MICROGRIDS

An Immediate Climate Solution

RESILIENCE | SUSTAINABILITY | EQUITY

ThinkMicrogrid

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Preface

The decisions of policymakers today establish and design the markets of tomorrow. Technology catches up with —and often outpaces—policy, which means that policymakers today bear a great responsibility. They are charged with designing utility markets that are resilient, clean and equitable. This is a daunting task, but they do not have to act in isolation.

This vision paper marks the start of an educational campaign to help policymakers understand how microgrids provide unique solutions for the pressing challenges of our time. Speaking with a unified voice, Think Microgrid provides political leaders with the resources they need to understand how microgrid technologies work, what role they can play in achieving policy goals and how regulatory reforms can proactively address barriers that exist today.

We are dedicated to ensuring that communities are positioned to capture the benefits of microgrid technology: resilience, sustainability and cost savings. This vision paper is imbued with a spirit of collaboration, combining the real-world experience of companies leading the way to a safer, cleaner and more equitable energy future with practical and pragmatic strategies to modernize policy.

Policymakers and regulators do indeed bear a great responsibility, but they also have great opportunities. They do not need to act alone. Think Microgrid is dedicated to ensuring that they have the support they need to design the future that every community deserves. We hope this vision paper helps lead the conversations that will create the microgrid solutions we need today—and tomorrow.

Cameron Brooks
Executive Director, Think Microgrid

Introduction

The number and severity of weather-related power outages continues to go up with each passing decade. In fact, the US experienced 70% more power outages from 2010-2019 than in the preceding decade. The effects of climate change are already upon us and are expected to accelerate. Meanwhile, our society's dependence on electricity grows.

The urgency of the situation demands a new approach—one where policymakers focus not only on reducing emissions but also on preparing for climate disaster.

Make no mistake, it is not the failure of either renewables or large power plants that cause the overwhelming majority of power outages. It is the failure of the wires-based system that delivers the vast majority of the electricity consumed in the US today. In fact, most power outages are caused by failures of the distribution system.

We know there is a solution to this readily foreseeable risk. Microgrids have proven themselves in disaster after disaster, storm after storm. And yet the technology faces a list of headwinds—most centered around outdated regulations—that hinder its wider use. It is time to chart a new course, one that allows our communities to prepare for the climate challenges ahead.

For our leaders, climate change presents three distinct and urgent challenges as they rebuild the nation's energy infrastructure. Leaders are being called upon to:

- Protect citizens and the economy from energy disruptions already upon us because of climate disasters.
- Redesign the electrical system with the future in mind, introducing cleaner energy technologies to counter even greater weather extremes in the decades to come.
- Make these changes in an equitable fashion, providing distributed clean energy—and the economic prosperity it can bring—to all communities.

Among emerging clean energy technologies, microgrids are unique in their ability to meet these challenges. Along with climate resilience, microgrids also offer additional benefits, including local control of energy, cost management and energy efficiency. This is why a growing number of communities, businesses, institutions, government agencies, utilities and military installations across the United States are building microgrids. Unfortunately, too often, they are installed after disastrous power outages. Had they been built beforehand, hardship could have been avoided.

So what can be done to speed the development of microgrids? And what is causing the delay?

We are witnessing a classic example of technology outpacing policy. Too often those seeking to install microgrids face delays and extra costs because of rules and regulations designed for an electric grid of the last century. These outdated rules make it difficult, and at times impossible, to fully capture the opportunities offered by software-based energy systems such as microgrids.

What Is a Microgrid?[1]

A local cluster of energy resources that can operate independently, microgrids keep the power flowing to single or multiple nearby customers when the central grid fails. Microgrids also act as a tool to help energy customers manage costs, participate in energy prosperity and reduce carbon emissions. In addition, they are designed not only for backup power, but to operate under "blue sky" conditions, providing important services to the central grid, and they can be a particularly valuable resource when the grid is under strain or needs flexibility to balance resources. In this way, microgrids typically provide customers with some combination of three core benefits, including resilience, cost savings and clean energy.

Microgrids require a different sort of policy support than solar, wind and other forms of climate-friendly energy generation. While there are good examples of incremental actions in some states, it is clear that regulators and policymakers have not yet seized the opportunity to put forward the kind of innovative policy mechanisms that can foster microgrids. Microgrids do not benefit from the same kind of policy attention and innovation enjoyed by solar, wind and other forms of climate-friendly energy. This is largely a problem of familiarity; while simple microgrids have been around since the days of Thomas Edison, today's advanced microgrids—fast, intelligent and clean—are newer to the scene than solar and wind energy. Yet, these microgrids dramatically extend the benefits of renewable energy, adding resilience and energy reliability.

Greater education about microgrids is clearly needed. In polls taken in 2020 and again in 2021, the Civil Society Institute found voters lacked knowledge about microgrids. Once the concept was explained, both Democrats and Republicans expressed strong support for the technology.

