The Oasis Community Microgrid: Reality or Mirage?

Special Report

A Critical Assessment of the “Big Three” Types of Microgrids

September 30, 2020

Hoffman POWER CONSULTING

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The Report in Brief

In the last few decades, many commercial/industrial (C/I) energy users, universities, military bases, and public facilities around the world have implemented microgrids to reduce electric power costs, incorporate clean power (decarbonize), and enhance power reliability and quality [1]. Today, another benefit of microgrids has emerged that further strengthens their value proposition: enhanced electric power resilience.

In recent years, the increasing intensity and frequency of wildfires and extreme weather – and the threat of cybersecurity and other attacks on the electric power infrastructure – have motivated utilities, communities, and energy users to enhance the resilience of electric power systems. As a result, these stakeholders have implemented various resilience solutions, including microgrids.

Each of the 2,200 existing microgrids provides resilience for a single customer (e.g., C/I user, university, or military base). In contrast, the emerging *community microgrid* provides all the benefits of its conventional cousin – plus resilience – for multiple customers (or even an entire community).

Extending this evolution, a handful of U.S. communities have built a third type of microgrid – one that acts as a centrally-located refuge (an "oasis") for community residents during extreme events. These few existing *oasis community microgrids* have demonstrated their resilience and decarbonizing capabilities, with other benefits.

Electric utilities, communities, citizens, local businesses, and microgrid developers each stand to benefit from these next generation microgrids in potentially thousands of U.S. collaborative projects. However, significant and numerous legal, regulatory, institutional, and financial barriers in some jurisdictions complicate widespread growth of community microgrids.

Starting from the well-established conventional microgrid market, this comprehensive report describes the community microgrid market opportunity, market drivers, business models, benefits/value, barriers to implementation (and recommended solutions), prototype installations, and recent regulatory/legislative activity. The report also describes insights from COVID-19 regional and local health, safety, and economic impacts that may strengthen the case for these microgrids.

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Executive Summary

For decades, the "sweet spot" for microgrids has been single electricity customers, including enterprises with sensitive loads, universities, military bases, and others with an especially acute need to minimize power interruptions. These conventional (single-customer) microgrids have served to successfully demonstrate the value of microgrids. In many situations and for some time, they are likely to remain the microgrid of choice.

The Next Resilience "Sweet Spot"

Yet, these microgrids can also form the foundation upon which to build a broader array of primarily multiple-customer (community) microgrids. This advancement can help address the corresponding evolution of community, energy user, and societal needs – enhanced resilience, clean energy, socio-economic diversity, protection of human health, and more.

According to various experts, including Senior Fellow Richard Heinberg of the Post Carbon Institute, the community level is the next sweet spot for maximizing the impact of actions to enhance resilience. "...our cities and states are traditionally the country's laboratories for social and economic innovation. One community's experiment can inspire thousands of others – providing insights and best practices, and ultimately building support for larger-scale change" [2]. What's more, the COVID-19 pandemic may further empower local communities.

Existing U.S. Community Microgrids

In the U.S. and Canada, the following six community microgrids (described in this report) illustrate what collaborations between utilities, communities, energy users, and microgrid developers can produce:

- The Borrego Springs (California) community microgrid [3,4]
- The Reynolds Landing community microgrid near Birmingham, Alabama [5,6]
- The Blue Lake Rancheria community microgrid in Northern California [7-10]
- The North Bay Community Energy Park in Ontario, Canada [11]
- The Parkville, Connecticut's fuel cell community microgrid [12,13]
- The Bronzeville community microgrid in Chicago [14,15]

These projects are forming a body of operational experience and lessons learned that microgrid developers can leverage.

The Potential Market

Today, microgrid developers and teams of supporting service providers and equipment manufacturers make their living on single-entity microgrids. This is likely to continue for the foreseeable future. However, leading microgrid developers are looking to the future, and the potential to produce large numbers of community microgrids, like the ones listed above. In the U.S., microgrid providers could conceivably partner with any of the over 3,000 U.S. electric utilities and 750 community choice aggregators, as well as over 3,000 U.S. cities, and 3,000 counties, to increase resilience to wildfires, extreme weather, cybersecurity and physical security attacks, and other threats.

The Business Opportunity

Microgrid providers, system developers and installers, and related enterprises can build on their expertise designing, installing, operating, and maintaining single-entity microgrid expertise to collaborate on community microgrids, and realize the following potential business benefits:

- Expanded and diversified client base
- Increased revenue
- Strengthened relationships with utilities, communities, and major electricity users, enabling further business benefits
- Cross-selling of complementary value-added services, such as improved energy efficiency in buildings, distributed renewable generation, distributed storage, and electric vehicle charging.

Why Now?

Market drivers for diversifying from single-entity microgrids to community microgrids include the following:

- **For microgrid providers**, market drivers include decreasing microgrid and component costs; rising community and business interest in resilient and cost-effective solutions; increasing regulatory interest in some regions; availability of microgrid lessons learned and mature off-the-shelf technology; and business models that spread project risk and benefits across stakeholders.
- **For communities**, drivers include the desire to protect resident health and safety; maintain business continuity for local enterprises; provide social and racial equity and environmental justice; expand use of clean energy; protect the environment; availability of microgrid business models that minimize upfront capital investment; and the need for resilient electric power to support other critical infrastructure, such as water, telecommunications, transportation, emergency response, education, and healthcare.

- **For electric utilities**, drivers include the need to enhance power system reliability and resilience; ensure social and racial equity across customers; protect utility worker and customer health and safety; ensure environmental and regulatory compliance; capitalize on a potentially rapidly growing market; and improve customer satisfaction.
- **For local energy users**, drivers include the need to reduce energy costs; increase reliability and power quality for mission-critical loads; help provide social and racial equity in their communities; generate revenue; meet clean energy and environmental goals; improve community relations; and enhance resilience to business and supply chain interruption.

All in One

Microgrid providers can sweeten the pot when proposing community microgrids by considering integration of the following resilience solutions into the microgrid:

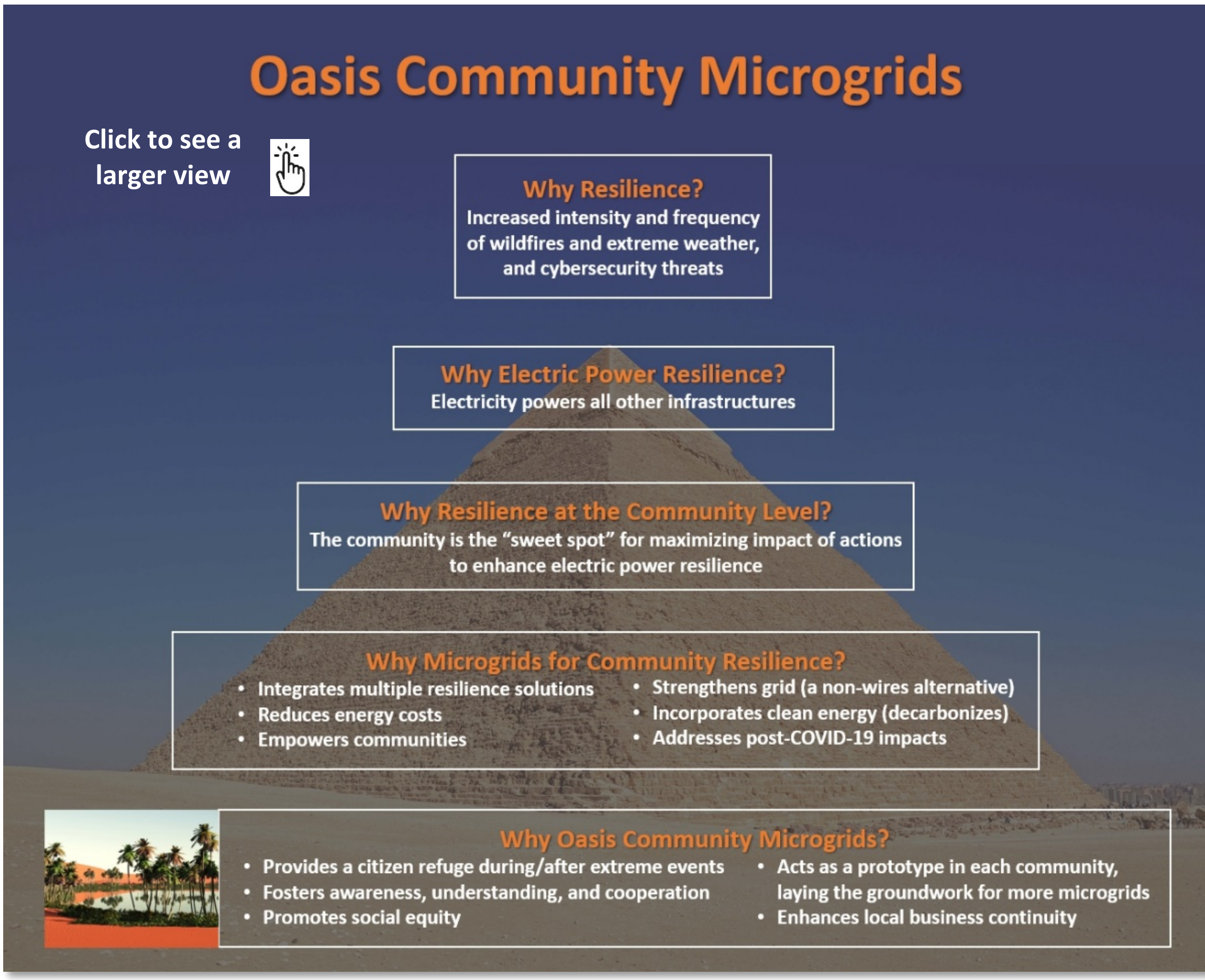
- Enhanced energy efficiency in buildings
- Distributed renewable generation and electric energy storage
- Vehicle-to-building and vehicle-to-grid storage (to support the renewable generation)
- Intra-microgrid demand response
- Natural resilience solutions

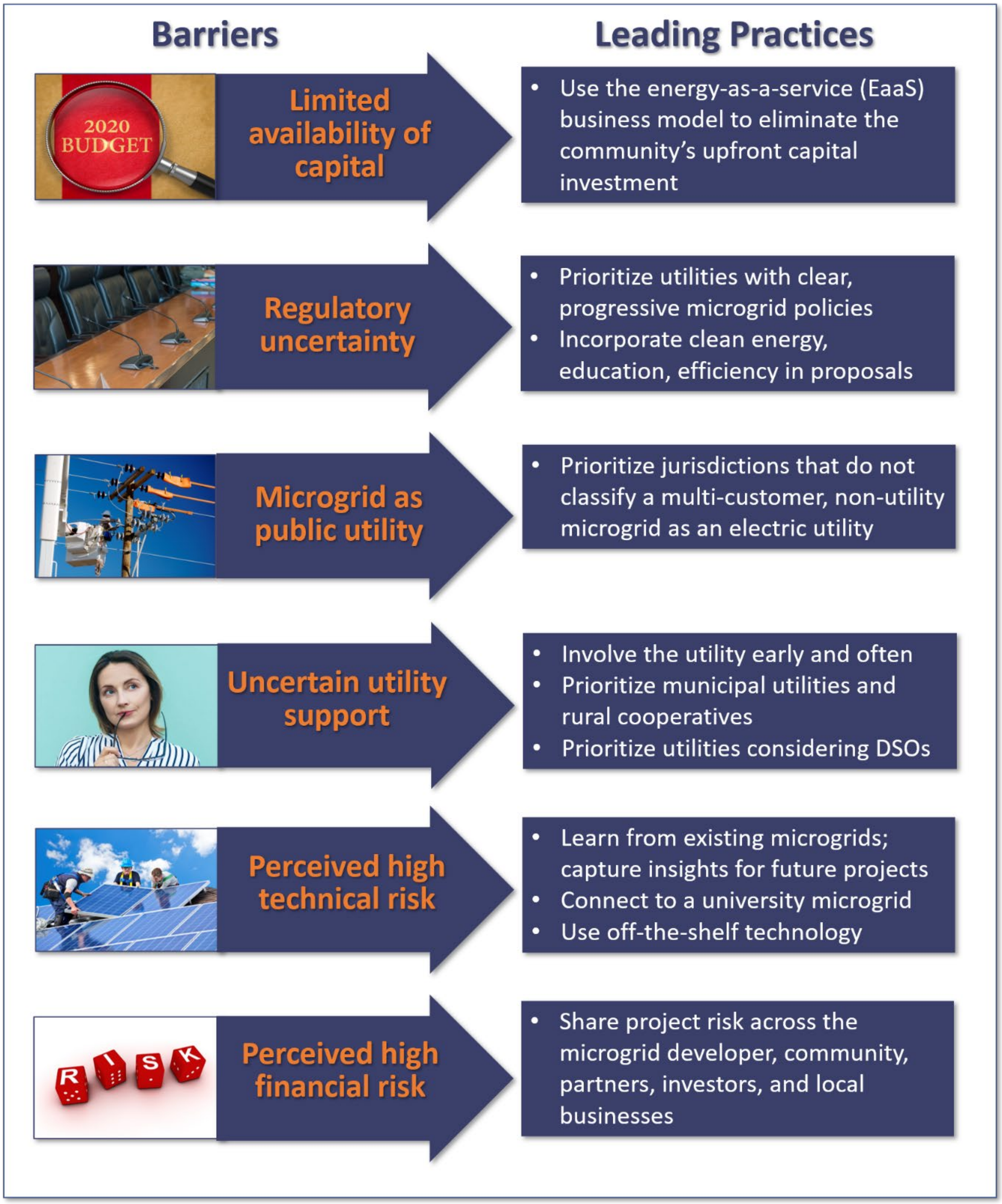
In addition to resilience benefits, each of these solutions offers day-to-day, value-added benefits to communities, residents, and businesses through distribution load management and energy savings.

The Oasis

Microgrid providers can consider extending the community microgrid's value so it acts as a refuge for its citizens during an extreme event – it becomes an "oasis." The *oasis community microgrid* can:

- Respond to the resilience priorities of citizens and businesses in the local community (e.g., desire for clean energy to address climate change)
- Demonstrate microgrid technical and economic feasibility and resilience value
- Build trust and cooperation between communities, utilities, microgrid providers, and local businesses





Barriers and Leading Practices

In many jurisdictions, various financial, regulatory, institutional, and perceptional barriers present significant challenges to community microgrid implementation. This report describes these barriers and leading practices for microgrid developers to consider for successful microgrid implementation (see the figure).

