White Paper

Nine Lessons Learned from Successful Community Microgrids

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Summary

Only a small number of the more than 2,200 microgrids worldwide are “community microgrids” – meeting the needs of communities and their citizens and local businesses, rather than discrete entities, such as individual universities, military bases, or commercial/industrial customers. Despite their limited number, existing community microgrid installations provide a wealth of leading practices. This white paper documents a comprehensive review of these community microgrids, which identified these practices. The lessons learned documented in this white paper can help microgrid developers and service providers work closely with communities, utilities, regulatory agencies, and other stakeholders to accelerate growth of the community microgrid market.

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Introduction

While most existing microgrids serve a single entity (e.g., a university, military base, or commercial/industrial customer), a community microgrid can serve more than 1,000 energy users. While the potential benefits of community microgrids are numerous for all involved parties,[1] to date, only a small number of community microgrids are operating or planned worldwide.[2]

Using Navigant 2018 data, a Swedish Energy Agency study identified 2,258 microgrid projects worldwide, which includes 13 community microgrids (six in the U.S. and Canada) [1]. In the U.S., the following six community microgrid projects provide a growing body of operating experience and leading practices:

- The Borrego Springs (California) community microgrid [2,3]
- The Reynolds Landing community microgrid near Birmingham, Alabama [4,5]
- The Blue Lake Rancheria community microgrid in Northern California [6-9]
- The North Bay Community Energy Park in Ontario, Canada [10]
- The Parkville, Connecticut's fuel cell community microgrid [11,12]
- The Bronzeville community microgrid in Chicago [13,14]

Awareness of projects like these, and lessons learned from them, can help microgrid developers and service providers make informed decisions when considering or embarking on community microgrid projects.

[1] To learn more about the potential benefits of community microgrids, refer to the companion white paper "What on Earth is a Community Microgrid?" on the publications page of Hoffman Power Consulting.
[2] To learn more, see "Six Barriers to Community Microgrids...and Potential Ways Microgrid Developers Can Overcome Them," on the publications page of Hoffman Power Consulting.

Overview of Lessons Learned from Existing Community Microgrids

A recent review of these operating community microgrids yields the following list of leading practices, each of which is described in more detail in the remainder of this paper:

- **Define the threats to resilience** in the geographical area; and during project planning, describe how the proposed community microgrid can effectively help mitigate these threats
- **Integrate improved energy efficiency of the buildings** in the proposed microgrid
- **Integrate distributed renewable generation and electric energy storage** into the proposed community microgrid project
- **Consider using the energy-as-a-service (EaaS) business model** to minimize or eliminate the need for the community or energy users to provide upfront capital for the project
- **Incorporate community education and learning activities** in the project
- **Create an "oasis" community microgrid** by incorporating a combination of resources into the project that provides the community various services needed in an extreme event
- **Provide benefits to traditionally underserved parts of the community**, which extreme events typically impact disproportionately compared to other parts of the community, due to their greater vulnerability and limited resources
- **Optimize site selection to consider various other factors**, including local power system reliability, future load growth potential, local substation condition, and critical local electric and other infrastructure that requires enhanced resilience
- **Tie the new microgrid to an existing single-entity microgrid**, such as a neighboring university or commercial/industrial customer microgrid

Define the Relevant Threats to Resilience

While microgrids can reduce electricity costs and generate revenue for customers, incorporate clean energy, and enhance power reliability and quality, they are also a solution to enhance community resilience to various extreme events. Defining these threats, and positioning the community microgrid as way to mitigate them, can enhance the likelihood of project approval.

For example, San Diego Gas and Electric Company (SDG&E) initially established the community microgrid in Borrego Springs, California in 2013 due to the town's vulnerability at the end of a single transmission line. However, the microgrid immediately demonstrated its resilience capabilities by enabling the town's faster recovery from severe thunderstorms in September 2013 than would have been possible without the microgrid. An upgrade completed in 2018 now enables the microgrid to island from the grid and maintain power to the entire town, including its 2,500 residential and 300 commercial and industrial customers [2,3].