1 American Lung Association Comments on the U.S. Environmental Protection Agency's Proposed Revisions to National Emissions Standard for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines, ("RICE NESHAP"), Docket ID No. EPA–HQ–OAR–2008–0708, August 9, 2012

Section I: A Grid Not Prepared for the 21st Century

Destruction from Hurricane Ida. Photo courtesy of Footprint Project.

Climate disaster is upon us. We are not ready.

Electricity is essential to survival and prosperity in a contemporary world, but the electric grid—the vehicle through which most electricity is delivered—is a clear casualty of climate change. A series of climate disasters has disrupted the electric grid over the last decade, highlighting the vulnerability and brittleness of the system.

High winds cause significant damage to utility infrastructure. The list is long of coastal storms that have led to massive power outages. In 2012, Superstorm Sandy left 8 million people without power, some for weeks. In 2017, Puerto Rico experienced the largest blackout in US history when its entire grid collapsed during Hurricane Maria. Some were without power for a year. During the last decade, we have also seen forced public safety power shutoffs in California and other western states, with utilities preemptively turning off electricity to prevent electrical wires from sparking wildfires. This disruptive practice could continue for as long as a decade, according to a California utility executive. In the Midwest, an August 2020 derecho spawned winds of 140 mph (equivalent to a Category 4 hurricane), creating the most expensive thunderstorm in US history, with an estimated $11.5 billion in damages. The storm knocked out power to nearly 2 million people. Most recently, on Aug. 29, 2021, New Orleans lost all eight of its transmission lines when it was struck by Ida, a Category 4 hurricane. More than 1 million people lost their power.

Windstorms aren't the only threat to our electric grid. Extreme heat and cold also interrupt the flow of electricity. Extreme heat throughout the West led to rolling blackouts in California in the summer of 2020, and extreme cold crippled Texas' electrical system in February 2021. In this last example, the situation was so dire that the entire Texas electric grid was moments from collapse—an event that would have knocked out power to most of the state for weeks, if not months, according to the Electric Reliability Council of Texas (ERCOT), the grid operator.

These are just a few examples of the storms and natural disasters that have caused expensive and sometimes deadly power outages in the US over the last decade. The US experienced 1.33 billion outage hours in 2020, up 73% from roughly 770 million in 2019, according to PowerOutage.US, an aggregator of utility blackout data. Grid outages vary from year to year, depending on the weather, but it is reasonable to assume they will continue to trend upward in the future, given that climate disasters are expected to intensify. Presently, grid quality in the US is ranked a lowly 23rd, below countries in Asia, Europe, the Middle East and South America.

Outages are more than an inconvenience. Injury and death can result when heating systems, air conditioning, and medical equipment do not function properly. More than 200 people died, most from hypothermia, during the 2021 Winter Storm Uri power outages in Texas. In 2017, 12 elderly people died in Hollywood, Florida, when a nursing home's air conditioning failed following a power outage caused by Hurricane Irma.

Power disruptions also lead to economic hardship, causing lost business sales, product spoilage, missed sales opportunities, manufacturing and shipping delays, and loss of work hours for employees. A 2021 survey by S&C Electric and Frost & Sullivan found that 80% of commercial and industrial companies with average revenues of $75 million per year experience outages every month, resulting in an annual loss of $1.2 million per company. And these outages do not need to be lengthy to be expensive. More than half of companies surveyed said it was very important that power be restored within one minute.

Electric vehicle charging. Photo courtesy of SWEEP.

Electrification is upon us. We are not ready.

All of this comes as the need for power grows. The United States is working toward the electrification of the transportation sector, and, to a lesser degree, the electrification of buildings and industrial processes. These changes, part of the country's effort to decarbonize, will double the need for generation capacity by 2050, according to the National Renewable Energy Laboratory. The Boston Consulting Group said that to facilitate growth of electric vehicles (EVs), utilities will need to invest between $1,700 and $5,800 in grid upgrades per EV through 2030. This could increase utility rates as much as 12%.

Such high cost is due, in part, to the need to rebuild the electric grid itself for the emerging era. EV charging requires a change in the pattern of energy use; for example, the US will need charging stations along remote roads that do not have adequate power lines because they required little power in the past. Expanding those lines can cost as much as $1.5 million per mile. Placing lines underground can increase the cost four to 14 times!

Demand will grow for electrical capacity in dense urban areas to serve fleets of delivery trucks and corporate vehicles. Unfortunately, these areas have little real estate available for new power plants, substations, or transmission and distribution lines. And, depending on the charging patterns of EV owners, the timing and location of demand peaks will likely change, redefining where energy infrastructure is needed.

Digitization, flexibility and decentralization transform energy

How can we ready the grid for 21st century electrification without the construction of expensive new large-scale energy infrastructure?

We can reduce outages and decrease these new infrastructure costs through refined energy management, made possible through intelligent software and distributed energy resources (DERs) like microgrids. The combination adds both flexibility and control over energy flows locally and across the grid, facilitated by automated market signals. This allows both consumers and producers to take advantage of the fact that emissions and energy prices are heavily influenced by the timing and location of energy use.