Regulatory Activity

Destructive wildfires and extreme weather in the last decade have stimulated a flurry of regulatory activity that may ease some regulatory barriers to community microgrids:

- The California Public Utilities Commission issued Rulemaking R. 19-09-009 that fast-tracks near-term solutions for California microgrids and resilience, facilitates local government involvement, and streamlines interconnection requirements [16].
- The State of New York's $40 million NY Prize received 130 proposals from its cities for community microgrids [17].
- The Massachusetts Clean Energy Center issued $1.05 million in funding for feasibility studies of 14 microgrid projects [18].
- The Connecticut Microgrid Grant and Loan Program has awarded over $30 million to a total of 13 projects [19].
- The New Jersey Board of Public Utilities (NJBPU) has established the Town Center Distributed Energy Resources (TCDER) microgrid program [20].
- In California, three community choice aggregators and a municipal utility issued a joint request for proposals to provide 32.7 MW of resource adequacy capacity and resilience using community microgrids [21].
- The Maryland Energy Administration's Resilient Maryland Program announced 14 microgrid projects, including community resilience hubs, that will gain a share of more than $1 million for feasibility analyses [22].
- The Australian Government's Regional and Remote Communities Reliability Fund announced round one funding of over $19 million (AUD) for 17 microgrid projects [23].
- The Puerto Rico Energy Bureau completed a utility integrated resource plan that requires the Puerto Rico Electric Power Authority to "directly incorporate promotion of microgrid resources into all of its transmission, distribution, and resource planning "because microgrids "form a critical part of the resiliency solutions envisioned" [24,25].
- The Federal Emergency Management Agency's (FEMA) $500 million Building Resilient Infrastructure and Communities (BRIC) grant program will give weight to grant applications that "mitigate risk to multiple 'lifelines,'" which are "fundamental services in the community that, when stabilized, enable all other aspects of society to function" [26].

COVID-19 Impacts

The impact of COVID-19 on microgrid remains to be seen. However, the following effects may strengthen the case for community microgrids:

- Enhanced need for resilience in light of unprecedented wildfires in the western U.S. and continued resilience concerns along the U.S. east coast in the wake of the Isaias storm
- Local community empowerment and interest in leading resilient solutions
- Enhanced public and business awareness of disaster preparedness
- More telecommuting, requiring resilience for a distributed workforce
- Concerns of economic disruption from simultaneous extreme events
- An increased comfort level with embracing independent, distributed systems connected to regional and national networks

The Bottom Line

To address the challenging barriers to microgrid implementation, the next round of oasis community microgrids requires committed community-utility-business partnerships. Despite these complexities, many public and private stakeholders (quoted in this report) say that community microgrids will ultimately be worth the effort. These microgrids may be one way for communities, microgrid developers, citizens, local businesses, and utilities to recover from COVID-19 with a clean, more resilient electric power infrastructure.

Contents

Foreword

Hoffman Power Consulting is pleased to provide this report on microgrids. We produced it with no outside funding. Hence, unbeholden to any research entity, news agency, client, or special interest group, we are able to present you this unbiased, objective evaluation.

We originally envisioned an 8-page white paper, but as you can see, it has grown to over ten times that length. Why the growth spurt? The more we researched, the more activity and interest in microgrids we found. What's more, we discovered that a broader range of (and more) stakeholders were talking about microgrids than we expected.

Another challenge was that as time passed, new important information surfaced. As we were about to distribute our report, *Microgrid Knowledge* held its virtual microgrid conference June 1-3, 2020, with 4,000 attendees. We wanted our report to be up-to-date, so we stopped the presses and incorporated insights from that event. Then in July 2020, California Public Utilities Commission staff proposed a new microgrid pilot program, a microgrid tariff, and other actions to overcome microgrid barriers [27], so we incorporated a summary. We ultimately realized the need to stop revising and publish.

This report describes how the effects of COVID-19 may strengthen the case for community microgrids in the mid-term future. In light of recent attention on racial equity and justice, we emphasize the importance of involving traditionally underserved communities – which extreme events disproportionately impact – in community microgrid efforts.

This latest version contains 184 unique references – most from the last two years – so you can learn more about various aspects of microgrids with a click of your mouse. We look forward to your feedback.

Stay well,

Steve Hoffman
Charles Carmichael
Jim Davis
Hoffman Power Consulting

September 30, 2020

PART I: VISION AND OPPORTUNITY

The Resilience Challenge

In recent years, extreme weather and wildfires have increased in intensity and frequency. According to a May 2020 Accenture survey of more than 200 utility executives, 87% of respondents said they are experiencing increasing severe weather events in their own regions. These executives also perceive that this change poses an "increased financial risk" (90%) and poses a "significant challenge to maintain network operations and safety" (73%). Only 24% "feel very well prepared to manage the challenges of extreme weather events" [28].

This trend also motivates electricity end users. According to Navigant Research's 2019 report on resilience, "Given the series of extreme U.S. weather events since 2011 and the wildfires that have hit California in 2017, 2018, and 2019, a growing pool of customers seek greater resilience since these threats to power reliability appear to be a long-term problem" [29].

As a result, public utility commissions and electric utilities have assessed and implemented electric power resilience solutions, including the following tactics to varying degrees and in varying combinations:

- **Preparation**, including taking steps before the event to improve response, restoration, and recovery (e.g., resilience training and drills, enhanced data gathering and analysis of local weather, and modified power system operating procedures)
- **Power system hardening** before the event to improve the ability to withstand the event, including but not limited to the following examples:
    - Hardening of transmission and distribution (T&D) electrical equipment, including poles, towers, conductors, transformers, and substations
    - T&D equipment inspection and maintenance
    - Improved vegetation management (tree pruning along T&D rights-of-way)
    - Elevating substations vulnerable to flooding
    - Selective T&D undergrounding

- **Prevention,** including public safety power shutoffs (PSPS) – utility attempts to prevent wildfire ignition by purposely de-energizing power systems under certain conditions and in locations with a high wildfire risk

- **Early threat detection** (especially for wildfires)
- **Response during the event** (e.g., improved storm response practices)
- **Power restoration** in the short-term after the event
- **Power system recovery** in the mid-term and long-term after the event

Resilience "Sweet Spots"

However, if an extreme event overwhelms the power system, these tactics alone may be insufficient. For this reason, industry stakeholders are now considering the resilience value of microgrids.

According to the Accenture survey, 93% of respondents "agree that self-islanding solutions will be a major contributor to improved resilience in the longer term, providing a route to improved resilience for buildings with storage and solar power" [28].

This resilience value of microgrids builds on its existing foundational set of benefits. For decades, the "sweet spot" for microgrids was single electricity customers, including enterprises with sensitive loads, universities, military bases, and others with an especially acute need to minimize power interruptions. Over 2,200 commercial/industrial (C/I) energy users, universities, military bases, and public facilities around the world [1] have successfully demonstrated the value of microgrids to:

- **Reduce electricity costs** for their customers by leveraging fluctuating electricity prices, efficiently managing their own supply, and participating in utility demand response programs
- **Generate revenue** for their customers by selling electricity and ancillary services to the central grid, and in so doing, strengthen the grid, reduce T&D system losses, and defer expensive grid upgrades

- **Incorporate renewable energy and decarbonizing technologies** (e.g., solar photovoltaics and energy efficiency) that help their customers meet clean energy and environmental goals
- **Enhance power reliability and quality** to support business- or mission-critical customer operations by islanding (operating separately) from the central grid during a power interruption

The added benefit of resilience strengthens this value proposition for microgrids. More generally, microgrids can now help address a broader set of community, energy user, and societal needs – enhanced resilience, cleaner energy, more socio-economic diversity, improved protection of human health, and more.

According to various experts, including Senior Fellow Richard Heinberg of the Post Carbon Institute, the community level is the next sweet spot for maximizing the impact of actions to enhance resilience:

> "Local and state governments often have great flexibility in making public decisions, as well as significant regulatory and investment power over the issues that most affect everyday life. That's why our cities and states are traditionally the country's laboratories for social and economic innovation. One community's experiment can inspire thousands of others – providing insights and best practices, and ultimately building support for larger-scale change" [2].

Combining the need for community action and the benefits of a microgrid, the result is a *community microgrid*. This class of microgrid can provide all the benefits of its conventional cousin – plus resilience – for multiple customers, rather than a single customer (e.g., C/I user, university, or military base). One community microgrid can increase the resilience of a large number of public facilities, homes, and businesses – or an entire community.

These community microgrids aim to:

- Reduce the incidence and severity of power outages
- Maintain electric power to critical loads
- Reduce electricity costs
- Expand use of clean energy
- Provide air emissions and related environmental benefits
- Meet sustainability goals
- Protect human health and safety, and save lives during extreme events

Re-envisioning the Community Microgrid

Microgrid providers and related enterprises can capitalize on the market for design, installation, operation, and maintenance of microgrids by meeting the needs of electric utilities, major electricity users, *and* communities. Understanding these needs, microgrid providers can design systems and services, market them, collaborate with other contractors, and develop financing strategies – all with their target audience in mind.

What do communities need that community microgrids can provide?

- Clean energy, environmental protection, and sustainability
- Protection of citizen health and safety
- Business continuity for local businesses, employee retention, and business retention to protect the local economy
- Social and racial equity across neighborhoods and socio-economic groups
- Resilient electric power infrastructure, which underpins other critical infrastructures in the community, including water and wastewater systems, emergency services, food services, healthcare services, telecommunications, and financial services

What do major electricity users in the community need that community microgrids can provide?

- Reduced electricity costs
- Increased reliability and power quality
- Social and racial equity in their communities
- Revenue generation
- Attainment of clean energy, environmental, and sustainability goals
- Improved community relations
- Enhanced resilience to business and supply chain interruption

What do electric utilities need that community microgrids can provide?

- Maintained high reliability of electric service to meet the obligation to customers and communities in the service territory
- Enhanced resilience of the power grid as efficiently and quickly as possible
- Social and racial equity across customers
- Protection of utility worker and customer health and safety
- Regulatory compliance
- Environmental protection
- Cost minimization to achieve these goals

Comparing the Big Three Types of Microgrids

One potential way to meet several of these utility, major electricity user, and community needs is to implement an *oasis community microgrid*.[1] This type of microgrid is a natural evolution from conventional microgrids and community microgrids.

Conventional (Single-Customer) Microgrid

The U.S. Department of Energy defines a microgrid as "a group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to operate in either grid-connected or island-mode" [30]. During extreme weather or wildfire events, the microgrid can enhance resilience by islanding from the main grid and using internal generation and storage resources. In this way, the microgrid continues to provide power to customers in the microgrid that otherwise may not receive it. This resilience benefit is most applicable to areas where the extreme weather or wildfire does not cause major electric power infrastructure damage, but that would lose power due to infrastructure damage in *nearby areas, or even remote areas* due to the interconnected nature of the main grid. Almost all microgrids today are in this conventional microgrid category, serving the following types of customers, one customer per microgrid:

- An individual C/I facility (e.g., to back up a data center, computer-controlled assembly line, or other critical load)
- A university or college (e.g., to protect valuable research and provide emergency power to campus students and staff)
- A military base (e.g., to maintain mission-critical capabilities)

Community Microgrid

A community microgrid can provide operational capabilities similar to those of a conventional microgrid. However, a community microgrid can be a microgrid for the people, responding to

[1] A prominent use of the term "oasis" microgrid is in the direct testimony of Commonwealth Edison Vice President Joseph Svachula to the Illinois Commerce Commission in July 2017 regarding the Bronzeville Community Microgrid. Mr. Svachula testified that "The Project will not only deliver benefits to the customers it directly serves, but during a major system disruption, it will also provide an "oasis" of functioning critical infrastructure where residents of neighboring communities can also obtain food and supplies" [31].

the resilience priorities of citizens in the local community, not only the needs of a specific enterprise, campus, or facility. If these priorities include use of clean energy for example, the community microgrid can be based on renewable resources.[2] In contrast to conventional (single-entity) microgrids, a community microgrid can conceivably serve more than 1,000 energy users, including public facilities, homes, and businesses.

Several community microgrids are operating or planned worldwide. According to the above definition and using Navigant 2018 data, a Swedish Energy Agency study identified 2,258 microgrid projects, which includes only 13 community microgrids (six in the U.S. and Canada) [1].

Oasis Community Microgrid

An oasis community microgrid can further extend the community microgrid to provide a centrally-located refuge – an "oasis" – for its residents during an extreme event. 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/town or county.

Thought leaders provide substantial support for this resilience approach (although they may not use the term "oasis"). According to a recent Rocky Mountain Institute (RMI) article: "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" [32].

At the June 1-3, 2020 *Microgrid Knowledge* Microgrid Virtual Conference [33], President of Smart Grid at Schneider Electric North America Mark Feasel explained: "Our approach to critical infrastructure must pivot to a new reality in which lower energy-intensity loads must be addressed (shopping centers, elder care, food processing, banks, etc.)" [34].

[2] Conversely, microgrids based on fossil-fuel-fired generation may have limited fuel supplies on hand, and their pollutant emissions can worsen air quality – especially important in wildfire-stricken areas [32]. These distributed generation technologies include small combustion turbines and microturbines, reciprocating internal combustion engines, and fuel cells – power with natural gas or diesel fuel. Allowed in June 2020 in California for one year [16], diesel-based microgrids can serve as a short-term transition to clean energy.

Oasis Community Microgrid Benefits

While single-customer microgrids enhance resilience for a single entity, an oasis community microgrid can keep electricity flowing across multiple customers and broader areas, thereby increasing the resilience of the local community. It can protect citizens equally well from a variety of threats, including extreme weather, wildfires, cybersecurity and physical security attacks, and others. It can help meet many community needs during an extreme event by including the following within its boundaries:

- A school, community center, senior center, or other facility where residents can congregate and supplies can be distributed
- A public EV charging station
- A food warehouse or grocery store
- A hardware store (for emergency supplies)
- An urgent care facility (for medical care)
- A gasoline service station

Incorporating a community center or a suitable substitute as a safe haven in an oasis community microgrid is important because it:

- **Provides temporary shelter** to warm citizens in the winter and cool them in the summer
- **Acts as a distribution center** for emergency food, water, medical care, and other essential or emergency services
- **Provides public health and safety**
- **Provides a footprint** that can accommodate solar generation
- **Accommodates large gatherings** to provide information, enable families to reconnect, and provide other community interaction
- **Builds morale** [35]

An oasis community microgrid has the potential to provide additional benefits to communities and utilities:

- **Demonstrates Feasibility and Value.** An oasis community microgrid can demonstrate that resilience is economically and technically feasible.
- **Fosters Awareness, Understanding, and Cooperation.** The project can educate all involved parties about disaster preparedness, energy efficiency, social and racial equity,

and new technologies (such as EVs). The project can serve as a symbol of cooperation and collaboration among community and neighborhood leaders, utilities, universities/colleges, citizen groups, microgrid providers, investors, and local businesses. The process of developing the project – and then the functioning result of the collaboration – demonstrates what these stakeholders can achieve when they work together for the good of the community.