In Montecito, California, mudslides destroyed 400 homes and killed 23 people in 2018. This "Goleta Load Pocket" is vulnerable to the failure of one set of transmission lines that winds through 40 miles of mountainous terrain. As a first step towards addressing significant resilience issues via a larger planned Goleta Load Pocket Community Microgrid, a 40-MWh utility-scale storage project is projected to go online in December 2020 [15].

In Alabama, a destructive and deadly tornado in March 2019 reinforced the need for electric power resilience in this part of the country. Partly motivated by this event, Alabama Power is now operating what it calls the Southeast U.S.'s first community-scale microgrid. This project is an example of a purely residential suburban microgrid, powering 62 new energy efficient homes in the Reynolds Landing neighborhood outside of Birmingham, Alabama. A 400-kW photovoltaics (PV) array, 400-kW natural gas generator, and a 600-kWh battery energy storage system (BESS) power the microgrid [4,5]. The neighborhood's efficient homes and the microgrid are the subject of an in-depth research project, which is intended to learn more about the benefits of this sort of system. The project includes Alabama Power, the Electric Power Research Institute (EPRI), Oak Ridge National Laboratory, homebuilder Signature Homes, and equipment vendors Carrier, Rheem, and Vivint [4,5].

In Brownsville, Brooklyn, Consolidated Edison Company of New York (ConEd) developed the Marcus Garvey Village Apartments microgrid, partly in response to Superstorm Sandy in 2012.

In Hartford, Connecticut, Hurricane Irene and soon thereafter a Nor'easter in October 2011 disrupted power to 750,000 homes, many for up to 11 days. As part of its response to enhance resilience during storms like these, the city worked with Constellation Energy to develop a community microgrid in a selected dense urban portion of its Parkville neighborhood [11, 12].

In North Bay, Ontario (Canada), municipal utility North Bay Hydro Services teamed with S&C Electric Company to install a community microgrid devised in response to the ice storm that disrupted power to over 600,000 customers and caused at least 27 deaths in December 2013 [10].

Enhance and Integrate Energy Efficiency of Buildings

Within a community microgrid, increasing the energy efficiency of buildings and facilities reduces the amount – and therefore the cost – of distributed generation and storage capacity needed to power the microgrid in island mode. Building energy efficiency also aids resilience to extreme events because it delays the depletion of on-site energy resources. For example, as the Rocky Mountain Institute (RMI) points out, a 10-kWh battery can power an efficient (US SEER 18)[3] 1.5-ton air conditioner for 3 hours, but can power a similar-capacity, low-efficiency unit (US SEER 9) for only about 1.5 hours [16]. On hot days, air conditioning increases in importance, especially for the elderly or medically vulnerable.

In a more energy efficient building, batteries that provide backup power at night and on cloudy days for a solar PV-powered microgrid can supply critical needs for longer periods. Energy efficient measures such as reducing air infiltration can extend the amount of time a building remains comfortable. Moreover, energy efficiency is a local, decentralized technology, which is less vulnerable to disruption than centralized technologies. This means that energy efficiency is well suited to complement microgrids as an integral part of a community resilience strategy.

Integrate Distributed Renewable Generation and Storage

Distributed Renewable Generation and Storage

A variety of energy resources can power a community microgrid. Local renewable generation such as hardened rooftop PV is resilient due to its lack of dependence on non-local fuels. This attribute, combined with its availability and decreasing cost, utility incentive plans, government tax incentives, and various clean energy mandates, makes it ideal for a community microgrid.

Diesel-fueled backup generators and natural gas-fired turbines and microturbines may be necessary to supplement the renewable generation. To support decarbonization goals and reduce fuel supply reliance, solutions involving fossil fuels need to be designed to support modular upgrades as the cost and availability of high performing, zero emission options continue to evolve rapidly. However, fossil-fuel-based resources are less resilient due to their reliance in most cases on non-local fuel supplies, which may be disrupted during and after extreme events.