Typically, when demand is high, energy prices rise. Emissions may also rise during periods of demand if grid operators are forced to employ their highest polluting resources to satisfy the immediate need for power. Distributed energy resources, such as microgrids, solar, energy storage and generators, provide an alternative. Because they are decentralized—found alongside businesses, homes and buildings dispersed throughout the grid—they can be customized to serve the grid in locations where large power plants cannot. These resources are also quick to respond as conditions change moment by moment on the grid.

Credit: Shutterstock.com

DERs give rise to customers who are more engaged. These customers control their own energy, both consuming and producing, and sometimes earn revenue and aid the larger grid in the process. When considered properly in planning grid upgrades, these software-based, distributed energy systems can help avoid costly construction of poles, wires and power plants. This is one reason why more brick and mortar for the electric grid is not the full answer in a digitized age. In fact, at times, it may be wasteful.

Why fixing the grid is not enough

While there is little doubt that the grid needs to be improved, it is clear that an exclusive large-scale, centralized approach is no longer viable. Work at this scale is expensive, slow and difficult to complete. Even with significant improvements, the centralized grid will remain vulnerable and brittle. We cannot achieve resiliency without investing in local distribution systems, the cause of most of the power disruptions that consumers experience. Placing distribution wires underground would be helpful, but the high cost of that solution makes microgrids an even more obvious choice.

In its report, "How Are We Going to Build All That Clean Energy Infrastructure?", the Niskanen Center points out the difficulty of improving the large-scale grid. Little of the interstate bulk-power transmission planned for 2010 in the western US was built. That same report states that the US would need to expand the amount of land it uses for power generation by a factor of 13 to achieve a net-zero carbon goal by midcentury. Wind and solar alone would require a land mass equal to Connecticut, Illinois, Indiana, Kentucky, Massachusetts, Ohio, Rhode Island and Tennessee combined. In other words, we can't even depend on large, centralized renewable energy projects. We must incorporate decentralized, strategically located renewables. The US needs to focus on building a grid that is flexible enough to incorporate more distributed solutions that help avoid construction of wires, poles and power plants by localizing and better managing energy.

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The grid is, by design, a centralized, one-way system. Moreover, the grid's problems are inherent, at least in part, in its very design. Electricity travels long distances from central power plants over transmission and distribution lines to population centers. This approach succeeded in extending power to the farthest reaches of the United States. But, today, we need a grid—and accompanying rules and regulations—that support a dynamic, two-way flow of power. To achieve this 21st century grid, policy and regulations must encourage the use of intelligent, flexible distributed energy.

The 21st century electric grid must solve other problems created by the 20th century grid:

Cascading failures: The wires and poles that make up the 20th century centralized grid are vulnerable to disruptions, and because the grid is interconnected, a disruption in one location can have widespread ramifications. A tree coming in contact with a power line on Aug. 14, 2003, in Ohio triggered a chain of events that knocked out power to 50 million people throughout the northeastern United States and parts of Canada. In a world now deeply reliant on electricity—and likely to be more so as the transportation system electrifies—such outages are untenable. Moreover, it is no longer storms, fires and accidents alone that make the grid vulnerable to widespread failure. The grid is a constant target of cybercriminals. In a June 6, 2021, interview with CNN, Energy Secretary Jennifer Granholm stated that attempted cyberattacks on the grid are "happening all the time."

In a world now deeply reliant on electricity—and likely to be more so as the transportation system electrifies—outages are untenable. Moreover, it is no longer storms, fires and accidents alone that make the grid vulnerable to widespread failure. The grid is a constant target of cybercriminals.

Inefficiency: Electricity dissipates when it travels over wires, a phenomenon known as electric line loss. By some estimates as much as 5% to 15% of the electricity generated by a power plant disappears by the time it reaches the consumer. Society pays the price for this inefficiency in higher energy costs and environmental harm. Line loss adds to carbon and other emissions with no justification—the energy is never even used. Given that 60% of electricity in the United States is derived from fossil fuels, reducing this phantom energy could take a meaningful bite out of the nation's emissions count.

Inequality: The grid's inefficiency, along with its lack of resilience and flexibility, creates another problem: energy inequality. The energy burden of low-income households is three times that of others, according to the US Department of Energy. An energy burden is considered high if it is over 6% of household income. For households with incomes below 150% of the federal poverty level, the energy burden is particularly onerous. They spend 12% of their income on electricity—double the amount considered affordable.

Inequity isn't only monetary. Disadvantaged communities also face a higher environmental burden. Too often, coal-fired power plants are sited within low-income and minority urban

Climate disasters like hurricanes and floods often impact disadvantaged communities disproportionately because these communities are more likely to be located in areas that are susceptible to weather shocks. And when a disaster strikes, members of these communities may lack the resources to evacuate or stay in hotels.

neighborhoods. While these plants may bring jobs and tax revenue to these communities, they also leave residents with abnormally high levels of asthma and other respiratory ailments. Low-income communities also face more health risks from air pollutants produced by diesel backup generators — a technology that microgrids can readily displace. (In 2012 comments to the Environmental Protection Agency[2], the American Lung Association noted that backup generators tend to be clustered in urban areas where minority and low-income populations live.)