- **Generates Revenue.** Microgrids can generate revenue (or avoid costs) by:
    - Lowering utility demand charges by decreasing peak consumption
    - Leveraging grid pricing
    - Providing ancillary services
    - Participating in grid demand response programs
    - Aggregating microgrid energy resources to form a virtual power plant [36].
- **Benefits the Macro Grid.** The microgrid can provide benefits back to the macro grid.
    - A microgrid can throttle "back and forth between resiliency at the site (microgrid) and sending energy back into the grid when it is most valuable," as a 2019 Navigant report describes [29].
    - A microgrid may enable the local electric utility to redirect power and response resources to parts of its service territory outside of the community microgrid or microgrids – areas that would otherwise not receive these resources due to various limitations.
    - A microgrid can delay or obviate the need to increase transmission line capacity into an area, thus reducing utility capital needs.
- **Enhances Economic Prosperity.** While enhancing resilience, the project can also provide economic value to the community in several ways [37]:
    - Enables enterprises to continue to operate during power interruptions, continuing to stimulate the economy
    - Encourages local businesses to remain (and expand) in the community by offering a premium power alternative that reduces costly outages and corresponding costs
    - Attracts high quality businesses that require premium power (e.g., data centers) to the community for similar reasons
    - Stimulates the local economy through construction and operation of the microgrid

- **Promotes Social and Racial Equity.** The microgrid project can attempt to demonstrate the importance of equitability across socio-economic groups, when improving community resilience, public safety, human health, economic vitality, and quality of life. Studies show that traditionally underserved or economically disadvantaged communities, as well as the elderly and medically sensitive citizens, are most vulnerable to natural disasters [32,38]. Because microgrids can help protect against the effects of these natural disasters, microgrids can aid these communities.

The Opportunity: Community Microgrid Market

While the market for single-customer microgrids is well-established, the potential market for community microgrids is significant. In the U.S. alone,[3] potential community microgrid project participants include the following (see Figure 1):

- **Utilities.** About 3,000 investor-owned and public power electric utilities, as well as at least 750 CCAs [39][4]
- **Communities.** More than 3,000 cities and towns with a population of 10,000 or more, and/or more than 3,000 counties [40]
- **Major Electricity Users.** Thousands of large organizations in these communities that consume large amounts of electricity, want to leverage their energy investments, and seek to boost their standing in the community

This means that many collaborative projects are possible in the U.S. for a *first* community microgrid in each city or county. Once a city or county completes its first community microgrid and realizes its various benefits, the potential for additional community microgrids increases.

Figure 1. Potential Community Microgrid Market

To complement existing single-customer microgrid business, community microgrids offer a significant new business opportunity for microgrid providers, enabling the following potential business benefits:

- Diversified client base
- Increased revenue

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[3] This report focuses on community microgrids in the U.S. Much can be learned from experience outside the U.S. – the topic of a planned future report from Hoffman Power Consulting.

[4] In some states, community choice aggregations (CCAs) are also known as municipal energy aggregations or community choice energy. The 2019 NREL report on CCAs lists 490 in Illinois, 120 in Ohio, 110 in Massachusetts, 15 in New Jersey, 9 in California, and 1 each in New York and Rhode Island [39].

- Cross-selling of complementary value-added services, such as improved energy efficiency in buildings, distributed renewable generation, distributed storage, and EV charging.
- Strengthened business relationships with utilities, communities, and major energy users, enabling further business benefits

Why Now?

Several drivers are aligning to accelerate the microgrid market:

- **Decreasing costs of**
  - Microgrids: 30% from 2014 to 2018 [36]
  - Distributed solar systems: 70% from 2010 to 2019 [41]
  - Local electric storage: 87% in battery prices since 2010 [42]
  - EVs for additional storage
- **Rising interest in resilient, cost-saving solutions** among communities and their residents and businesses due to the increased intensity and frequency of wildfires and extreme weather
- **Motivation for clean energy solutions** (primarily solar), which can form the backbone of a community microgrid, to decarbonize and address climate change
- **Increasing regulatory interest** in community microgrids in some regions as a means to enhance resilience and achieve climate targets
- **A growing list of lessons learned** from the increasing number of operational and planned community microgrids
- **Mature, off-the-shelf technology** by virtue of the more than 2,200 conventional microgrids currently operating around the world
- **Growing acceptance of business models** that minimize the need for communities or electricity users to invest the significant capital that community microgrid projects require

Over the long term, these drivers may propel this market for microgrid providers through the following stages:

- **Prototypes:** More prototype community microgrids across the country
- **Clusters:** More community microgrids connected to nearby conventional microgrids (e.g., an existing university microgrid) for effective resource sharing

- **Propagation:** A community microgrid in many cities
- **A network of microgrids?**

In 2018, Navigant Research projected that overall microgrid spending would increase from about $2 billion to $10 billion in North America from 2018 to 2027 [43]. Even if COVID-19 slows this market growth, will community microgrids become a large – yet also highly competitive – market, and if so, how can microgrid developers capitalize on this opportunity? This report suggests strategies to answer this question.

PART II: COLLABORATION AND VALUE

Collaboration: The Name of the Game

The Community Role in Microgrid Projects

Through committed in-person interaction between community stakeholders, the local utility, and microgrid providers, a microgrid collaboration team can meet its self-defined community resilience and social and racial equity priorities. An understanding of these priorities helps microgrid providers tailor their outreach to communities, major electricity users in the community, and electric utilities.

According to Heinberg of the Post Carbon Institute (PCI), "it's both ethical and practical for community members to be at the heart of community resilience building work. Everyone in a community is a stakeholder – and stakeholders need the opportunity not only to participate in resilience building, but to have some responsibility for it." In PCI's *Think Resilience* series, Heinberg also states that "decades of research underline how important it is for local stakeholders to have real power in decisions that affect them" [2].

Community officials, neighborhood leaders, and concerned citizens and business people are likely best informed to answer questions like the following:

- **What community facilities** are best suited to serve as emergency centers for citizens during extreme events?
- **Which urgent care** or other healthcare facilities would best meet citizen needs in an emergency?
- **How can clean water supplies** continue to flow (powered by electric pumps) in an extreme event?
- **Which gasoline service stations** are best situated, and hence need to be prioritized for backup generation and storage, to keep the public mobile in an extreme event?
- **Which grocery markets** or food warehouses can best serve the needs of the most citizens?

- **Where is the best tight cluster** of these community resources that would make an oasis community microgrid most feasible?
- **What are other siting factors,** such as site hazard risks (e.g., flooding, wildfires, etc.) and environmental and permit considerations? To provide long-term system resilience, geographic risk assessment can include not only known current environmental risks and impacts, but also predicted changes due to ongoing climate change impacts over the design life of the project.

The Microgrid Team

Community, utility, major electricity users, and microgrid provider partnerships involve a variety of complexities. Hence, effective collaborative agreements and strategies are needed, and various resources are available to aid this process. As a starting point, one useful resource is a recent paper from the World Resources Institute and the Institute for Market Transformation that describes ways to structure, develop, and ensure successful delivery of city-utility partnership agreements, specifically to achieve climate and energy-related goals [44]. Other initiatives involving city-utility-third-party collaborations that are likely to have useful resources include:

- The RAND Corporation's "Resilience in Action" [45]
- The Rockefeller Foundation's now completed "100 Resilient Cities" and its follow-on Global Resilient Cities Network [46]
- The American Cities Climate Challenge [47]
- The Urban Sustainability Directors Network [48]
- The EPIcenter in San Antonio, Texas [49]
- PCI's "Think Resilience: Preparing Communities for the Rest of the 21st Century" [2]

Collaboration Across Microgrid Technology Vendors

Another dimension of collaboration is across technology vendors. Each microgrid project poses a unique combination of technical, financing, and regulatory challenges:

- **Technologies.** Each project can integrate a unique combination of technologies, such as solar generation, electric energy storage, thermal energy storage, diesel generators, fuel cells, cogeneration, wind, and even district heating.
- **Financing and Business Models.** Project considerations include various ownership and operational models, state and federal tax incentives, renewable energy credits in some areas, demand response opportunities, insurance risk offsets, and compensation for grid services.

Each microgrid project requires a detailed engineering, operational, and financial assessment, as well as assessment of community needs and resources. “I think you could argue that it’s extremely difficult, if not impossible, for any single technology player, even folks in the energy business like Schneider, to make all those decisions on their own,” explained Mark Feasel, Schneider Electric’s Vice President of Smart Grid, in a 2019 interview. “This is why so often you see us go in the market with a consortium around best in class technology providers” [50].

Microgrid providers include engineering and construction companies, component and system developers and installers, system integrators, consultants, and other enterprises in this space. At a minimum, most community microgrid projects are a collaboration between:

- A lead microgrid contractor (the glue that holds the project together)
- Supporting contractors/vendors
- A community (city or county)
- The local electric utility or community choice aggregator (CCA)
- The relevant regulatory authority
- Major electricity users (employers/businesses)

Multi-Customer Microgrids Can Offer Several Resilience Solutions in One

A multi-customer microgrid (such as a community microgrid or oasis community microgrid) can be an integrated system of resilience solutions; it can incorporate several resilience solutions in one:

- Enhanced energy efficiency in the buildings within the microgrid
- Distributed renewable electricity generation and storage
- Vehicle-to-microgrid and vehicle-to-building electricity storage
- Intra-microgrid electric demand response
- Natural resilience solutions

Enhanced Energy Efficiency in Buildings

In their 1982 book on electric power resilience, Amory Lovins and L. Hunter Lovins identified energy efficiency as the resilience solution that provides the "most resilience per dollar" [51].

Within a 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. Energy efficiency aids resilience because it delays the depletion of on-site energy resources when in islanded mode. For example, RMI points out that a 10-kWh battery can power an efficient (U.S. SEER 18)[5] 1.5-ton air conditioner for 3 hours, but

[5] Seasonal energy efficiency ratio

can power a similar-capacity, low-efficiency unit (U.S. SEER 9) for only about 1.5 hours [32]. 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 photovoltaics (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.

Distributed Renewable Generation and Storage

A variety of energy resources can power a 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 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 can 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 can be less resilient when they rely on non-local fuel supplies, which may be disrupted during and after extreme events.

Large-scale or distributed renewable generation that is not physically connected to a 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 T&D grid goes down [29]. By contrast, PV arrays within a microgrid remain available to customers connected to that microgrid.

Local battery energy storage systems (BESS) can extend the period of time that PV provides backup in a microgrid. 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[6] [52].

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

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

- A 2016 RMI study on EVs as DER shows that the 60-kWh battery in the Tesla Model 3 stores enough energy to power an average home for two days [32,53].
- 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 [54].

Recharged EVs can also supply power and other grid services back to the 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" [53].

At a January 2020 California Public Utilities Commission (CPUC) meeting, San Diego Gas and Electric Company (SDG&E) proposed to "install electrical infrastructure and electrical vehicle ('EV') charging stations at critical facilities within the microgrids that SDG&E is deploying in anticipation of the 2020 fire season. This charging infrastructure would mitigate customer mobility issues arising from a public safety power shutoff ('PSPS'), including emergency

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

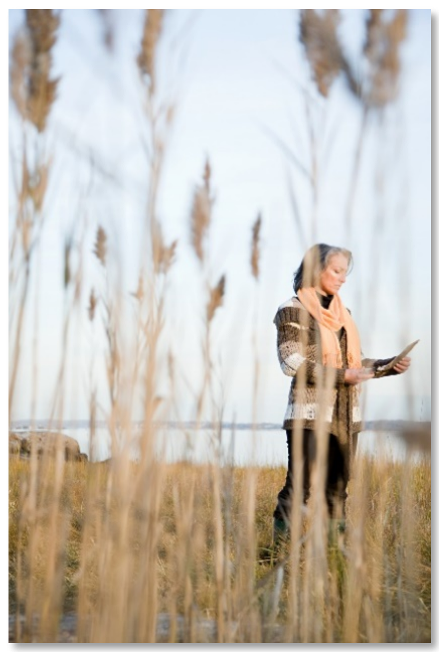
evacuation" [55]. While this proposal emphasizes mobility rather than vehicle-to-building or vehicle-to-microgrid resilience, it acknowledges that EVs have an important role in microgrids.

In this way, the EV acts as an alternate source of electric storage, extending the value of microgrid renewable generation and addressing the economic and capacity limitations of BESSs. The 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 flexibility holds promise as a resilience solution and can add to the already substantial list of EV benefits.

Intra-Microgrid Demand Response

In the main grid, demand response occurs when customers voluntarily shift the timing of their electricity usage or allow the utility to shift this usage. A microgrid can also use demand response approaches to reduce the needed peak capacity of internal 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.

Natural Resilience Solutions



Using solutions inspired by nature, a microgrid can be *naturally* resilient. These solutions include:

- White roofs (to reflect heat)
- Urban tree canopies (to provide shade and reduce heating load)
- Wetland and riparian resource restoration (to provide natural flood resistance
- Other natural resilience solutions

While natural solutions are widely touted to mitigate global climate change, when incorporated into microgrid design, they can also provide ecosystem benefits and reduce the impact of extreme natural events.

The Value of Microgrids

A Comprehensive Look at Microgrid Costs and Benefits

Assessing the costs and benefits, and hence potential value, of microgrids is a complex process due to the variety of costs, benefits, financial assumptions, and other factors that vary from one implementation to another.

In 2015, as part of its NY Prize project, the State of New York developed a comprehensive set of materials to help project participants evaluate the potential costs and benefits of community microgrids in particular. Its contractor, Industrial Economics, Incorporated (IEc), developed a cost-benefit tool and documented it with a user guide, analysis spreadsheet, facility questionnaire, data capture sheets, a webinar, and webinar Q&A. Although designed specifically for participants in the NY Prize, the tool and its supporting materials contain useful information for community microgrid cost-benefit evaluation outside of New York State. The tool's cost analysis covers initial design and planning costs, capital investments, operation and maintenance, and environmental costs. The tool's benefits analysis includes energy (energy cost and capacity cost savings), reliability, power quality, environmental, and resilience benefits [56].

The NY Prize itself is part of the State of New York's Reforming the Energy Vision – established partly in response to the impact of Superstorm Sandy in 2012. The New York State Energy Research and Development Authority (NYSERDA), with support from the Governor's Office of Storm Recovery, established this innovative competition to help communities create and finance microgrids. The NY Prize is a first-in-the-nation competition that aims to help communities "reduce costs, promote clean energy, and build reliability and resiliency into the grid" [17].

The Value of Microgrid Resilience: A Closer Look

The process of defining a microgrid's resilience value is particularly complex and merits closer examination. According to industry expert Peter Larsen of Lawrence Berkeley National Laboratory (LBNL), there is no "silver bullet" method for quantifying the value of microgrid resilience. In fact, Larsen indicated that he is "advocating for development of a new tool to assess the full economic impact of outages lasting from minutes to weeks" [57].

