Jamestown, independent of the grid," said Letkiewicz.

Since the core only consumes 9 MW—and the Carlson station offers 43 MW—the microgrid also will be able to serve buildings and residences beyond the core.

When completed, the Jamestown facility can serve as a model for other communities where relatively minor changes can bring microgrid capabilities to existing infrastructure.

Other examples of community microgrids in operation or planning

Brookhaven

Brookhaven, New York is working on a community microgrid design that will help it reach its goal of a 50 percent reduction in greenhouse gases by 2020. The plan incorporates a town hall in Farmingville for emergency operations and shelter, the adjacent Sachem East High School as an emergency shelter, and possibly the Cayuga Elementary School as an emergency shelter and emergency supply distribution center. Brookhaven also may bring nearby homes into the microgrid.

Credit: National Renewable Energy Laboratory

With some distributed energy already in place, the Long Island community sees itself as well-situated for a microgrid. The town has a 10-kW wind turbine installed at the town hall as well as an on-site sewage treatment plant. A high school adjacent to the town hall also has a 10-kW wind turbine. And large parcels of land nearby create opportunity for solar photovoltaics.

Co-Op City

New York City's Co-Op City, managed by RiverBay, is one of the world's largest cooperative housing developments. Located in the Bronx, it also is home to a community microgrid that includes a 40-MW combined heat and power plant.

The microgrid serves :

- 50,000 residents
- more than 15,000 apartment units
- 35 high rise buildings
- seven townhouse clusters

Co-Op City made headlines during SuperStorm Sandy because its residents did not lose power thanks to the microgrid.

Blue Lake Rancheria

Humboldt State University is developing a low-carbon community microgrid for the Blue Lake Rancheria, a tribal community in Humboldt County, California.

The project will include a:

- 500-kW ground-mounted solar array
- 175-MW biomass gasifier fuel cell
- 800-kWh energy storage system (battery)

The system is expected to offer cost savings for the tribe and ease stress on California's grid through demand response, peak shaving and load shedding. The community serves as an American Red Cross critical support facility, so it is important that it maintain power in a crisis, particularly since it located in Northern California, an area prone to earthquakes and wildfires.

Burrstone Energy Center

Located in Utica, New York, the Burrstone Energy Center provides heat and electricity to a local hospital, nursing home and college.

The system includes:

- a combined heat and power plant with three 1100-kW
- one 334-kW natural gas fired reciprocating engines

The plant, which began operating in 2009, can provide:

- 3.6 MW of 13.2 kV electricity
- 7000 lbs/hr of 85 psig steam
- 700 gpm of hot water

The facility also is capable of exporting power back to the grid.

Hoboken

Hoboken, New Jersey is prone to flash floods and subsequent outages, so is planning an underground community microgrid that may serve as many as 55 facilities. The undergrounding adds to construction costs, but hardens the microgrid to storms. The distribution backbone—all conduits—will be flood-proofed and buried. Hoboken's microgrid design differs from others described in this guide, in that it would be a stand-alone facility, not connected to the grid, as now conceived.

Credit: Wikimedia Commons

Hunters Point

Hunters Point is a community in San Francisco that has struggled for decades with poverty, unemployment and toxic waste following the closing of a shipyard. As part of its economic revitalization Hunters Point is developing a microgrid designed to serve 20,000 residents. The grid-connected microgrid would generate most of its power, about 50 MW, from solar installations on rooftops or in parking lots. The project is modeling how to integrate bulk power onto the grid at the substation level.

Northampton

The western Massachusetts town of Northampton plans to develop a microgrid that will serve three facilities during a crisis: a hospital, a vocational school, and the city's department of public works.

The city is studying:

- critical loads
- a microgrid control strategy
- feasibility of interconnecting across a public way, economical natural gas generation and possible alternative on-site generation or storage

Red Hook

The New York Power Authority is assisting with microgrid evaluations in the Brooklyn neighborhood of Red Hook. The public housing complex of 2,800 apartments in Brooklyn is particularly vulnerable to storms because it is near the waterfront.

The study analyzes various possible local energy sources for the Red Hook microgrid, among them combined heat and power, emergency generators, and heat and hot water systems.

NYPA on behalf of New York City Housing Authority commissioned OBG to investigate how improvements to existing infrastructure—electric, natural gas, steam, and emergency or backup power—can bring greater storm resiliency to the community.

Red Hook may serve as a model for resilient development by the New York Housing Authority for its more than 334 public housing developments.

Sherburne

Sherburne, New York is studying installation of a microgrid to provide energy reliability and resiliency to the village's fire and police departments, the Village Hall, a health clinic, and a wastewater treatment plant. The project will include combined heat and power and renewables, such as solar photovoltaics.

Woodbridge

The small Connecticut town of Woodbridge is developing a microgrid in partnership with local utility United Illuminating.

The microgrid will feature a:

- 7.8 MW of renewable energy
- 2.2 MW fuel cell

Under the agreement, the utility owns the fuel cell and maintains it, while the town owns and controls the microgrid. The fuel cell will supply power to the grid during normal operations. But during a power outage, the microgrid can island and keep electricity flowing to the:

- town hall
- library
- fire and police stations
- public works
- high school
- emergency shelter

The fuel cell will be installed at the high school, where it will supply waste heat.

Further Reading on Community Microgrids

- "Community Microgrids in New York," Thomas Bourgeois, Pace Energy and Climate Center.
- "Microgrids – Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts," Massachusetts Clean Energy Center
- "Strategies for Integrating Solar and Distributed Generation for Emergency Power & Resiliency Deployment," The City University of New York
- "The Integrated Grid: A Benefit-Cost Framework," Electric Power Institute
- "Microgrids: From Resiliency to Solvency: The Business Case for Community Microgrids," Navigant Energy
- "Microgrids: An Assessment of the Value, Opportunities, and Barriers to Deployment in New York State," NYSERDA
- Reforming the Energy Vision, New York Department of Public Service

Special thanks to the International District Energy Association (IDEA) and OBG for making this guide possible.

About the International District Energy Association

Established in 1909, the International District Energy Association (IDEA) serves as a vital communications and information hub for the district energy industry, connecting industry professionals and advancing the technology around the world. With headquarters just outside of Boston, Mass., IDEA comprises over 2,000 district heating and cooling system executives, managers, engineers, consultants and equipment suppliers from 25 countries. IDEA supports the growth and utilization of district energy as a means to conserve fuel, increase energy efficiency and reduce emissions to improve the global environment.

About OBG

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