Replacing coal plants with clean energy generation may solve this health problem, but it also risks economic damage to communities because the new wind and solar farms replacing coal require acres of open space, which are typically found in rural areas far from urban communities.

As we are beginning to learn, climate disasters like hurricanes and floods often impact disadvantaged communities disproportionately because these communities are more likely to be located in areas that are susceptible to weather shocks, according to the Brookings Institute. For example, low-income neighborhoods in Houston experienced greater damage from Hurricane Harvey because they tended to be clustered in flood prone areas. In addition, only 17% of homeowners in the eight counties most severely affected by Harvey had flood insurance policies. And when a disaster strikes, members of these communities may lack the resources to evacuate or stay in hotels.

The repercussions of a climate disaster can affect poorer families for years. A decade after Hurricane Katrina, those whose homes were flooded had lower credit scores and lower rates of home ownership than those less affected. Further, county-level poverty tends to rise after very large disasters (those responsible for at least 100 deaths). Housing prices also decline. Wealthier households tend to relocate from these areas and poor families migrate in, according to Brookings.

Microgrids cannot single-handedly eliminate energy inequality nor can they ameliorate all of the consequences of extreme weather, but they have an important role to play in any policy decisions that aim to solve these issues. Microgrids and distributed generation of the 21st century grid are one answer to an important question: How can we ensure that build back better also means build back fairer?

Key questions the US must consider

Archaic or anti-competitive tariffs are thwarting new microgrid investment. We have an opportunity now to create new policies that allow open access to the distribution system, policies that are agnostic to technology, but that reward flexibility and resilience.

Regulatory decisions from the last century and resulting private and public investments helped us build a grid that provided universal access to every business and home in the United States. But it is time to rethink those policies. The changes we need to make cannot wait decades. In so many ways, energy regulators hold the keys to these solutions. Interconnection policies need to be updated. Archaic or anti-competitive tariffs are thwarting new microgrid investment. We have an opportunity now to create new policies that allow open access to the distribution system, policies that are agnostic to technology, but that reward flexibility and resilience.

We are building the plane while flying it, as the expression goes. The effects of climate change are already upon us. One in 10 Americans live in communities that are experiencing record high temperatures. More than 3,100 counties have breached the 2-degree Celsius warming limit, a critical threshold. Record heat and cold, and intensifying storms and wildfires are disrupting our energy system and causing fuel shortages and power outages. The time has arrived to transition our carbon-intensive energy system to low- and no-carbon alternatives.

So, what can we build now to address the threats outlined here? How do we manage the energy transition while maintaining safety and security? How do we restructure our infrastructure so that urban communities can breathe clean air and share in the prosperity of today's clean energy revolution?

In the next section, we demonstrate why microgrids are the 21st century solution to today's energy problems.

2 American Lung Association Comments on the U.S. Environmental Protection Agency's Proposed Revisions to National Emissions Standard for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines, ("RICE NESHAP"), Docket ID No. EPA–HQ–OAR–2008–0708, August 9, 2012

Section II: Microgrids for a 21st Century Grid

Montgomery County microgrid. Credit: Ameresco

But a microgrid doesn't only protect its customers during a power outage. It also can provide grid-connected services whenever they are needed. In fact, under normal operation, the microgrid takes from the grid and gives back to the grid in a symbiotic relationship.

Strategically placed microgrids can reduce strain on the electric grid, which can reduce costs and power outages that result from too much demand for electricity chasing too little supply. This happens, for example, on hot summer days, when the grid is working full tilt to supply electricity for air conditioners. Businesses and communities would benefit from microgrids in such a circumstance, using locally-generated microgrid electricity instead of expensive peak energy from the utility grid, a situation that may save money while freeing up utility grid resources for others to use. Microgrids can also earn revenue by participating in demand response programs offered by utilities and grid operators. These examples speak to the locational value of microgrids—which can be built in areas where large energy facilities cannot.

Microgrids are local, flexible, cost-effective and clean

Microgrids are proving themselves to be the energy technology of our time. A form of local energy, they keep the power flowing to nearby customers when the utility grid fails. Microgrids also help customers manage costs, gain energy prosperity and reduce carbon emissions. Microgrids provide services to the utility grid—they can be a valuable resource when the grid is strained or unbalanced.

To review: A microgrid is a self-sufficient energy system that serves a discrete geographic footprint, such as a college campus, factory, hospital complex, business center, military installation or neighborhood. Microgrids can operate independently from the grid using power generated on-site; they can also be used for backup power. Microgrids are designed to operate consistently in both "blue sky" and emergency situations supported by a range of energy resources, such as renewable energy, energy storage, combined heat and power or generators. It's easy to know which buildings have microgrids. They are the ones lit up during grid outages, while surrounding buildings remain in the dark.