Nevertheless, microgrid providers need to demonstrate some understanding of various methods of quantifying microgrid project benefits in order to:

- **Help utilities** justify the project cost to regulators
- **Help communities** justify the project cost to City Council, residents, and local businesses

- **Help financiers, energy users, and other third parties** justify their project investment

To aid this understanding, this section provides an introductory summary of proposed methods for quantifying the value of resilience, including but not limited to estimating the value of avoided power outages, to inform microgrid provider discussions with utilities, communities, energy users, and investors.[7]

In her 2017 article "What is the Value of Microgrid Resilience?" Anna Chittum, formerly of the American Council for an Energy-Efficient Economy (ACEEE), summarized existing financial tools and methods used to quantify the value of resilience in microgrids [58]. These include:

- **Reliability indices**, such as system average interruption duration index (SAIDI) and system average interruption frequency index (SAIFI), which are publicly available through 2018 from U.S. utilities as "reliability" data collected on U.S. Energy Information Administration Form EIA-861 [59]
- **The Performance Excellence in Electricity Renewal** (PEER) rating process to compare reliability of various power systems and to rate individual microgrid performance [60]
- **The 2015 LBNL meta-analysis of value-of-service** estimates from utilities to view the wide range of outage costs according to customer size and sector [61]
- **Customer interruption costs**, including the 2018 update of the 2006 LBNL data [62], to measure customers' true outage costs in microgrid valuation analyses
- **Outage financial impacts** using Hartford Steam Boiler's Blackout Risk Model [63,64]
- **Comparison of combined heat and power** (CHP) project benefits to microgrid project benefits (using CHP project sources such as the California Self-Generation Incentive Program [65] and the New York CHP programs [66])
- **Insurance company analyses** (e.g., companies that underwrite energy projects, such as Energi and Hartford Steam Boiler)
- **The Interruption Cost Estimate (ICE) Calculator**, which incorporates interruption cost data [67]

With regard to the ICE Calculator, according to Peter Larsen of LBNL, the ICE Calculator is not intended for use to assess costs of interruptions lasting longer than 16-24 hours, and hence, its

[7] As this is a complex topic, this section is not intended to provide a comprehensive evaluation of resilience value quantification, but instead a brief introduction to the subject.

usefulness for calculating the value of resilience is limited. The reason is that the customer interruption cost surveys on which the ICE Calculator is based posed questions about customer impacts from outages up to 16 hours in duration. Fundamentally different impacts to customers and the broader economy occur for longer outages, especially during extreme events, which can extend for days or weeks [57].

A 2017 Electric Power Research Institute (EPRI) white paper on "A Cost-Benefit Analysis Framework for Evaluating Microgrids," suggests surveying C&I company decision makers considering an investment in a single-customer microgrid on their willingness-to-pay for various levels of microgrid resilience (e.g., the length of time the microgrid can operate in islanded mode) [68].

In 2017, EPRI[8] published a report that evaluated various methods of measuring the value of resiliency, including customer damage function, discrete choice experiment, and computable general equilibrium (CGE) models. For each method, the report explains the technique and compares key features [69]. However, in a paper EPRI published in the proceedings of a 2019 LBNL workshop, the Institute points out that the following practical considerations are likely to determine the optimal method in each particular situation:

- **Data gathering difficulty** (e.g., time and money)
- **Scalability and extensibility of results**, in order to consistently address various planning, regulatory, and policy needs
- **Cross-threat applicability** (e.g., natural disasters and man-made threats such as cybersecurity or physical attacks)
- **Qualitative judgment** as to whether the method produces information that meaningfully covers the various threat possibilities, including impacts of other infrastructures besides electricity [70]

In 2018, IEc published a study for NYSERDA on a method of estimating regional economic benefits of community microgrids. Using its cost-benefit analysis model, the project team

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[8] In March 2020, EPRI announced that it "has launched a new project to assemble a broad collaborative of stakeholders across the industry to identify technical approaches and use cases, accelerate learning, and develop improved and consistent methods to valuing resilience..." [71].

estimated the benefits of a microgrid in sustaining economic activity during an extended outage. The report examined one of the NY Prize Stage 2 proposed microgrids (Rockville Center) to illustrate the process [72].

The 2019 LBNL workshop proceedings also described several innovative methods of estimating the value of resilience, including [73]:[9]

- **A micro-economic framework and model of estimating business interruption costs** (Eyer-Rose) by 1) examining trade-offs between investments in actions taken after the event occurs versus proactive/preventive actions taken in advance, and 2) defining a resilience metric that is "the ratio of avoided outage-induced loss of economic output to a potential (or counterfactual) total economic output baseline condition."
- **Survey results of residential customer willingness-to-pay** to receive service during a 24-hour summer outage (Baik, et al.)
- **Estimating economic consequences of large-scale, lengthy outages** (up to one month in duration) using a simple CGE model, as an alternative to the more challenging full-scale CGE models (Sue Wing-Rose)
- **Stated-preference methods to estimate avoided outage value**, as part of a planned Nexant/LBNL guidebook (Shawhan)
- **Data challenges** in the economic analysis of widespread, long-duration outages (Nexant)

In April 2019, Converge Strategies published a report for the National Association of Regulatory Utility Commissioners on the value of resilience for DER [74]. (The study includes microgrids as part of its DER definition.) The report describes four case studies that quantified the value of DER resilience, in the form of avoided power interruptions, using the following methods and tools:

- **The aforementioned ICE Calculator** [67,74]
- **The Federal Emergency Management Agency Benefit-Cost Analysis (FEMA BCA)**, which uses a damage cost methodology to estimate the costs of degraded fire, police, and emergency services [75]
- **IMPLAN** (originally "impact analysis for planning"), which is a "commercially-available input-output tool with historical datasets that allows users to model economic impacts" [74,76]
- **Generator cost calculation**, which uses the defensive behavior method (i.e., the cost that customers pay, such as procurement of a diesel generator, to avoid the negative consequences of a power interruption) [74]

[9] Authors of each listed method are shown in parentheses.

A 2019 Navigant Research study addressed quantification of microgrid value by applying the National Renewable Energy Laboratory's (NREL's) open-source Renewable Energy Integration and Optimization (REopt Lite) tool [77]. The study assessed the value of microgrids (considering capital costs, lifetime costs, reliability, expected outage durations, and emissions profiles) with five different combinations of distributed resources in two use cases (a grocery store and a hospital) [29].

A more recent report estimated avoided outage costs for C&I businesses. In March 2020, Frost & Sullivan and S&C Electric released a report that surveyed 255 C&I companies in various verticals with average annual revenue of $4 billion [78]. The report concluded that:

- Sixty-one percent of the companies plan to install backup generation, companies are increasingly reliant on reliable power, and one-third of the businesses are willing to pay a premium for power reliability during extreme weather.
- Twenty-nine percent of companies that suffered a power interruption at least once per week estimated losses at $2 million or more per event.

Sandia National Laboratories developed the Regional Economic Accounting (REAcct) tool for U.S. Department of Homeland Security (DHS) scenario analysis. Using a theoretically-established input-output method, REAcct uses geospatial data computational tools to model regional effects and publicly-available economic data. It provides rapid first-order estimates and comparisons of economic impacts for various scenario analyses, including a range of natural or man-made events. According to its documentation, REAcct is low cost, transparent, and relatively easy to use. A documented application for a hurricane in the southeast U.S. demonstrates its estimation of direct and indirect impacts by county, industry, region, state, etc. It assesses the "interdependent relationships between critical infrastructures, economic industries, and consumers" [79].

A new report from the American Society of Civil Engineers shows that severe weather accounts for one-half of U.S. outages and that power outages are becoming more frequent and costly. The study found that the average outage cost at a data center, for example, increased from about $500,000 in 2010 to about $740,000 in 2016 (or almost $9,000 per minute of outage). The report describes a methodology for estimating outage costs by sector and within specific industries [80].

Potential Barriers/Limitations: Comparing the Three Microgrid Types

Overview of Community Microgrid Barriers

Despite these potential benefits, communities and electric utilities face myriad financial, legal, and regulatory barriers to implementing community microgrids.

- **Limited availability of capital.** Particularly in light of expenditures to manage the COVID-19 pandemic, communities and energy users may suffer from limited capital to invest in community microgrids. Hence, any consideration of community microgrids is likely to require a business model that eliminates community upfront investment.
- **Regulatory uncertainty.** Multiple-customer microgrids, such as community microgrids, do not easily fit into legacy regulatory concepts that public utility commissions across the U.S. established primarily for vertically-integrated utilities with centralized resources [81]. Further, these commissions do not consistently define the legal and regulatory status of community microgrids.
- **Microgrid as public utility.** In some utility service territories, nonutility microgrids producing power for sale could be considered a public utility, and hence be subject to significant state regulations and an "obligation to serve" requirement, potentially discouraging communities from embarking on community microgrid projects.[10] In some situations, nonutility microgrids cannot cross public rights-of-way without municipal permission, usually in the form of a franchise [82].
- **Uncertain utility support.** Some utilities may view nonutility microgrids as a threat to their revenue stream. Hence, some utilities may not fully support multi-customer microgrid development.
- **Perceived high technical risk.** Although the technology exists today to construct and operate community microgrids, few are operating, and hence operational experience is limited. This raises concerns about the technical viability of such systems.
- **Perceived high financial risk.** Because of other barriers listed above, many utilities and communities perceive community microgrid projects to be risky propositions. Electric utilities must justify all investments that are included in its rate base, including investments in community microgrids. Communities also need to justify investments to local government. Municipal utilities and rural electric cooperatives need to justify their investment to the respective governing body and constituents.

[10] The California Public Utility Commission (CPUC) is addressing this barrier by crafting a bill (SB 1215) that exempts microgrids that will serve multiple customers from definition (or responsibilities) of an "electricity corporation." On May 26, 2020, the California Senate's Energy, Utilities and Communications Committee passed the bill [83].

Business Models to Address Limited Capital

In recent years, solutions to institutional considerations, such as ownership, financing, and other aspects of the microgrid business model, have evolved. Third-party ownership and financing, and various types of energy-as-a-service (EaaS) models are now dominating microgrid projects, rather than customer-owned or community-owned models. Such arrangements, which typically include some sort of power-purchase agreement (PPA) or pay-as-you-go model, minimize or eliminate the need for customers or communities to invest the significant 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 from community microgrids.

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 [29].

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" [84].

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 [85]. 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" [86]. 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 [36,87].

An alternate business model is community ownership and management of a community microgrid via a nonprofit cooperative or trust, with financing provided through an entity such as (in California) a Community Facilities District.[11] EcoBlock, the California Institute for Energy and Environment, and several partners are in the second phase of a California Energy Commission (CEC) Electric Program Investment Charge (EPIC) program grant ($6.5 million total) to demonstrate this concept. This project also aims to incorporate deep energy efficiency retrofits of existing buildings, use 100% solar power, and provide affordability for low-to-middle income neighborhoods [88].

From 2016-2018, the NY Prize conducted a series of four webinars on community microgrid project financing, which included several presentations on this topic. Although intended for NY Prize participants, the presentations contain useful information for community microgrid financing outside of New York State [89]. A discussion of the extensive useful information in these webinars on a variety of funding considerations, resources, and recommendations is beyond the scope of this report.

Addressing Regulatory Uncertainty

Several states are passing laws and implementing regulations to accommodate microgrids. For example, the California legislature passed a bill in 2018 directing the CPUC to develop "standards, protocols, guidelines, methods, rates, and tariffs that serve to support and reduce barriers to microgrid deployment" by December 2020 [90]. During the first half of 2020, the CPUC opted to emphasize immediate utility action to quickly implement as many utility-owned microgrids as possible. By the end of July 2020, the CPUC staff released a set of proposals to address many of the regulatory and financial barriers to community microgrids [27]. For more information, refer to the later section in this report on "The California Legislative and Regulatory Push."

As California edges closer to a system more favorable to community microgrids, the legal and regulatory status of microgrids is likely to remain in flux for the near future, as well as evolve at different rates on an individual state, utility, and potentially city basis. To identify prime markets for community microgrids, prudent microgrid developers carefully investigate utility, state, and local regulations and policies.

Microgrid as Public Utility?

In general, microgrid developers attempt to avoid classification of a proposed microgrid as an electric utility, unless an electric utility is a partner in the microgrid project. If a nonutility, third-party, multiple-customer microgrid is deemed to be a distribution utility, then it may be

[11] Also known as Mello-Roos, CFDs are special districts that local governments in California establish to obtain public funding.

required to assume a legal obligation to serve and be subject to other utility regulations. If a third party-owned microgrid provides service to a separate customer – transferring power through a utility's service territory – legal and regulatory issues arise [91].

Uncertain Utility Support?

Utility-owned microgrids typically encounter barriers such as considerations of customer fairness/equity and cost justification. For example, in 2018, the Maryland Public Service Commission rejected two proposed microgrids (one from Potomac Electric Power Company and another from Baltimore Gas and Electric Company) on the "grounds of unequal distribution of benefits to ratepayers and the inability to quantify resilience benefits" [92]. On the other hand, Commonwealth Edison's (ComEd's) multi-customer Bronzeville Community Microgrid received approval from the Illinois Commerce Commission (ICC), which cited "community learning benefits" [92]. The ICC approved rate base inclusion of ComEd's $25 million share of the microgrid, agreeing that learning from the project would benefit all customers [93]. In its study of the value of resilience for the National Association of Regulatory Utility Commissioners, Converge Strategies reviewed these same three regulatory proceedings, and concluded that the three "Commissions did not consider a specific value for resilience in their decision making and instead focused on other quantified benefits. The regulatory decisions in each of the three cases were driven by factors other than resilience" [94].

Another barrier for some utilities seeking to implement community microgrids is policies in deregulated states, in which utilities usually are not permitted to own power generation resources. Utility microgrid projects also face the efforts of private microgrid providers that oppose utility ownership of microgrids, citing the utility's ownership of the grid, its ability to charge all ratepayers [95], and its monopoly status as unfair competition [96].

Hybrid microgrids, in which multiple parties share ownership, are sometimes preferred in states with deregulated generation, where electric distribution utilities usually cannot own power generation facilities. This arrangement has the advantage of providing an incentive for the utility to cooperate and benefit financially by earning a return on its investment in microgrid equipment. In this situation:

- The municipal, cooperative, or investor-owned utility might own the microgrid's distribution equipment.
- A second company might own a solar array feeding the microgrid.
- A third company might own the microgrid battery storage.
- A fourth company might own the microgrid control equipment, as well as operate and maintain the microgrid.

An example of a hybrid community microgrid now moving forward Is the Redwood Coast Airport Microgrid on the northern coast of California [97]. The main customer of the Redwood microgrid will be the local airport and a U.S. Coast Guard air station, and a few commercial customers will also be connected. The local utility, Pacific Gas & Electric (PG&E), will own and operate the physical microgrid and oversee its operation. The Redwood Coast Energy Authority (the CCA in the area) will own and operate a 2.2-MW solar facility and maintain a 2.2-MW (8.8-MWh) battery storage system and EV charging station that will take part in demand response programs. The first multi-customer microgrid in the PG&E service territory, the project is intended to "provide a test bed for the policies, tariff structures, and operating procedures necessary to integrate microgrids into California's electric grid. Lessons learned will help create a road map for microgrid interconnection across the state." Commissioning and full operation is scheduled for November 2021.

An Easier Path to Community Microgrid Success for Municipals and Cooperatives?