[3] Seasonal energy efficiency ratio

Large-scale or distributed renewable generation that is not physically connected to a community microgrid is a less resilient solution. Although developers installed more than 7 GW of distributed PV generation in California from 2007 to 2018, most of it is not available when the grid goes down [17]. By contrast, PV arrays *within* a community microgrid remain available to customers connected to that microgrid.

Local BESSs can extend the period of time that PV provides backup. Although BESS costs have decreased significantly in recent years, their ability to economically complement PV is currently limited to about four hours of storage for most customer-facing outages[4] [18].

SDG&E's Borrego Springs Microgrid is home to what the California Energy Commission (CEC) calls "California's first renewable energy-based community microgrid." A 26-MW central PV system, 3.6 MW of distributed generators, 3 MW of customer-owned rooftop PV systems, and local storage power the microgrid [2,3].

Vehicle-to-Building and Vehicle-to-Microgrid Storage

A community microgrid can incorporate public charging stations for EVs (powered from a central community PV array), so that residents can retain their mobility. Recharged EVs can also supply power back to a home or other building in the microgrid (i.e., vehicle-to-building resilience):

- A 2016 RMI study on EVs as distributed energy resources (DER) points out that the

[4] This estimated storage time period depends on BESS capacity and whether both the main grid and distributed generation charge the batteries.

60-kWh battery in the Tesla Model 3 stores enough energy to power an average home for two days [16,19].

- Another example is potential use of electric school buses to provide backup power to schools, which can act as emergency shelters, meeting places, and centers for distribution of emergency supplies.

In 2019, electric cooperative Holy Cross Energy in Basalt, Colorado was considering the latter application to enhance community resilience in the wake of a wildfire that swept through Roaring Fork Valley in 2018 [20].

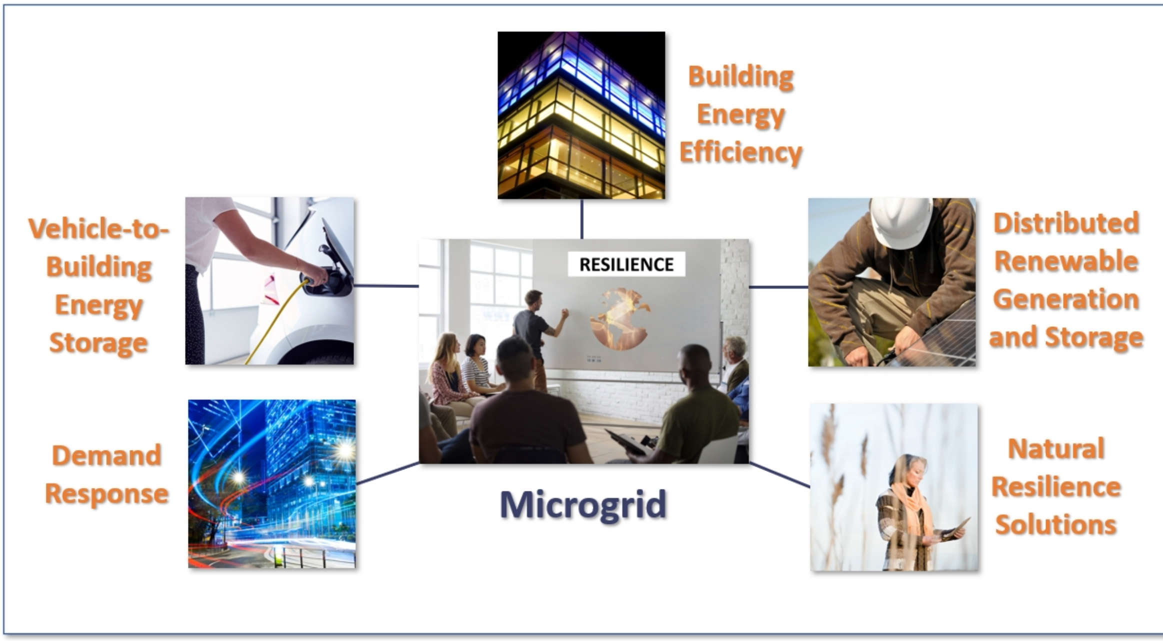
Recharged EVs can also supply power and other grid services back to the entire microgrid (i.e., vehicle-to-microgrid resilience). According to the RMI study, "Considered as a pooled resource, the growing number of electric vehicle batteries could provide a wide range of valuable grid services, from demand response and voltage regulation to distribution-level services, without compromising driving experience or capability" [19].