Microgrids provide flexibility through software intelligence, allowing energy to provide a range of services depending on the needs of the host customer and the electric grid as a whole. In fact, what sets a microgrid apart from other energy technologies is its ability to operate while connected to the grid and also while disconnected from the grid, based on conditions at any given moment. If a storm, wildfire or other disaster causes a grid outage, the microgrid will separate from the grid to prevent the buildings it protects from succumbing to the outage. The microgrid then serves the load itself using on-site energy resources.

Microgrids also serve local utilities by helping them manage the ever-growing number of distributed energy resources on their systems, such as solar panels, interactive buildings, electric vehicles, batteries and virtual power plants. Microgrids use advanced controllers, software and sometimes artificial intelligence that allow them to undertake sophisticated energy management operations, transforming what can be a confusion of grid inputs into an organized whole.

Advanced intelligence within a microgrid can program its generation resources to achieve specific goals, such as producing the lowest cost, most efficient or cleanest energy in response to changes in weather, wholesale price shifts or availability of sunlight, wind or fuel. A microgrid may, for example, use renewable fuels like solar to serve as a hedge in power markets to reduce the cost of electricity to its customers.

Microgrids are not one size. They are built to the needs of their offtakers, which might be a single building (sometimes referred to as a nanogrid) or something larger: a neighborhood, community, business park, college campus, medical center, critical facility, military base or any other entity that would benefit from on-site energy. And not all microgrids use the same generation resources. Solar, batteries and generators are common, but some microgrids also use fuel cells, wind power, flywheels, hydroelectricity and other forms of energy. Regardless of the technologies at play, microgrids are distinguished by their ability to operate independently, flexibly and reliably.

Types of Microgrids

Mobile military microgrid.
Credit: US Air Force photo by Donna Lindner

Microgrids are typically defined according to the customers they serve or the way in which the microgrid operates.

Here are a few common types:

- **Remote:** A microgrid that serves an island or other remote location. Remote microgrids typically stand alone—they are not connected to the central utility grid.
- **Grid-connected:** As the name implies, it's a microgrid that is connected to the central power grid, but that can be separated from the central grid when conditions warrant.
- **Mobile:** A simple microgrid that can be easily transported, sometimes on trailers, and quickly set up.
- **Advanced:** A microgrid that uses sophisticated software, controls and sometimes artificial intelligence to manage multiple energy resources. Most of the microgrid types listed here can be configured as advanced microgrids.
- **Hybrid:** A microgrid that combines renewable energy, storage and fossil fuels.
- **Renewable:** A microgrid that is fueled primarily by renewable energy and possibly storage.
- **Community:** A microgrid that serves critical facilities within a community, such as emergency response centers, water and wastewater treatment plants, grocery stores, fueling stations, government buildings and shelters. In some cases, community microgrids extend to noncritical buildings or homes.
- **Utility:** A microgrid that is owned and operated by an investor-owned or public utility.
- **Campus:** A microgrid that serves multiple buildings on a single large parcel of land, often for a single offtaker. Examples include business parks, medical centers and educational facilities.

Microgrids are superior to backup generators

During power outages, microgrids are a more finely tuned and robust resource than conventional backup generators. Conventional generators are incapable of undertaking the sophisticated energy management that emergencies require, and they are less reliable than microgrids. Since these generators are typically used only in emergencies, operators often discover at the last minute that a given generator is broken. During Superstorm Sandy, 16% of emergency medical services organizations reported that emergency generators did not perform as expected, according to a report from the American College of Emergency Physicians. Microgrids, on the other hand, run more frequently—some run all the time—so they are constantly maintained, reducing the likelihood of an unhappy surprise during an emergency.

Advanced microgrids also typically draw from a variety of energy resources. So in an emergency, if one resource is unavailable, another can step in. For example, if a cloud prevents solar panels from providing adequate generation, the microgrid's energy storage system can do so. If the battery is depleted, its generators can step up. This allows the microgrid to provide power indefinitely, as long as one of its generating resources can provide power. By contrast, backup generators that are not part of a microgrid lack this resource redundancy. They can fall victim to fuel shortages, especially when severe weather disrupts truck deliveries or pipelines freeze or fail.

Solar Is Good. Solar Microgrids Are Better.

It is a common misconception that solar panels provide backup power when the electric grid fails. This leaves many homeowners and businesses perplexed when they face their first power outage after installing solar panels. For safety and engineering reasons, most solar panels cease to operate when a storm or other calamity knocks out grid power. However, if the solar panels are integrated into a microgrid, and can thus be disconnected from the utility, the home or business can use the power generated by the panels.

How microgrids solve our energy problems

Given these benefits, microgrids are a crucial technology in the campaign to meet the overarching goals described at the beginning of this paper:

- Protect citizens and the economy from energy disruptions already upon us because of weather climate disasters.
- Redesign the electrical system with the future in mind, introducing cleaner energy technologies to counter even greater weather extremes in the decades to come.
- Make these changes in an equitable fashion, providing distributed clean energy—and the economic prosperity it can bring—to all communities.