All three types of utilities (municipal, cooperative, and investor-owned) consider issues such as customer and social equity, as well as conduct cost-benefit analyses [98]. However, municipal and cooperative utilities, as well as CCAs, typically have greater flexibility, because they need to justify their investment decisions to only a local board or directors. Investor-owned utilities (IOUs) must justify their expenditures to state regulators and shareholders.

After reviewing dozens of applications for community microgrid planning funding (as part of the NY Prize) [17], NYSERDA indicated that microgrids in municipal utility or cooperative service areas have "an easier pathway to success" [99]. Municipals or cooperatives already own or control the infrastructure, controls, communications networks, and interfacing elements required for a microgrid. Hence, municipals and cooperatives essentially own and operate an existing power grid within a larger interconnected utility power grid. When implementing a microgrid within a municipal or cooperative service area, the points of common connection and interaction agreements with the larger utility power grid remain unchanged. Conversely, a microgrid within an IOU service territory "must work out these agreements from scratch with an IOU that is uncertain of the role of the microgrid, concerned about encroachment upon their service territory and customer base, and is working with existing policies that predate the concept of the community microgrid and its potential benefits to the power grid" [99].

Municipal and cooperative utilities, as well as CCAs and regional transmission and planning authorities, are nonprofit entities. In contrast, shareholders expect IOUs to earn a profit – a competitive return on their investment. IOUs are permitted to earn a return only on those investments that regulators deem to be "prudent." Those investments are allowed into the utility's rate base, on which the utility earns a defined rate of return.

Because an IOU's earnings are directly related to its infrastructure spending that regulators approve, some observers believe this approach discourages IOUs from encouraging third-party investments in innovative technologies such as microgrids. If a business other than the utility seeks to implement a microgrid, due to the existing regulatory environment in many jurisdictions, many IOUs are likely to view this as a two-fold threat:

- The utility may lose revenue.
- The utility may not gain an addition to its rate base, on which its earnings are based [100].

These concerns can be addressed as regulators develop a microgrid tariff, which could provide the utility a revenue stream to cover use of its facilities and provision of backup power [101].

According to the NYSERDA report on feasibility assessments,[12] the most successful microgrid proposals generally have garnered the support and cooperation of local utilities. Agreements between proposed microgrids and interfacing utilities are quite complex, encompassing:

- The utility's policies
- State and utility commission regulations
- Ownership of equipment and controls
- Compensation to the utility for use of distribution equipment and operations
- Microgrid operation and maintenance arrangements
- PPAs for microgrid-generated power
- Provisions that address other legal and financial considerations [99]

The DSO: A Potential Long-Term Solution?

Some companies such as S&C Electric and policy groups such as the Center for Energy Efficiency and Renewable Technologies (CEERT) argue that the solution to many of the conflicting policies that currently inhibit community microgrids is to adopt the distribution system operator (DSO) model [102,103]. Under this model, rather than remaining dependent on increasing electric sales and infrastructure investments, the utility becomes a distribution system operator (similar to a transmission system operator). According to S&C Electric, a DSO will derive "a significant portion of its revenue...from incentives, providing ancillary services, and serving as a market platform...The DSO will manage a system with better information and low market barriers, enabling energy solutions to meet customer needs while the utility profits from meeting its performance metrics" [102].

[12] NYSERDA funded a number of microgrid feasibility studies under the umbrella of the "NY Prize." Its evaluation of these feasibility studies contains useful examples of the complex components of community microgrids [104].

In its comments to the CPUC on PG&E's safety practices, CEERT reiterated earlier comments in which it urged PG&E to become a DSO. CEERT argued that without this service model, PG&E (and presumably other utilities) would not be able to support truly resilient infrastructure. CEERT argues that "creating the infrastructure for truly resilient service requires distribution system operation to be a platform that welcomes and facilitates DER interconnection, encourages evolution of linked local grids that prioritize neighborhood level needs, developed in conjunction with city and county planners, and that enable all resources on the grid to transact power and grid services and to function as 'non-wires alternatives' to offset grid infrastructure investments" [103].

Leading Practices: Overcoming Barriers

Based on a review of successful (and some not implemented) community microgrids, following are leading practices for microgrid developers to consider when addressing microgrid financial, legal and regulatory barriers. Figure 2 summarizes the limitations and proposed practices.

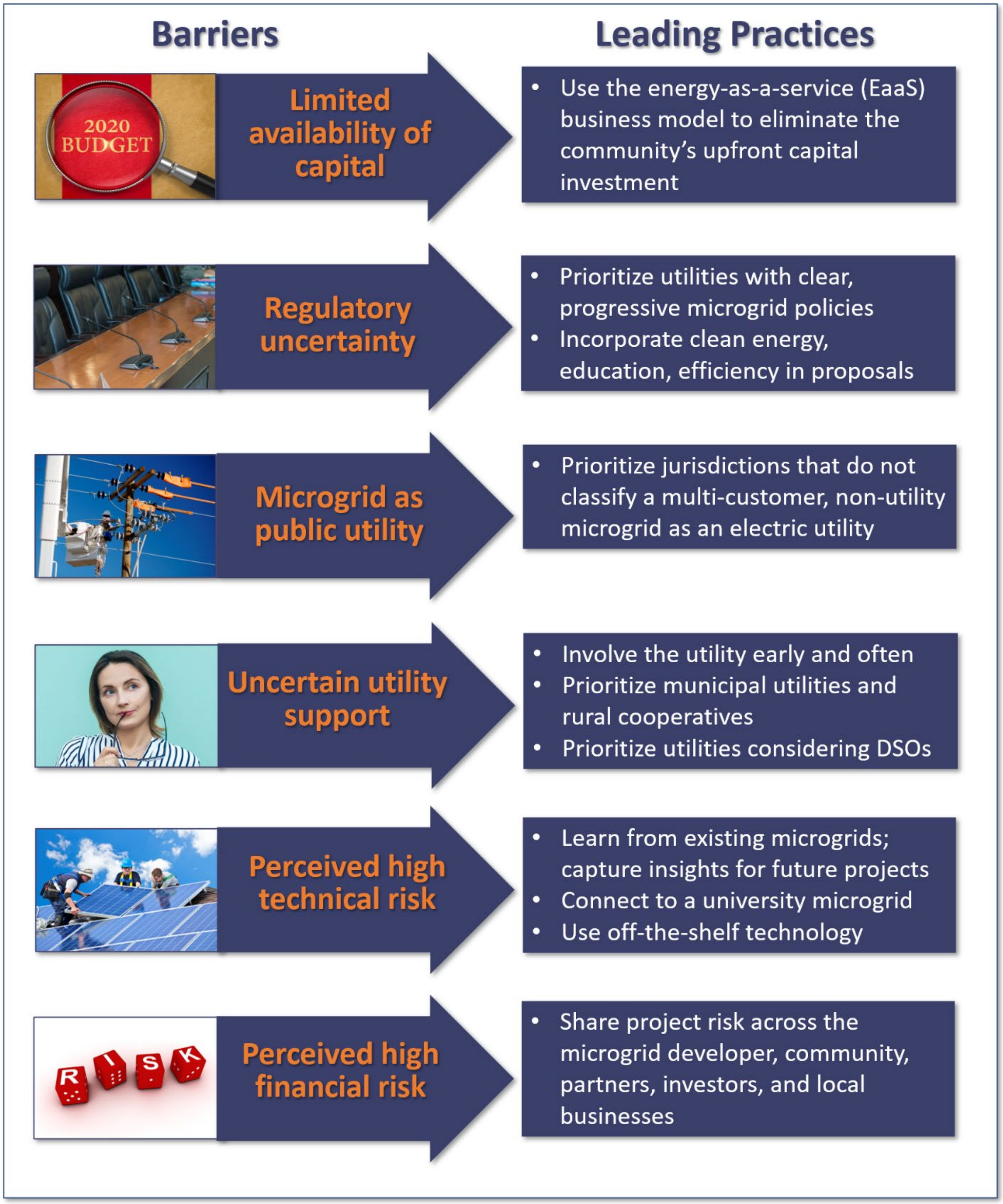

Figure 2. Summary of Community Microgrid Barriers and Leading Practices

Limited Availability of Capital

- **Consider the EaaS model.** To address capital investment limitations of communities and individual energy users, consider employing EaaS business models.

Regulatory Uncertainty

- **Seek areas with microgrid policy clarity.** Prioritize microgrid projects in states/utility service territories with laws and regulatory requirements that provide clarity about microgrid policies.
- **Maximize likelihood of regulatory approval.** Pursue at least some community microgrid projects that offer a high probability of regulatory approval, rather than only engaging in projects that set a regulatory precedent. For example, incorporate into microgrid proposals:
    - Outside funding, including local, state, federal, or private grants
    - Public/private partnerships
    - Building and process energy efficiency and conservation [99]
- **Focus on social and racial equity.** Develop microgrid projects in traditionally underserved neighborhoods to provide social and racial equity and environmental justice, address the impact on housing affordability, and emphasize these aspects to regulators.
- **Incorporate an educational component** for elementary, high school, and college students and the public
- **Integrate environmental initiatives**, including clean energy goals, climate action plans,[13] and other environmental and non-carbon emission benefits
- **DSO consideration.** Prioritize microgrid projects in jurisdictions considering or implementing a DSO model

Microgrid as Public Utility

- **Prioritize jurisdictions** that do not classify a multi-customer, non-utility microgrid as an electric utility

[13] Climate action plans are "comprehensive roadmaps that outline the specific actions that an agency will undertake to reduce greenhouse gas emissions" [105].

Uncertain Utility Support

- **Garner utility involvement and support.** Work closely with the local utility early and often during project planning and implementation, in an effort to gain utility support and benefit from their expertise
- **Identify projects for municipal utilities and rural cooperatives.** Identify municipal utilities and rural electric cooperatives that are seeking microgrid partners

Perceived High Technical Risk

- **Incorporate lessons learned.** Learn from existing microgrids, use off-the-shelf technology, and incorporate best practices into new microgrid projects.
- **Collaborate with a local university.** Locate the microgrid next to a university, preferably one with an existing campus microgrid, to demonstrate resource sharing across the two microgrids, motivate establishment of educational programs on microgrids, and physically connect to the second microgrid.

Perceived High Financial Risk

- **Share project risk and choose partners carefully.** Select value-adding partners that will share project risk, including various microgrid service and solution providers, investors, local energy users, neighborhood and community leaders, and community leadership.
- **Emphasize avoided utility costs.** Describe and emphasize to regulators how the microgrid avoids utility necessary expenditures or investments in T&D upgrades (i.e., non-wires alternatives).

PART III: PROTOTYPES AND GROWTH

Learning from Existing Oasis Community Microgrids

Microgrid providers can glean best practices by examining the following operating or planned oasis community microgrids.

Operating Oasis Community Microgrids

Quintessential Oasis: Borrego Springs, California

The Borrego Springs Microgrid in SDG&E's service territory in California lends new meaning to the term "oasis" community microgrid. Located 50 miles from the nearest town, Borrego Springs is an oasis in the Anza Borrego Desert. It is also home to what the CEC calls "California's first renewable energy-based community microgrid." Initially established in 2013 due to the town's vulnerability at the end of a single transmission line, the microgrid demonstrated its resilience capabilities by enabling the town's much faster recovery from severe thunderstorms in September 2013 than would have been possible without the microgrid [3,4].

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. A 26-MW PV system, 3.6 MW of distributed generators, 3 MW of customer-owned rooftop PV systems, and local storage power the microgrid. According to the CEC, "this project has significantly increased the microgrid knowledge base, particularly regarding advanced microgrid controllers and implementing non-utility owned resources" [3,4]. In the next step, SDG&E plans to use a $4.5 million DOE grant to upgrade the microgrid to run entirely on renewable energy [106].

With regard to the above-mentioned microgrid controllers, at a January 2020 CPUC meeting, SDG&E described a technology that is "important to microgrid control and operations and a critical component to the timely implementation of the microgrid projects." Explaining that localized microgrid controllers are an emerging technology, the utility proposed deployment of a local area distribution controller (LADC) that will [55]:

- Provide the utility centralized, fast-acting control of microgrids needed to ensure "timely, safe, and reliable operation of a microgrid"
- Control multiple DER devices within microgrids "to provide resiliency through black-start (via grid-forming DER), minimal-impact island transition, and load-shedding"
- Detect outages and switch microgrids to islanding mode automatically
- Shed noncritical loads in the microgrid and maintain power to critical loads automatically

- Reconnect islanded microgrids to the grid when grid power is stabilized
- Maintain microgrid voltage and frequency within defined limits while in island mode

All Residential: Reynolds Landing, Alabama; and Marcus Garvey Village in Brooklyn, NY

A destructive and deadly tornado in Alabama 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 Southeastern 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 PV array, 400-kW natural gas generator, and a 600-kWh BESS power the microgrid [5,6].

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, EPRI, Oak Ridge National Laboratory, homebuilder Signature Homes, and equipment vendors Carrier, Rheem, and Vivint [5,6]. In June 2020, *POWER* Magazine presented Alabama Power with its 2020 Smart Grid award. According to executive editor Aaron Larson: "I think it's safe to say that with a community-scale microgrid, rooftop solar panels, battery energy storage, a super-tight building envelope, comprehensive duct-sealing, triple-pane windows, radiant barrier roof decking, smart thermostats, connected and controllable heat pump water heaters, air-source heat pumps, and electric vehicle chargers, as well as home automation and security packages, including smart door locks, lights, and voice control, the Jetsons would be quite happy living in Alabama Power's Smart Neighborhood" [107].

In a similar-sized but more urban example of an all-residential microgrid, Consolidated Edison Company of New York is now operating the Marcus Garvey Village apartments microgrid in Brownsville, Brooklyn. Enel X worked with building owner L+M Development Partners on the project, which includes 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) to the 625-unit, eight-city-block affordable housing complex. Partly developed in response to Superstorm Sandy, the project is the first of its kind for a multi-family residential development in New York City. 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 [108,109].

Life-Saving Microgrid: Blue Lake Rancheria, California

Blue Lake Rancheria PV System, California. Image Credit: Blue Lake Rancheria, U.S. Department of Energy

A Northern California microgrid energized in 2017 proved its worth during the PSPSs in October 2019 when it was one of only a few locations in the area with backup power. During the outages, the award-winning Blue Lake Rancheria Microgrid was credited with saving multiple lives by powering hotel rooms for critically ill hospital patients who required electrical medical equipment. The microgrid provided residents and emergency responders with fuel, ice, internet access, handheld device charging, ATMs, refrigeration for medicines, and other services that would not otherwise have been available [7-10]. One year earlier, the microgrid maintained power during the Shasta and Trinity County Carr Fire in the summer of 2018 [110]. Then, during the week of August 15, 2020, the microgrid's operators voluntarily moved it into island mode, without financial compensation, to conserve power during California's rolling blackouts [111].