In this way, the EV acts as an alternate source of electric storage, extending the value of local renewable generation and addressing the economic and capacity limitations of BESSs. Thus, an EV provides a flexible and mobile rechargeable electricity storage device. While still in its infancy and rarely deployed in this way, vehicle-to-building or vehicle-to-microgrid storage holds promise as a resilience solution and can add to the already substantial list of EV benefits.

By integrating building energy efficiency, distributed renewable generation, distributed storage, as well as intra-microgrid demand response[5] and even natural resilience

[5] A community microgrid can also use microgrid demand response approaches to reduce the needed peak capacity of generation and storage resources during peak demand periods. This demand response capability, along with energy efficiency, can significantly reduce microgrid infrastructure costs and payback period, while increasing investment value.

solutions,[6] a community microgrid can become an integrated system of resilience solutions (see figure below). In addition to resilience, each of these solutions can also offer day-to-day value-added benefits to communities, residents, and businesses through distribution load management and energy savings.



A community microgrid can be an integrated system of resilience solutions.

Consider Using the Energy-as-a-Service (EaaS) Model

In recent years, ownership, financing, and other aspects of microgrid business models have evolved. Third-party ownership and financing, and various types of EaaS models are now the models of choice for microgrid projects, rather than customer-owned or community-owned options. Such arrangements, which typically include some sort of power-purchase agreement (PPA) or pay-as-you-go system, minimize or eliminate the need for customers or communities to invest the significant upfront capital that many microgrid projects require. Resiliency-as-a-service (RaaS) is also emerging as a means to monetize the combined energy and risk mitigation benefits of community microgrids.

[6] Using solutions inspired by nature, a community microgrid can be *naturally* resilient. These solutions include white roofs (to reflect heat), urban tree canopies (to provide shade and reduce heating load), and wetland and riparian resource restoration (to provide natural flood resistance).

A 2019 Navigant study found that, as of the second quarter of 2019, 81% of microgrid projects worldwide use an EaaS model. In contrast to a utility rate-base or owner financing approach, EaaS "simplifies operations, reduces capital cost barriers to deployment, and syncs up well with the recent trend on developing modular microgrids," according to the report [17].

Wood Mackenzie Power & Renewables tracks 2,250 microgrids. In March 2019, it reported that more than 50% of 2018 U.S. microgrid projects were third-party-owned, and that third-party financing supported 80% of new microgrids in 2018. "Financing options for microgrid development are making microgrids a more accessible solution for price-sensitive organizations," explained Isaac Maze-Rothstein of Wood Mackenzie. "These organizations can now tap new opportunities for demand-charge management, and are not required to allocate capital away from their core business" [21].

Schneider Electric, which has designed, built, and maintained more than 300 microgrid and controls projects in North America, agrees that advantageous business models avoid a requirement for large upfront capital investment [22]. In its 2017 white paper on microgrid business models and value chains, Schneider Electric called this a microgrid-as-a-service model. The report explains that the PPA can have an equity and debt financing structure, and that part of the structure can be volumetric and part can include a capacity charge. The authors opine that it "offers a flexible ownership structure and presents the best opportunity to capitalize on this growing market" [23]. A *Microgrid Knowledge* Special Report from AlphaStruxure and a *Microgrid Knowledge* white paper from Scale Microgrid Solutions and Shell also describe the EaaS microgrid model [24,25].