Electric reliability and resilience are the top reasons microgrids are installed. Advanced microgrids provide power so seamlessly that the building experiences no disruption in power flow when the grid goes down. The lights, air conditioning and other electric appliances in the building continue to run.

Such was the case at the 700-acre Gordon Bubolz Nature Preserve in Appleton, Wisconsin, which has a microgrid that uses on-site solar, a hydrogen fuel cell, battery storage, a microturbine and a natural gas generator to power its 18,000-square-foot environmental center building. Torrential rain and wind knocked out power to about 10,000 of the preserve's neighbors on Sept. 17, 2018. But those inside the center, protected by the microgrid, had no idea an outage had occurred until they were told. As luck would have it, members of the International Association of Electrical Inspectors happened to be on a tour of the building when this happened. "Everybody was amazed there wasn't even a flicker at the building. The microgrid was operating up to speed, and all of these electrical contractors got to witness it," said Don Wingate, vice president of sales, utility solutions for Schneider Electric, which worked with Faith Technologies to build the microgrid.

Community microgrids

It's not just those in a microgrid-fitted building that benefit from their ability to provide power during severe weather and disasters. Some microgrids serve community resources, offering a place to charge phones, get hot food and seek shelter.

Perhaps the most renowned of these is Blue Lake Rancheria, a tribal community in Humboldt County, California, whose microgrid—which uses solar, battery storage and diesel backup—is credited with saving four lives in October 2019.

When the county experienced a wildfire related power shutoff, Blue Lake Rancheria opened its doors to its neighbors, including people whose lives depended on reliable electricity. Four of these neighbors needed electrical medical devices to stay alive and were invited to stay in the community's hotel.

In addition, the tribe provided EV and cell phone charging and access to the internet for local families. It also gave Humboldt's daily newspaper a place to publish, kept a gas station up and running and provided fuel for services outside the reservation, such as the town of Blue Lake's municipal water system and the Mad River Fish Hatchery so it could keep pumps running to keep fish hatchlings alive.

"In all, we estimate we served about 10,000 people, about 10% of the county's population, during the outage," said Jana Ganion, director of sustainability and government affairs at Blue Lake Rancheria.

Because of their value, community microgrids are being built by local, state and tribal governments, school districts and utilities.

Blue Lake Rancheria Microgrid, Blue Lake, CA. Credit: Siemens

For example, Connecticut utility United Illuminating installed a microgrid at a regional high school in the town of Woodbridge to power police, fire and shelter services. The microgrid, which uses fuel cell technology, is designed to activate when the surrounding grid loses service during a storm or other event. When the fuel cell is not providing emergency power, it contributes renewable energy to the state's power grid. The fuel cell also helps heat the high school, as waste heat from the plant's operation is transferred to the school building's heating system.

Ports and airports

Microgrids are increasingly being built by ports and airports to ensure safe passage of people and goods. An 11-hour power outage at the world's busiest airport, Hartsfield-Jackson Atlanta International, underscored the need for these critical facilities to shore up their energy resilience. The December 2017 outage left scores of passengers stranded after flights were canceled and rerouted. Delta Airlines took a $40 million hit as a result.

Airports and ports that have since turned to microgrids include:

Pittsburgh International Airport in July 2021 became the first major US airport completely powered by an on-site solar energy and natural gas microgrid. This microgrid was created not only to ensure resilience but to give the airport energy independence. The 20-MW microgrid is now the primary power supply for the entire airport, including the airfield, terminals, hotel and fuel station. In a reverse of the typical microgrid/grid relationship, the grid will serve as the backup system should the microgrid fail. Peoples Natural Gas built the microgrid in partnership with other organizations including Duquesne Light, the local utility, LLI Engineering, IMG Energy Solutions, CNX Resources and EIS Solar.

The Redwood Coast Airport microgrid, a 100% renewable microgrid in Humboldt County, California, is being built by the Schatz Energy Research Center at Humboldt State University, Redwood Coast Energy Authority and Pacific Gas & Electric. It will serve both a regional airport and a US Coast Guard Air Station that runs search and rescue missions for 250 miles of rugged coastline.

The Port of San Diego is building a microgrid, scheduled for completion in late 2021, to provide resilience-specific port facilities. The microgrid, which will use solar and energy storage, is especially important because San Diego is a strategic port that provides services to the US military. The military can take over the terminal within 48 hours notice to respond to natural or man-made emergencies. Being installed by EDF Renewables, the microgrid is expected to bring $3.2 million in energy savings to the port over 20 years.

The Port of San Diego is building a microgrid, scheduled for completion in late 2021, to provide resilience-specific port facilities. Being installed by EDF Renewables, the microgrid is expected to bring $3.2 million in energy savings to the port over 20 years.

The Port of Long Beach microgrid, a Schneider Electric project, ensures a stable supply of energy using innovative features like a mobile battery that can extend the microgrid's reach throughout the port during emergencies.

New York City's JFK Airport has included microgrid technology in the redevelopment of its Terminal One. Another Schneider Electric project, the microgrid is expected to not only improve the terminal's electric reliability, but also reduce the total amount of fuel required to operate the terminal by as much as 30% and contribute to the airport's goal of reaching 100% renewable energy usage within the next decade.