Benefits like these – providing essential services, reducing human suffering, and saving lives – illustrate the power of community microgrids. Located on a Native American reservation in Humboldt County, the microgrid powers critical American Red Cross safety shelter-in-place facilities. A 420-kW PV array and 500-kW/950-kWh lithium-ion (li-ion) BESS power the project developed in collaboration or coordinated with Humboldt State University's Schatz Energy Research Center, Siemens, Idaho National Laboratory, CEC, PG&E, and others. Future plans include doubling the battery storage system, adding more PV, integrating more EV charging, and participating in demand response programs [7-10].

"Resiliency Hub": North Bay Community Energy Park, Ontario, Canada

In North Bay, Ontario (Canada), municipal utility North Bay Hydro Services has teamed with S&C Electric Company to install a community microgrid. Now operating, the project was devised in response to the ice storm that disrupted power to over 600,000 customers and caused at least 27 deaths in December 2013 [11]. During normal operation, the North Bay Community Energy Park powers three public facilities using two natural gas generators and solar systems (789 kW total). During 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” [112].

Fuel Cell Microgrid: Hartford, Connecticut

Urban settings provide challenges for microgrids with solar and battery storage due to footprint limitations. 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. 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 [12,13].

Hartford, Connecticut

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 [12,13].

The Higashi Matsushima Microgrid, Japan

In the wake of the 2011 Great East Japan Earthquake and Tsunami, Japan has been particularly active in developing disaster-resilient community microgrids. The country’s National Resilience Programme has developed several microgrids, including the notable Higashi Matsushima City Smart Disaster Prevention Eco Town. Located in the Miyagi Prefecture on Japan’s northeast coast, the city was badly damaged in the 2011 disaster and many lives were lost. The microgrid there consists of a 460-kW solar array, 480-kWh battery storage system, and a 500-kW biodiesel generator. The microgrid can power the town’s earthquake-resistant 70 houses and 15 apartment buildings (which house many people who lost their homes in 2011) or it can be redirected to hospitals and a community hall. Renewable energy today meets 35% of the town’s demand, with plans to increase this to 120% by 2026. Opened in 2016, the town also features a disaster-resilient regulating pond to manage flood risks, and will be a net zero city by 2022 [113].

Planned or Proposed Oasis Community Microgrids

The Perfect Microgrid? – Bronzeville Community Microgrid, Chicago

The first utility-operated microgrid "cluster," the Bronzeville Community Microgrid that Exelon subsidiary Commonwealth Edison Company (ComEd), developer VLV Development, and the Chicago Housing Authority are installing on the South Side of Chicago, 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. 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 [14,15].

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 [114].

According to *Microgrid Knowledge*'s Lisa Cohn, who touts the "social justice benefits" of the project, VLV Development's stated goal is to develop one clean energy microgrid in each of the 50 Chicago wards, for a total of 50 MW of solar-plus-storage for at-risk residents [115].

This project is also interesting because of the comprehensive manner in which ComEd identified the site. According to ComEd, "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" [116]. 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. ComEd then evaluated each of these according to "existing reliability, capacity for future growth, substation condition, and presence of critical infrastructure that requires resilience" [117].

Gold Star Example of a Microgrid and Local Education

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. The first powers a 25-kW, 100-kW (85-kWh) Li-ion battery solar greenhouse, and the second is a 1.5-MW solar, 500-kW (500-kWh) Li-ion battery campus microgrid [118].

Wildfire Motivated: SDG&E Community Microgrids and PG&E Community Program

In a proposal submitted to the CPUC on January 21, 2020, SDG&E summarized three of its microgrid projects that it indicates have the potential to be in service by the end of 2020. One of these, Cameron Corners, is particular interesting because of its community microgrid characteristics. SDG&E describes Cameron Corners 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" [55]. On September 1, 2020, the utility announced that it still plans to move forward with the Cameron Corners microgrid, as well as microgrids at the Ramona Air Attack Base, Butterfield/Agua Caliente, and Shelter Valley to "allow communities and critical facilities to remain energized during a PSPS" [119].

At a January 2020 CPUC webinar, PG&E proposed a Community Microgrid Enablement Program (CMEP) to "empower local stakeholders to initiate critical facility community microgrid solutions." According to PG&E, the CMEP "provides a framework in which communities bring their innovative ideas and local expertise to the table and PG&E provides utility technical and, as appropriate, financial support for projects that are designed to mitigate PSPS impacts, focusing on the most critical and vulnerable customer groups." More specifically, PG&E's proposed CMEP will provide a "financial incentive to participating local governments, in the form of a one-time matching funds payment, to offset some portion of the utility infrastructure upgrade costs associated with implementing the islanding function of a critical facility community microgrid" [120]. Here, PG&E is essentially proposing to incentivize development of community microgrids.

The Vallecito Energy Storage Resilience Project: First Step in the Goleta Load Pocket

As a first step towards a larger planned Goleta Load Pocket Community Microgrid, a 40-MWh utility-scale storage project is projected to go online in December 2020. The Vallecito Energy Storage Resilience project is the first of several staged projects planned for the next few years to address the significant resilience issues of the area. The Goleta Load Pocket covers 70 miles of Southern California coastline, including Goleta, Santa Barbara, Montecito, and Carpenteria. In 2018, mudslides destroyed 400 homes and killed 23 people in Montecito. The area is also vulnerable to the failure of one set of transmission lines that wind through 40 miles of mountainous terrain. The ultimate goal is to provide 100 percent resilience via installation of 200 MW of solar and 400 MWh of storage, according to Craig Lewis of the Clean Coalition. The envisioned community microgrid will serve the Carpenteria High School, which is an official Red Cross emergency shelter [121].

Primetime Microgrid: Ragged Island Community Microgrid, Bahamas

The community microgrid nearing completion on Ragged Island in the Bahamas may be small (390-kW/1260-kWh), but it is likely to have a big impact [122]:

Hurricane Dorian in September 2019

- When operational in 2020, it will provide 93% of the island's energy needs.
- It is being constructed to withstand hurricane force winds akin to the 185 mph winds of the category 5 Hurricane Dorian that battered the island in August and September 2019.
- It has provided significant exposure for microgrids, with its coverage in a March 2020 segment of the CBS show *60 Minutes*.
- It will serve as a jumping off point for further microgrid work on the Abaco Islands with the Government of the Bahamas, RMI, and Bahamas Power and Light.

Solar Emergency Microgrids

In addition to these projects that encompass a moderate or large number of customers, microgrid developers are also involved in several projects to provide "solar emergency microgrids" (SEMs) for individual loads that are crucial during extreme events. These loads include fire and police stations, hospitals, emergency operations centers, emergency shelters, cell phone towers, water treatment plants, as well as critical transportation hubs such as airports and seaports. This work is motivated in part by the lack of solar power backup for critical infrastructure in Puerto Rico after Hurricane Maria in September 2017.

As an example of this solution to enable islanding of critical infrastructure, the first fire station in the U.S. to begin operation of such a microgrid (September 2017) is in Fremont, California. Now consisting of three fire stations,[14] the total deployment includes 115-kW of solar and 333 kWh of li-ion battery storage. The project is a collaboration of the CEC, the Fremont Chamber of Commerce, and Gridscape Solutions; the latter provided a cloud-based predictive DER management software and energy management system [10]. The Peninsula Advanced Energy Community [123], Montecito, CA fire district, and others are planning similar solar emergency microgrids [124].

[14] The latter two fire stations became operational in October 2018 [10].

The California Legislative and Regulatory Push

The series of destructive wildfires in California from 2017-2020 has stimulated a flurry of recent legislative and regulatory activity in California regarding microgrids in general, and community microgrids in particular. Awareness of the specifics of these activities can help microgrid providers develop and market solutions that are consistent with these regulatory trends.

California Senate Bill SB 1339: Groundwork for Microgrids

In 2018, California passed Senate Bill SB 1339 that called for the CPUC, the CEC, and the California Independent System Operator (California ISO) to take various actions by December 1, 2020 to "facilitate the commercialization of microgrids for distribution customers of large electrical corporations" [125]. Meanwhile, the series of wildfires spurred the three large California IOUs to implement PSPSs. Many utility customers and other stakeholders have criticized this tactic due to the consequent inconvenience, disruption, and health risks. While PSPSs may enhance resilience, their economic cost is significant. Michael Wara of the Stanford Woods Institute for the Environment used the ICE Calculator to estimate the cost of one California PSPS affecting 800,000 residential and small commercial and industrial customers for 48 hours at $2.5 billion [126].

California IOU Wildfire Mitigation Plans

In December 2019, the CPUC published an updated template for the Wildfire Mitigation Plans (WMPs) that the three California IOUs are required to file annually. Among other provisions, the template calls for a "plan to support and actions taken to mitigate or reduce PSPS events in terms of geographic scope and number of customers affected, such as installation and operation of electrical equipment to sectionalize or island portions of the grid, microgrids, or local generation." For certain sections of the grid, the template also called for the IOUs to "outline any analysis that was conducted around islanding, serving with microgrids, or providing backup generation, all to reduce the impact of PSPS events and reduce ignition probability and estimated wildfire consequence at the lowest possible cost" [127].

CPUC Rulemaking R. 19-09-009: Accelerating Microgrids

On December 20, 2019, the CPUC's Assigned Commissioner's Scoping Memo and Ruling for Track 1 of Rulemaking R. 19-09-009 designed "a framework surrounding the commercialization of microgrids associated with Senate Bill 1339." Track 1 of this rulemaking "is focused on fasttracking near-term solutions for microgrids and resiliency," and covers "deploying resiliency planning in areas that are prone to outage events and wildfires, with the goal of putting some microgrid and other resiliency strategies in place by Spring or Summer 2020, if not sooner" [128].

Of particular relevance to utility and community cooperation on resilience, including microgrids, two issues covered in track 1 are "facilitating local government access to utility infrastructure and planning data to support the development of resiliency projects; and investor owned utility proposals for immediate implementation of resiliency strategies, including partnership and planning with local governments" [128].

The track 1 rulemaking also calls for "prioritizing and streamlining interconnection applications to deliver resiliency services at key sites and locations," where "key sites and locations" is defined to include but not be limited to "...customers with access and functional needs, medical baseline customers,[15] police stations, fire stations, schools (e.g., educational facilities), water and waste water facilities, community centers, senior centers, and disadvantaged and hard to reach communities" [128]. This list is interesting for three reasons:

- **Similar to Bronzeville and Cameron Corners.** These customer loads are similar to those in the Bronzeville Community Microgrid and Cameron Corners Community Microgrid.
- **Community Loads.** Customer loads like these are not included in the vast majority of existing microgrids.

- **Social and Racial Equity.** The mention of "disadvantaged and hard to reach communities" recognizes the importance of social and racial equity when implementing resilience solutions, including oasis community microgrids.

Track 2 of SB 1339 takes the next step on microgrids in California. It calls for "developing standards, protocols, guidelines, methods, rates, and tariffs to support and reduce barriers to microgrid deployment statewide, while prioritizing system, public, and worker safety, and avoiding cost shifts between ratepayers." Further, track 3 will "consider the ongoing implementation requirements of SB 1339 as well as any future resiliency planning" [128].

[15] "Medical baseline customer" is a term the CPUC and California utilities use for an assistance program for residential customers who have special energy needs due to qualifying medical conditions [129].

A CPUC Energy Division Staff Proposal issued January 21, 2020[16] recommended California IOU information sharing with local government entities, including [130]:

- **Educating local government agencies** on vulnerable infrastructure and critical operations
- **Developing a guide** to engage local governments on the IOUs' process of interconnecting a resilience project
- **Creating a dedicated team** to manage inquiries from local governments about resilience projects
- **Creating a separate data portal** for local governments with information on resilience project development

On March 9, 2020 and March 17, 2020, the CPUC Executive Director transmitted letters to the three California IOUs, instructing them to take steps immediately to implement resiliency solutions. Among other instructions, these letters instructed the IOUs to [131]:

- Implement the above recommendations about information sharing with local governments (with some variation across the IOUs as appropriate)
- Prepare to "implement directives that are reasonably likely to result" from track 1
- Remember that track 1's objective is to make changes to deploy more resilience projects "before the 2020 wildfire season"
- Take "no regrets" actions now to "help reduce the impacts of wildfires and PSPSs in 2020"

On April 29, 2020, the CPUC issued a proposed decision on R. 19-09-009 [132], and on June 11, 2020, the CPUC issued the Rulemaking [16]. Upon the release of this decision, PG&E's CEO and President Andy Vesey issued this statement: "As PG&E continues our enhanced and expanded efforts to reduce wildfire risks, we are also working to reduce the scope, duration and impact of future PSPS events. A key piece of this strategy is developing and deploying microgrids" [133].

The June 11, 2020 R. 19-09-009 also granted PG&E permission to use temporary diesel generation at substations, mid-level feeders that serve commercial customers, and backup power support. The Rulemaking limits this use of diesel generation to the serving of customers impacted by PSPS outages for at most one year, limiting it to "short-term, interim and targeted use only." The Rulemaking explains: "Indeed, large diesel generators – even when localized in select areas – present potential health risks for individuals who live or work near a temporary generation site. We weigh this risk presented by limited, localized use of temporary diesel generation against the near-term impact of the upcoming wildfire season and potential PSPS outage events as we calibrate a balanced approach to ensure electrical service necessary for

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[16] The cover page of the staff proposal is erroneously dated January 21, 2019.

public health, safety, welfare and societal continuity in times of crises" [16,132]. PG&E had originally sought to implement clean energy microgrid in time for the 2020 wildfire season, but PG&E Director for Grid Innovations Quinn Nakayama said "We concluded it is not feasible to execute it by June of 2020" [134,135].

As part of R. 19-09-009, on September 14, 2020, the Microgrid Resources Coalition (consisting of 25 stakeholders) encouraged the commissioners to finalize a microgrid tariff for single customer microgrids by January 2021 and implement a multi-customer microgrid by mid-2021. The Coalition is suggesting that such tariffs reward microgrids for the variety of services they provide, including resilience, resource adequacy, generation, storage, and load management [136].

Removing Impediments to Microgrids in California: Proposed SB 1215

On May 26, 2020, the California Senate's Energy, Utilities and Communications Committee passed California Senate Bill SB 1215. The bill proposes to amend existing law to promote community microgrid use in California. If enacted, it would exempt microgrids that serve multiple customers from responsibilities of an "electrical corporation." It would also:

- Require the CPUC to create a database of critical facilities and infrastructure
- Require the CPUC and California ISO to account for the value of resource adequacy for distributed storage by March 31, 2021

The bill also implies that all customers bear the cost of distribution system improvements needed for the microgrid [83]. The bill analysis includes a concise summary of the "resiliency benefits of microgrids":

> "From wildfires, to flooding, to extreme weather events, microgrids may help provide additional reliability and resiliency to allow a customer or community to withstand the event while maintaining their electric power for critical services. In addition to the increased reliability, microgrids...have the potential to provide lower electricity bills for the customer and cleaner air by displacing the need for energy generating resources with higher emissions" [83].