Incorporate Community Education and Learning

Incorporation of community education and learning opportunities into community microgrid projects can significantly enhance their likelihood of regulatory approval. This approach also serves to increase awareness of microgrid benefits in the community across a range of stakeholders, including local regulatory and government agencies, utility leaders, community and neighborhood leaders, citizens, local businesses, investors, and the media.

One notably successful example is the Bronzeville Community Microgrid that Commonwealth Edison Company (ComEd) is installing on the South Side of Chicago. This microgrid obtained regulatory approval in part for its learning benefits, which were enhanced by locating it near an existing university microgrid (the Illinois Institute of Technology). The Illinois Commerce Commission (ICC) cited the project's "community learning benefits" [26] and approved rate base inclusion of ComEd's $25 million share of the microgrid, agreeing that learning from the project would benefit all customers [27]. This initiative includes a partnership with the neighborhood's Dunbar High School to form an Energy Academy that will help teach students about energy-related careers [13,14].

In what *Microgrid Knowledge* calls a "gold star example" of microgrids and education, Santa Fe Community College (SFCC) in New Mexico is partnering with Siemens to establish a Building Energy Automation and Microgrid Training Center, in conjunction with development of two linked microgrids [28].

Create an "Oasis"

Microgrid developers and service providers can extend the community microgrid's value so it acts as a refuge for its citizens during an extreme event – it becomes an "oasis." A community center or school in the microgrid can provide a place for residents to gather information and obtain moral support, recharge their cell phones and EVs, receive medications and medical treatment, obtain emergency fresh food and water, etc. This first microgrid in the community can act as a demonstration project that increases awareness and can lay the groundwork for additional community microgrids in the city or county.

In March 2020, an RMI article summarizes the need: "Cities need to make resilience a feature of their communities by investing in essential facilities that can provide direct relief during emergencies and can serve as a foundation for more expansive local microgrids in the future" [16].

However, urban settings provide challenges for community microgrids with solar and battery storage due to footprint limitations. In Hartford, Connecticut, the city worked with Constellation Energy to develop a community microgrid in a selected dense urban portion of its Parkville neighborhood.

During an emergency, the microgrid powers a school, community center, gasoline station, and grocery store – "all essential resources that people need during a power outage," according to Hartford City Architect Antonio Matta [11,12].[7]

The North Bay Community Energy Park in North Bay, Ontario (Canada) powers three public facilities using two natural gas generators and solar systems (789 kW total) during normal operation. In an emergency, the park operates in island mode and provides the community a centrally-located shelter with heat and power, childcare facilities for first responders, and EV and cell phone charging. Matt Payne, President and Chief Operating Officer for North Bay Hydro Services said, "We are proud to be setting the example for other utilities around the world who are considering a resiliency hub microgrid to better their communities" [29].

[7] Using a state grant, the city constructed the compact 800-kW fuel-cell-powered community microgrid that operates today. Fuel cells produce no pollutant emissions due to their electrochemical reaction (rather than combustion), are highly energy efficient, and consume less space per kW than PV [11,12].

Provide Benefits to Traditionally Underserved Populations

Traditionally underserved populations in communities are typically more vulnerable to extreme events, can be more impacted by these events, and have fewer options for coping with them when they occur. Few residents in low-income communities have energy efficient homes, solar PV, local storage backup, or EVs for backup. Few residents and businesses in these communities are part of a local microgrid, and most of these neighborhoods have overhead (rather than underground) distribution systems, which are more vulnerable to extreme event damage. In extreme events, low-income residents and business owners may have fewer temporary living opportunities when evacuation is needed. Hence any solution to enhance resilience, including community microgrids, should be equitable across neighborhoods.