Grocery stores

Grocery stores are also "critical facilities" that must be kept up and running during a disaster. H-E-B in Texas, Rouses in the Gulf Coast states and Stop & Shop in the Northeast are among well-known store chains that have turned to microgrids to ensure food will be available to the local community.

A strong economic motivation exists for stores to avoid power outages. Even relatively short power outages can be costly to grocers. Federal government guidelines recommend discarding any perishable foods, such as meat, fish, poultry and eggs, that have been held at temperatures above 40 degrees Fahrenheit for longer than two hours. The value of perishable foods runs anywhere from $400,000 to $900,000 at a single store, according to a report from Western Illinois University. In addition, losses from power outages are commonly not covered by insurance. Although some policies cover perishables with a spoilage rider, grocers still tend to face high losses because most insurance policies have a 12- to 24-hour waiting period. Contrarily, most spoilage occurs within the first three hours after an outage.

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H-E-B was fortunate to have microgrids up and running before Hurricane Harvey hit Houston in August 2017. That storm knocked out power for 300,000 Texas utility customers. Enchanted Rock, which developed the H-E-B microgrids, uses a 24/7 network operations center to monitor the electric grid so the company knew when to island H-E-B microgrids from Houston's main power grid. As Harvey made landfall on the Gulf Coast, the stores began receiving power from the microgrids' on-site generators. Eighteen H-E-B stores received full facility backup power for five consecutive days during the storm. One store not only continued to serve customers, but also acted as a home base for emergency responders.

H-E-B microgrids continued to perform in subsequent storms, including Winter Storm Uri, an unusual Texas freeze that caused 34,000 MW of conventional power to stop operating, leaving millions of Texans with no heat and causing the near collapse of a large swath of Texas' grid. During that time, about 70 of Enchanted Rock's customers had on-site microgrids that kept electricity flowing to their premises. Many of these are stores that were able to stay open to supply food, prescriptions and gas during the crisis. In addition to H-E-B, they included Buc-ee's and Walmart stores.

Microgrids kept Rouses supermarkets up and running on the Gulf Coast in the aftermath of Hurricane Laura, which left 616,000 without power in Entergy's Gulf Coast service territory in 2020, and Hurricane Ida, which the next year caused more than 1 million outages. The microgrids, installed and operated by PowerSecure, enabled the stores to offer food, water, ice, baby formula and medicines during the storms.

During Hurricane Laura, two of the stores were in the direct path of the storm. The storm's eye passed over these stores and the microgrids continued to operate, undamaged. Because they continued to receive electricity, refrigerators and freezers worked, protecting perishables and preventing economic loss. First responders, utility linemen and other essential service workers relied on the stores for essential supplies.

"If you've ever been through a hurricane and been at a location where people just want the basic essentials, folks are just looking to a store that they can go to get those essentials. It's nice to be able to be there, serving those communities, opening our doors. The human impact is real," said Ozzie Osborne, director of facilities operations for Rouses Markets.

Health care

Health care facilities, of course, are another form of critical infrastructure that must have reliable power. Many examples of hospital microgrids exist, among them the Richmond Medical Center microgrid in California, a Kaiser Permanente facility that combines a solar PV-parking lot canopy, a lithium-ion battery energy storage system and an on-site heat and power system. With the help of the microgrid and other resources, Kaiser Permanente became the first nonprofit health care system in the US to achieve carbon neutrality.

As the COVID-19 pandemic strained hospitals and beds became scarce, some facilities began building pop-up field hospitals in parking lots, convention centers and other usable spaces to accommodate hospital overflow.

Given the amount of reliable power that hospitals require, finding quick-to-install, clean power systems for these hospitals was no small concern. Bloom Energy provided a microgrid solution using its fuel cell technology at two field hospitals in California. The microgrids were installed in less than a week at the field site of a national hospital system in Vallejo and at Sleep Train Arena in Sacramento. The microgrids spared the hospitals from using backup generators that would harm local air quality and possibly put COVID-19 patients at greater risk. A Harvard study found that even a small elevation in fine particulate matter can significantly increase the death rate from COVID-19.

Near the US-Mexico border a solar microgrid powers a pop-up field hospital, this one a 20-bed intensive care unit designed to treat asylum seekers with COVID-19. The microgrid is contained in a medical tent next to the field hospital. By relying predominantly on solar, rather than backup generators, the system offsets 20,000 pounds of carbon dioxide per month, according to SimpliPhi Power, which provided the batteries and engineering and design services to help Footprint Project develop the facility.