In a Silicon Valley Leadership Group (SVLG)[17] letter to this Senate Committee, SVLG proposes amendments to the bill and relates the importance of the proposed legislation to PSPSs:

> "The Silicon Valley Leadership Group supports, if amended, Senate Bill 1215, legislation that would help facilitate the development of community microgrids that serve facilities and infrastructure, and provide backup power during outages. While Public Safety Power Shutoffs (PSPS) serve a safety function, their

[17] SVLG is a public policy association of more than 360 companies in Silicon Valley.

economic costs and costs to local governments and communities begs attention for microgrid projects that can serve multiple customers. This bill highlights the important role microgrids can play in mitigating the impacts of PSPS events" [137].

Removing Impediments to Microgrids in California: CPUC Staff Proposal (July/August 2020)

By the end of July 2020, the CPUC staff released a set of proposals to address many of the regulatory and financial barriers to community microgrids. The "Staff Proposal for Facilitating the Commercialization of Microgrids Pursuant to Senate Bill 133, "described these CPUC staff proposals [27]:

- **Allow microgrids to serve critical customers on adjacent parcels**. The proposal would alter the rule prohibiting one building or premise from serving another. Utilities view this "over the fence" rule as a safety and reliability measure, but microgrid providers see it as a barrier to resilience, efficiency, and economy, preventing them from serving a nearby (but not adjacent) facility during a grid outage. The CPUC recommended an exemption from the rule for critical facilities that municipal corporations own, but only for ten microgrids within the service territories of the three California IOUs.
- **Develop a microgrid rate schedule**. Lack of a microgrid rate schedule (tariff) leads to rate complexity (a regulatory barrier), high initial costs (a financial barrier), and high operating costs (another financial barrier). Rate complexity follows from different net metering rules for solar, solar plus storage, fuel cells alone, or various combinations of these technologies. High initial costs could prevent optimal microgrid investments that would be in the public interest. High operating costs such as departing load charges (when the utility loses customers) and standby charges could also depress investment below a socially desirable level.

  The staff recommended that utilities be directed to develop a single rate schedule for any combination of technologies that meet current interconnection requirements. However, the staff also recommended against granting additional exemptions from cost responsibility surcharges beyond those already in existence, thus limiting the risk of cost shifting.
- **Develop a microgrid pilot program**. The proposal suggests that utilities be required to develop an incentive program to fund clean energy microgrids that support the "needs of vulnerable populations most likely to be impacted by grid outages." The staff proposed a pilot program administered by the three IOUs consisting of 15 microgrids capped at $15 million each by January 31, 2022 and funded by ratepayers in the same county where the project is located.

In August 2020 comments on the staff proposals, the Local Government Sustainable Energy Coalition objected to the CPUC staff's preference for utility construction of the 15 pilot microgrids. This Coalition, which includes 13 cities and 23 counties in California and claims to represent three-fourths of California's population, encouraged regulators to give local communities control of the administration and funding of the pilot microgrid program [138].

Proposed California Energy Resilience Act (SB 1314)

On February 21, 2020, California Senator Dodd introduced a bill (SB 1314) that would establish a council to operate a grant program for local governments to develop community energy resilience plans. In addition to incorporating "equitable access to reliable energy," the plans would be required to "ensure a reliable electricity supply is maintained at critical facilities and identify areas most likely to experience a loss of electrical service." Due to the COVID-19-shortened 2020 legislative calendar, the bill has not yet progressed through committees [139].

California State Budget Impact

Despite the financial impacts of COVID-19 on the state, California's signed 2020-2021 budget maintains a $50 million fund for "community power resiliency" [140]:

> "Maintain $50 million onetime General Fund to support additional preparedness measures that bolster community resiliency. Building on the state's 2019-20 power resiliency investments, these measures will support critical services still vulnerable to power outage events, including schools, county election offices, and food storage reserves."

Additional Regulatory and Incentive Activity

The NY Prize: Incentivizing Community Microgrids in New York

The NY Prize (summarized earlier) solicited bids for community microgrid feasibility funding, and received responses from 130 cities – in a single state. To date, the $40 million NY Prize has awarded funding for 83 "stage 1" (feasibility study) projects (completed in 2016) and 11 "stage 2" (comprehensive engineering, financial, and commercial assessment) projects in six regions across the state [17]. For example, in one of the stage 2 projects, the City of Syracuse community microgrid would serve about 2,000 residential and small commercial energy end users, a 911 dispatch center, a hospital, a senior housing complex, a nursing home and several long-term care facilities, a fire station, schools and a community college, as well as other energy users [141].

Syracuse, New York

The MassCEC Community Microgrids Program

The Massachusetts Clean Energy Center (MassCEC), the state's economic development agency, has established a community microgrids program to "catalyze the development of community microgrids throughout Massachusetts to lower customer energy costs, reduce greenhouse gas (GHG) emissions, and provide increased energy resilience" [142]. In February 2018, the state issued $1.05 million in funding for feasibility studies of 14 projects [18]. For example, the City of Pittsville proposal for a 2.9-MW solar-powered community microgrid would serve a hospital, local emergency operations, emergency shelters, a fire station, a police station, city hall, and affordable housing. Similarly, the Town of Palmer proposes a community microgrid that would support local emergency operations, emergency shelters, a wastewater treatment plan, a regional hospital, a fire station, a police station, a high school that can serve as an emergency shelter, local food sources such as grocery stores, and a gasoline station [143].

MassCEC awarded grants totaling $150,000 to a collaborative of nine organizations "dedicated to environmental justice and energy democracy" to conduct feasibility assessments of community microgrids in Chelsea, Massachusetts and Boston's Chinatown. The team includes the Green Justice Coalition, Resilient Urban Neighborhoods, GreenRoots Chelsea, the Chinese Progressive Association, Eversource, and others [144,145]. The proposed Chelsea project would serve a hospital, regional produce distribution center, emergency shelters, and affordable housing. The Chinatown project would serve a school, eight affordable housing complexes, and a neighborhood emergency shelter [146].

In parallel, the Boston Planning & Development Agency (BPDA) adopted the Smart Utilities Policy for Article 80 Development Review, which "aims to integrate the resilience and efficiency benefits of district energy and microgrids into the planning and design process for large new developments." Here, a "district energy microgrid" is defined to provide both thermal and electrical services [147,148]. The C40 Cities website explains that this policy "requires proponents of new developments 1.5 million square feet or larger to submit a technical and financial feasibility assessment for advanced energy systems, including a district energy microgrid." This article also states that "Boston's requirement for large developments to study and install district energy microgrids is a first in the country" [149].

The Connecticut Microgrid Grant and Loan Program

In 2012, the State of Connecticut enacted Public Act 12-148, Section 7, which created a Microgrid Grant and Loan Program. It was created as a "result of multiple episodes of severe weather that caused widespread power outages for extended periods and is designed to help create ways to ensure that critical buildings remain powered during electrical grid outages." Through August 2019, more than $30 million had been awarded to a total of 13 projects, including more than $13 million in the most recent round 4 [19].

The New Jersey Microgrid Program

In the aftermath of Superstorm Sandy, the New Jersey Board of Public Utilities (NJBPU) established the Town Center Distributed Energy Resources (TCDER) microgrid program to help New Jersey become more resilient. The program defines eligible microgrids as "a cluster of critical facilities within a municipal boundary that may also operate as shelter for the public during and after an emergency event or provide services that are essential to function during and after an emergency situation. The critical facilities are to be connected to a single or a series of DER technologies that can operate while isolated and islanded from the main grid due to a power outage."

The NJBPU granted 13 applicants (one applicant withdrew) a total of $2 million in funding for Phase I TCDER microgrid feasibility studies. These 13 entities are also eligible to apply for a portion of the $4 million in funds that NJBPU approved for Phase II detailed microgrid designs. The Phase II application deadline was extended to May 29, 2020 [20,150].

California Aggregator Activity

In California, three community choice aggregators (CCAs) and a municipal utility,[18] which act as load serving entities (LSEs) in California, issued a joint request for proposals (RFP), due December 23, 2019, from developers/vendors to "provide resource adequacy (RA)[19] capacity and resilience to LSEs' residential and commercial customers through the development of customer-sited DERs." The solicitation describes these DERs as battery storage and solar PV systems that can island to provide resilience to participating customers – essentially community microgrids. The solicitation calls for a total of 32.7 MW, with a portion to be deployed by September 2020 and the remainder by September 2021. The project's stated objective is to "identify new and existing DER systems capable of providing capacity to satisfy RA requirements while also supporting the development of DERs to increase resilience in each service territory" [21].

As of August 2020, none of these four LSEs had publicly issued an update on the RFP award process. However, on June 11, 2020, the CPUC adopted a framework that designates PG&E and SCE as the central buyers to procure local, multi-year resource adequacy. The Commission considered but rejected a model in which individual LSEs, such as the California CCAs or municipal utilities, would procure all resource adequacy. Commissioner Liane M. Randolph explained that "Having numerous entities buying small strips of local resource adequacy is not cost-effective and creates market power concerns" [151]. On June 17, 2020, four California CCAs (EBCE, SVCE, PCE, and San Jose Clean Energy) issued a joint statement that criticized the ruling, saying that it "directly undermines current and future value streams from investments in local community-supported energy investments we are making and creates unnecessary regulatory uncertainty for all future investments" [152]. It is not clear how this ruling will affect the LSEs' resource adequacy RFP summarized above, nor is it clear if this precedent will affect other public utility commission decisions across the country.

California CCAs also offer or are planning a variety of additional resilience initiatives related to community microgrids, including:

- The Lancaster Choice Energy's zero net energy microgrid communities
- Monterey Community Power's two-part microgrid program called SmartConnect
- Sonoma Clean Power's microgrid development in fire-prone areas [153].

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[18] The three CCAs are East Bay Community Energy (EBCE), Peninsula Clean Energy (PCE), and Silicon Valley Clean Energy (SVCE), and the municipal utility is Silicon Valley Power [21].

[19] According to the CPUC, resource adequacy "provides sufficient resources to the California ISO to ensure the safe and reliable operation of the grid in real time, and provides appropriate incentives for the siting and construction of new resources needed for reliability in the future" [154].

The FEMA Grant Program

In mid-2020, the Federal Emergency Management Agency (FEMA) boosted the concept of community microgrids when it announced a $500 million grant program. The Building Resilient Infrastructure and Communities (BRIC) program will fund projects that lessen disaster risk, reduce threats to public health and safety, and improve recovery efforts. At the urging of microgrid companies, FEMA indicated it would give weight to grant applications that "mitigate risk to multiple 'lifelines.'" FEMA defines *community lifelines* as "fundamental services in the community that, when stabilized, enable all other aspects of society to function" [155].

The oasis community microgrid concept described in this report enables multiple community lifelines simultaneously, based on the community's priorities. FEMA's endorsement of community lifelines – and by extension community microgrids – may present an opportunity for communities with "shovel ready" oasis microgrids to receive priority weighting in this competition for funds.

Seven Community Microgrids Proposed in Colorado

As part of a 400-acre smart city project, a microgrid is currently operating in Denver, Colorado at the Peña Station NEXT. In a partnership between Xcel Energy and its subsidiary Public Service of Colorado, Panasonic, and battery maker Younicos, the microgrid currently consists of a 1.859-MW solar PV system and a 1-MW/2-MWh li-ion battery system [156,157].

"Planning for resiliency continues to emerge as an important issue for our communities and we are pleased to help demonstrate how emerging technologies such as solar and storage can play an important role in helping back up critical facilities," said Charles Gouin, Xcel Energy business technology consultant, in Xcel's testimony to the Colorado Public Utilities Commission. "In the future, projects like these may help inform our distribution planning process." According to Jack Ihle, director, regulatory and strategic analysis at Xcel, who also testified in the proceeding, "The concept of community resiliency is becoming more relevant as, across the country, Americans seek to navigate the risks posed by extreme weather events or other disruptions" [158].

Using lessons learned from the Peña Station NEXT installation, the utility is currently seeking approval from the commission (Proceeding 19A-0225E) for seven additional community microgrids. On May 26, 2020, *Microgrid Knowledge* related that Xcel Energy had reached a settlement agreement with various interests that moves the utility one step closer to implementing the proposed $23.4 million project [159]. As of August 2020, no decision has been issued on this proceeding.

Puerto Rico Commission Activity

In May 2018, as one measure to respond to destruction of the island's electric system after Hurricane Maria in 2017, the Puerto Rico Energy Commission adopted a regulation on microgrid development. This regulation "sets the legal and regulatory framework required to promote and encourage development of microgrid systems in Puerto Rico...increase system resiliency, foster energy efficiency and environmentally sustainable initiatives and spur economic growth by creating a new and emerging market for microgrid services" [160].

As summarized in *Microgrid Knowledge*, the Puerto Rico Energy Bureau completed its mandated utility integrated resource plan (IRP) in late August 2020. The IRP requires the local utility, the Puerto Rico Electric Power Authority (PREPA), to "directly incorporate promotion of microgrid resources into all of its transmission, distribution, and resource planning" because microgrids "form a critical part of the resiliency solutions envisioned." The IRP also calls for PREPA to issue requests for proposals "for provision of renewable energy...and...battery energy storage ..in support of integration requirements for renewable energy generation" [161,162].

Hawaii Commission Activity

Also aware of the Hurricane Maria impact, in May 2018, the Hawaii State Legislature passed a law that "directs the Public Utility Commission to establish a microgrid services tariff to encourage and facilitate the development and use of energy resilient microgrids" [163]. The text of the law states that "microgrids can provide a building or set of buildings with emergency power for critical medical equipment, refrigeration, and charging critical communications devices. Microgrids can also provide backup power for hospitals and emergency centers. The legislature believes that the use of microgrids would build energy resiliency into our communities, thereby increasing public safety and security" [164].

In response, the Hawaii Public Utilities Commission instituted Order 36481, which states that the initial priority for the tariff is to "facilitate applications of microgrids that improve energy resiliency, particularly the islanding of microgrids during emergency events and grid outages to provide backup power to customers and critical energy users" [165]. As of a February 27, 2020 Microgrid Services Tariff Working Group report, the Commission expected to issue a draft tariff March 30, 2020 and receive comments from parties by April 27, 2020 [166].

According to *Microgrid Knowledge*, the tariff in Docket No. 2018-0163 “is receiving mixed reviews as the state attempts to break new ground in creating microgrid compensation.” The article quotes Richard Stuebi of the Boston University Institute for Sustainable Energy, who states: “There is relatively little conceptual agreement on whether and how the local utility should be involved, and how the utility would be compensated for its involvement, in a prospective microgrid” [167].

Resilient Maryland

In June 2020, the Maryland Energy Administration’s (MEA) Resilient Maryland Program announced 14 microgrid projects that will gain a share of more than $1 million for feasibility analyses, engineering, planning, and design. MEA selected the awardees from 25 proposals across the state [22]. Established in response to extreme weather that has caused extended power outages in Maryland, the projects include establishment of multiple community resiliency hubs in some of Baltimore’s marginalized communities. The hubs will “provide a centralized, trusted community location where community members can access reliable power for their essential devices, continue to receive information as emergency situations develop, store medications sensitive to temperature, and safely congregate until proper emergency response services arrive” [168]. Subsequently, MEA announced its FY21 Resilient Maryland program; applications are due January 29, 2021 [169].