In one example of a microgrid that aids traditionally underserved populations, ConEd is now operating the Marcus Garvey Village apartments microgrid in Brownsville, Brooklyn. Serving a 625-unit, eight-city-block affordable housing complex, the microgrid incorporates 400-kW of rooftop solar, a 400-kW fuel cell, and a 300-kW/1200-kWh Li-ion battery system, which can provide about 1.1 MW (of the 1.5 MW peak power). The project is the first of its kind for a multi-family residential development in New York City [30].

A small community itself, the complex includes a community center and central offices. When in island mode, the microgrid controller prioritizes power to these central facilities, so that residents can congregate to charge electronics and cook in good lighting and comfortable temperatures – effectively forming a mini community microgrid [30].

In a proposal submitted to the California Public Utility Commission (CPUC) on January 21, 2020, SDG&E summarized its planned community microgrid in Cameron Corners, which the utility describes as a "remote, low-income community." The utility plans to establish a microgrid there that will serve critical customers such as a medical care facility, CAL FIRE station, telecom central office (911 switching center), local food establishments, convenience stores, and gas (and propane) stations, "that can provide residents of this remote community with important goods and services during an outage" [31].

Optimize Site Selection

Community microgrid site selection can be a complex task. In the Bronzeville Microgrid project, ComEd used a comprehensive process to identify the site. According to the utility, "the study developed an overall resiliency metric for small sections of ComEd's northern Illinois service territory and identified locations where a microgrid could best address both security and resiliency, with a focus on public good" [32]. A *T&D World* article that three ComEd employees authored further clarified that the utility used the U.S. Public Land Survey System to divide its service territory into nearly 13,000 subsections. The utility then evaluated each of these according to "existing reliability, capacity for future growth, substation condition, and presence of critical infrastructure that requires resilience" [33].

Tie-in to an Existing Single-Entity Microgrid

Installation of a single oasis community microgrid in each community is not the end game to enhance resilience. Ultimately, each community may need multiple integrated microgrids. With this goal in mind, demonstration of interconnected microgrids would be beneficial.

The first utility-operated microgrid "cluster," ComEd's Bronzeville project will be able to share resources with an adjacent existing microgrid serving the Illinois Institute of Technology. Ultimately powered by 750-kW of solar and a 500-kW, 2-MWh battery storage system, the completed 7-MW Bronzeville Microgrid will serve about 1,000 customers, including a public library, police headquarters, a nursing and living center, various care centers, small colleges/academies, residential customers, and more. In 2019, the utility successfully tested an islanding of the first phase (2.5-MW) of the microgrid. The project is part of ComEd's Community of the Future initiative in Bronzeville [13,14].

This project is particularly interesting because it is one of the first community microgrids that plans to use solar and storage in a dense urban setting. It is likely to provide lessons for other cities considering community microgrids in dense urban locations. A Siemens paper describes and diagrams the Bronzeville Community Microgrid architecture and details technical benefits of the project [34].

To Learn More

To learn more, refer to the following white papers and report from Hoffman Power Consulting, available at Hoffman Power Consulting Publications:

- *What on Earth is an "Oasis" Community Microgrid?* Steve Hoffman and Charles Carmichael, Hoffman Power Consulting, white paper, September 2020.
- *Six Barriers to Community Microgrids...and Potential Ways Developers Can Surmount Them*, Steve Hoffman and Charles Carmichael, Hoffman Power Consulting, white paper, September 2020.
- *The Oasis Community Microgrid: Reality or Mirage? A Critical Assessment of the "Big Three" Types of Microgrids*, Steve Hoffman, Charles Carmichael, and Jim Davis, Hoffman Power Consulting, special report, September 2020.
- Visit Hoffman Power Consulting for more thought leadership papers and reports on microgrids, electric power resilience, and related topics.

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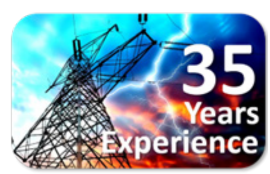

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