Australia: Regional and Remote Communities Reliability Fund – Microgrids

The Australian Government has established the Regional and Remote Communities Reliability Fund to support “feasibility studies looking at microgrid technologies to replace, upgrade or supplement existing electricity supply arrangements in off-grid and fringe-of-grid communities located in regional and remote areas” [23]. On June 5, 2020, the Government announced funding of 17 microgrid projects with over $19 million (AUD) in Round One of this program. From 2019-2024, the fund will provide a total of $50.4 million (AUD) [170]. Several of the projects intend to enhance resilience for entire small communities, and several address indigenous (Aboriginal) communities. Intended program outcomes include [170]:

- Microgrid scale-up and implementation
- Increased human skills and knowledge on microgrids
- Demonstrated feasibility, reliability, and security of microgrids
- Reduced barriers to microgrid implementation
- Increased technology and knowledge dissemination

The Uncertain Impact of COVID-19

The impact of COVID-19 on growth of all types of microgrids remains to be seen. “In the short term, we see some disruption such as longer timeframes for bringing projects online in 2020 and stretching into 2021, “explains Peter Asmus, research director at Guidehouse. “Over the long run, we see the coronavirus outbreak as accelerating microgrid growth. A pandemic is just another disruption to society. Add it to the list of contingencies that need to be accounted for in infrastructure planning, which include global climate change, terrorist threats, wildfires, etc.” [171].

Effects of COVID-19 that may stimulate interest in microgrids include the following:

- Enhanced need for resilience
- Local community empowerment and interest in leading resilient solutions
- Enhanced public and business awareness
- Increased telecommuting (working from home) requiring resilience for a distributed workforce
- Heightened concern about economic disruption from simultaneous major threats
- An increased comfort level with embracing independent, distributed systems

Enhanced Need for Resilience

The unprecedented wildfires in 2020 in the Western U.S., ongoing concern about resilience along the east coast of the U.S. in the wake of the August 2020 storm Isaias, and other threats across the country are increasing resilience concerns.

On the east coast, despite major utility efforts to shore up resilience in the area, Isaias caused widespread outages, which were almost as extensive as those from Hurricane Sandy in 2012. On August 5, 2020, Public Service Electric and Gas (New Jersey) reported that 700 critical facilities, including seven hospitals, were out. “That’s hospitals, police/fire/ambulance, gas stations, transit systems, supermarkets, nursing homes – other utilities – water and sewage companies,” said the utility. However, microgrids in the area seemed to help. PowerSecure indicated that 167 customers, including grocery stores, hospitals, and industrial facilities, continued to receive power from their microgrids. Bloom Energy said that its 14 microgrids prevented 25 outages in the area on August 4th, 2020 [172].

Local Community Empowerment

As cities and counties assumed leadership roles in establishing measures to address the COVID-19 pandemic (e.g., county-specific shelter-in-place orders), these entities became the primary decision makers and responsible parties for many areas of the country. According to the

National Association of Counties (NACo), "America's counties are on the front lines of our nation's response to the coronavirus pandemic" [173].[20] While the seven San Francisco Bay Area counties led the county charge as the first U.S. jurisdictions to issue shelter-in-place orders (March 16, 2020), NACo reports that 864 U.S. counties have declared an emergency and 169 additional counties have issued "shelter-in-place,"[21] "safer-at-home," or business closure policies (see the figure) [174].[22] This represents about one-third of the approximately 3,000 total U.S. counties.

As a result of this leading role of local government to respond to a healthcare resilience crisis, some of these same jurisdictions may be more amenable to assuming a major role in enhancing resilience to other threats, including wildfires, extreme weather, and cybersecurity threats. Oasis community microgrids may be one way for cities and counties to take action to enhance the resilience of their communities.

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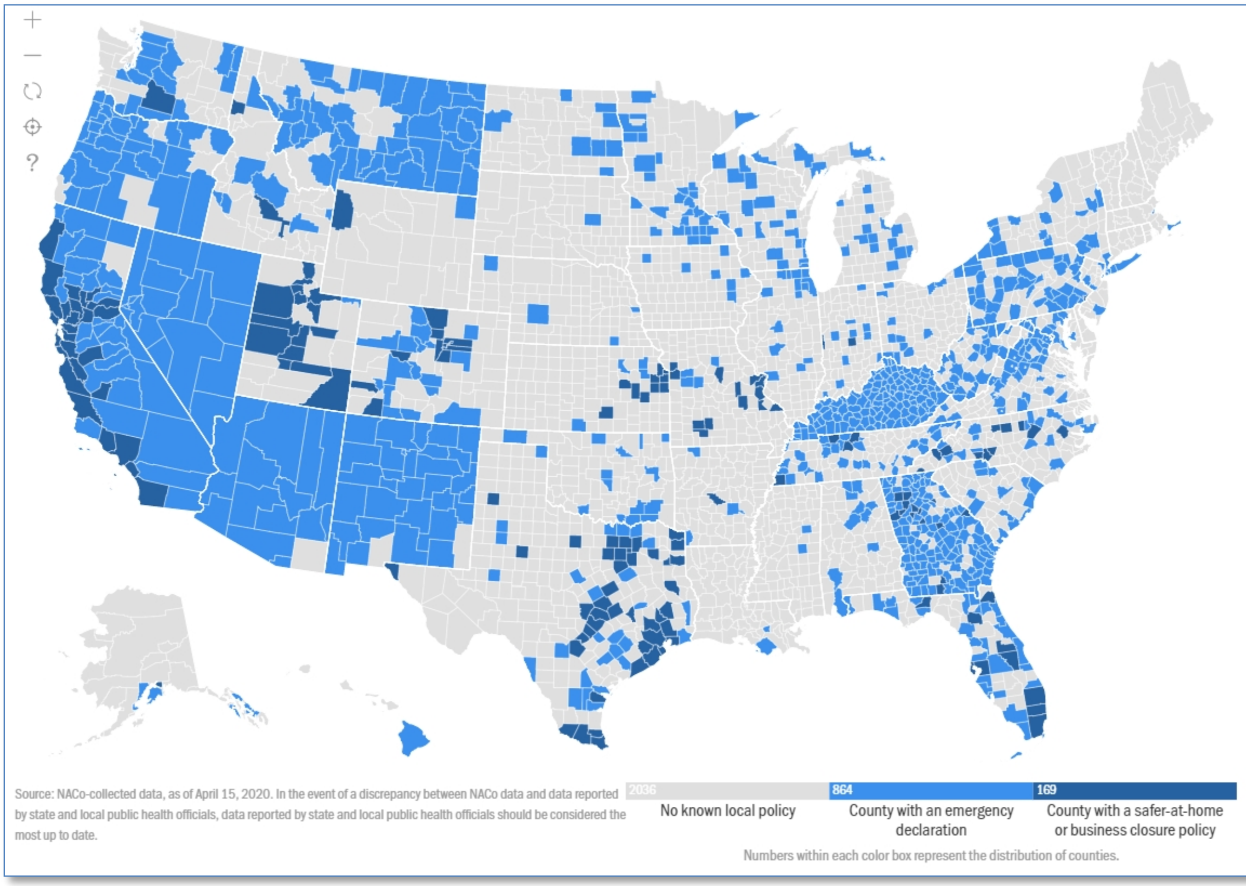
[20] The National League of Cities offers a similar message, saying that "cities, towns and villages are on the front lines of responding to the outbreak of coronavirus disease (COVID-19) in their community" [175].
[21] Climable.org extends "shelter-in-place" one step further to "prosper-in-place," saying that the resilience goal of a microgrid "is to allow residents who can't evaluate to not only survive but thrive during an emergency" [176].
[22] This data is effective April 15, 2020. As of September 17, 2020, NACo had not updated this data.



County Declarations and Policies in Response to COVID-19 Pandemic (as of April 15, 2020).

Source: The National Association of Counties – County Explorer [174]

Enhanced Public and Business Awareness

COVID-19 has also modified public perception in three ways:

- **Preparedness.** Public awareness of the need to be prepared for extreme events has increased. Many consumers were frustrated with the unavailability of basic consumer goods during the pandemic. Consider how these consumers would react to loss of electricity for an extended period of time, especially if they are working from home.
- **Neighborhoods.** In a related outcome of the pandemic, many consumers feel more connected to their neighborhood, as the shelter-in-place orders or safer-at-home policies in most states led many citizens to spend much more time at home, walk in their communities and meet neighbors, and ensure that the elderly in their neighborhood receive needed supplies.
- **City/County Leadership.** During the crisis, citizens and businesses grew accustomed to the increased role of their county in their lives and businesses.

Oasis community microgrids can offer a form of preparedness, can provide this preparedness at a neighborhood level, and are likely to be most effective when the city or county is closely involved in their development. When these local governments reach out to citizens and businesses with proposals to establish oasis community microgrids, the combination of these three effects may help motivate citizens and businesses to support such initiatives.

On the business front, Ameresco Sr. Engineering & Technology Development Lead John Hostetter, Sr. explains how businesses are becoming more aware of how microgrids can enhance resilience: “COVID-19 has introduced a heightened awareness around the importance of healthy, safe, and resilient working environments. Many are keeping this front of mind as they implement re-opening strategies across the world. The consideration of microgrid and demand controls at this time could integrate on-site generation that adapts to facility usage in order to match demand rates and variable occupancy due to stay at home or work from home orders” [177].

Increased Telecommuting

COVID-19 has altered personal and business perception of the practicality of working from home in many professions. Previously skeptical employees and employers alike are discovering that although working from home is an adjustment, telecommuting is:

- Practical and feasible
- Reduces commuting time and cost
- Reduces the environmental impact of commuting
- Provides employees flexible work hours
- Usually improves employee productivity
- Lowers organization costs
- Affords other benefits

However, a shift to telecommuting means that a workforce previously centralized in one location (e.g., an office complex) is now at least partially decentralized to many locations (e.g., employees’ homes). As a result, organizations need to revise their business continuity plans previously established for centralized locations – including backup electricity provision – to a decentralized paradigm. Employees need reliable, resilient electricity to power their devices (e.g., computers and smartphones) and to conduct business, including video conferencing services.

Hence, as businesses scale back their centralized operations and associated costs, investing in community and work-from-home resilience is likely to make good business sense. As a form of reliable, resilient, decentralized electricity, oasis community microgrids may be able to support business continuity with expanded telecommuting.

Heightened Concern about Simultaneous Threats

Resilient community microgrids may also help address simultaneous threats. According to the May 2020 Accenture survey of utility executives [28]: "When a utility is facing extreme weather and a secondary event (such as cyber-attacks, earthquakes, geomagnetic storms, warfare, wildfires, and as we now see, pandemics such as COVID-19) occurs, the situation can quickly move from bad to worse. Greater resilience is the answer."

2020: A Year for Simultaneous Threats

The year 2020 is proving to be a year of significant simultaneous threats. Concurrent with COVID-19, the season includes record-breaking wildfires in the western U.S. ignited primarily by dry lightning storms (and simultaneous widespread PSPSs), and a record-breaking Atlantic hurricane season. As of September 30, 2020, 3.75 million acres had burned in California wildfires. This surpasses the previous all-time record of 1.98 million acres (2018), with potentially several weeks remaining in the fire season. As of September 30, 2020, five of the ten largest wildfires in California history occurred in 2020, including the largest in California history (the August Complex, with 949,000 acres burned) [178].

As of September 16, 2020, forecasters expected a total of 28 Atlantic storms, which would tie the record for most Atlantic storms in a season (2005). AccuWeather raised its prediction to 13 hurricanes, including six major ones, for the 2020 season; an average season consists of six hurricanes, including three major ones [179]. Elisa Wood of *Microgrid Knowledge* addresses the potential role of microgrids in disasters like these: "History tells us that disasters tend to spur interest in microgrids" [180].

A Reliability Analogy: N-1 Resilience

Applying a principle of reliability to resilience helps clarify the challenge of simultaneous threats. A fundamental tenet of bulk power system operation is "N-1 reliability" – the ability to avoid power outages during the unplanned loss (contingency) of any single power system asset (e.g., a power plant or substation). Can "N-1 resilience" be defined as the ability to *avoid large-scale outages* due to any single regional extreme event, including extreme events that do not primarily disrupt the electric power infrastructure (e.g., COVID-19)? Using this definition, during the pandemic, the power system in some regions of the U.S. with high infection/death rates can be considered to be at N-0 resilience. According to this definition, this means that the power system in these areas may be unable to avoid large-scale power outages due to a simultaneous extreme event (e.g., a hurricane).

Cybersecurity and Microgrids

Retired Vice Admiral John Shkor suggests that vulnerability to a pandemic raises the question of vulnerability to other threats, such as a sophisticated cybersecurity attack on the electric power system [181]. Can a microgrid enhance cybersecurity? The Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) Joint Capability Technology Demonstration (JCTD) demonstrated a "cyber-secure microgrid architecture with integration of smart grid technologies, distributed and renewable generation, and energy storage on military installations for enhanced mission assurance." The project also aimed to "transfer the knowhow to non-military critical infrastructure" [182]. In a 2020 *T&D World* article, an S&C Electric expert described "a cybersecure microgrid as containing perimeter firewalls, multiple backup controllers, hardened hardware via removal of unnecessary software and communication points, encryption of internal data, removal of nonessential code and protocols, use of whitelisting and other authentication protocols for devices attempting to access the system, and monitoring of internal communications and processes" [183]. If a microgrid can provide cybersecurity, can it help maintain resilient electric power during the combination of a cybersecurity attack and a pandemic?

Embracing Independent, Distributed Systems

COVID-19 may have increased the comfort level with embracing independent, distributed systems connected to regional and national networks. The fact that the June 2020 *Microgrid Knowledge* Microgrid Conference was a *virtual* conference is *apropos* to microgrids. The over 4,000 individuals that joined the conference from around the world were "connected" in a network of sorts that constituted the largest microgrid gathering in history. Vice President of Siemens Digital Grid Ravi Pradhan explained how working from home in a distributed fashion can influence our view of the electrical grid. "In many ways, microgrids embody the quality that we will emerge with as we recover from this [COVID-19] crisis, the idea of independence...of the need to be able to be isolated and yet to keep functioning and providing essential services that are needed. Microgrids give us great independence and the resilience to withstand the shocks of grid isolation which is not that dissimilar from some of the social isolation that we're experiencing in the crisis today" [184].

PART IV: FOR MORE INFORMATION

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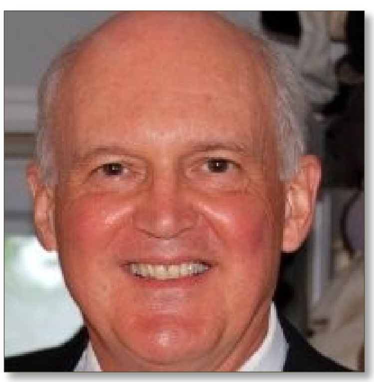

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