In York, Pennsylvania, Wellspan York Hospital, a Level 1 trauma center, had accumulated a variety of backup generators of varying voltages as the facility underwent a series of expansions. Its chilling and imaging functions had never been connected to backup generation and to do so would've required expensive investments in distribution panels and wiring. PowerSecure, however, was able to provide what a Wellspan administrator refers to as an "elegant connection." Instead of an expensive retrofit, PowerSecure was able to serve the entire hospital — including backup to imaging and chilled water operations for the first time—by building a microgrid that uses the hospital's normal distribution system. The microgrid added Tier 4 diesel generation, switchgear equipment and a utility interconnection to Commonwealth Edison. The result is 12 generators that run on a common bus with double-ended substations, 100% standby power resiliency, including increased capacity to cover chilling and imaging, 24/7 remote monitoring and the ability to cut or defray costs by earning revenue from participating in PJM Interconnection's demand response program.

Utilities

Severe weather in February 2021 left about 200,000 Portland, Oregon, households in the dark, some for several days.

The outage followed a wildfire-related public safety power shutoff the summer before in the Mt. Hood region, affecting about 5,000 customers near the mountain known for its outdoor recreation opportunities.

For Portland General Electric (PGE), the utility that serves Portland and the surrounding areas, the outages underscore the need for its new resilience programs that test utility use of energy storage situated on the premises of its customers. PGE created the pilot programs to help the utility respond to outages sparked by different types of disasters, including earthquakes, wildfires and storms.

Under two PGE pilot partnerships, the utility owns and deploys batteries behind the meter at customer sites and the customers provide solar and other on-site resources to create microgrids. PGE has also launched a residential pilot program under which customers buy their own batteries — in some cases, at a discount—that can be aggregated and utilized by PGE.

"When we have customer-sited energy storage, it can provide grid services day in and day out without emissions impact. And it still provides customer support in the event of grid scale outages," said Darren Murtaugh, senior manager, grid edge solutions for PGE. "When the utility participates, it leverages so much more value."

This model will help PGE reach for its goal of 100% clean energy, he added.

PGE has already deployed a battery at the Beaverton Public Safety Center and is planning to deploy another one at the Oregon National Guard's Anderson Readiness Center. At the Beaverton Public Safety Center, PGE aims to provide resiliency with a microgrid that is grid connected and can island. The microgrid includes 250 KW/1,000 kWh of battery storage—owned by PGE—300 kW of solar and a 1-MW diesel standby generator owned by the city. The microgrid controller comes from PXiSE.

This project, now operating, showcases a model in which the utility owns the storage and the local government owns the solar and other assets such as diesel. The partnership establishes a division of assets that allows PGE to prioritize storage for grid services under normal operations. The storage system can discharge to the grid to support frequency. It can also support voltage at the feeder level by charging or discharging in response to the needs of the grid.

Military

It's not surprising that the US military, with its mission to uphold national security, was an early and strong champion of microgrids. The military has demonstrated sophisticated and innovative microgrids that serve as a learning ground for microgrids developed for the civilian sector.

Parris Island: Ameresco has developed a 10-MW microgrid for US Marine Corps Recruit Depot Parris Island, South Carolina, that is designed to withstand storms and earthquakes. The Marine Corps trains about 20,000 recruits annually on Parris Island, and the microgrid is meant to keep power flowing so that training can go on uninterrupted. As is increasingly the case on military bases, the microgrid is part of a larger improvement program that also focuses on energy and water efficiency.

Parris Island microgrid. Credit: Ameresco

As a result, Parris Island will save $6.9 million annually in utility costs, reduce utility energy demand by 75% and water consumption by 25%. The microgrid's advanced microgrid controller will monitor and coordinate the dispatch of energy assets and emergency diesel generators, continuously check the health of the utility connections, and island the microgrid during a grid outage. The on-site energy sources will then supply the military base. The controller also will facilitate fast load shedding.

Another Ameresco military microgrid project, this one at the **Norfolk Naval Shipyard** in Portsmouth, Virginia, is expected to generate $411 million in guaranteed cost savings over the term of the 22-year performance period. The microgrid includes combined heat and power and battery energy storage. Under the contract, energy upgrades are paid for through savings achieved by making the facility more energy efficient. The upgrades and microgrid control system will create long-term energy security for the site—an important priority for the military. It's expected to reduce the electricity imports from the grid by 68%, giving the base substantial energy self-sufficiency.

Located on Cape Cod in Massachusetts, the **Otis Air National Guard Base** serves as a model of how military microgrids can provide economic benefits to both the base and the regional grid. Otis is doing so by participating in a utility demand response program and providing frequency service to ISO New England, the regional grid operator.

The microgrid can meet all of the military facility's power needs while islanded. It uses wind power, lead acid battery energy storage and a diesel backup generator.

In addition, the Otis microgrid is:

- The first microgrid in the eastern Massachusetts territory of local utility Eversource and within ISO New England to provide ancillary (grid) services.
- The first microgrid to integrate enough wind power and batteries to meet 100% of the electricity needs, 24/7, at a military base or defense facility.
- The first US military facility connected to an independent system operator.
- The first microgrid to leverage a battery-based energy storage system to form a basewide microgrid completely independent from any utility grid or other external power provider.

The microgrid is expected to pay for itself in five years or less. It has an estimated savings-to-investment ratio of 2:1 over its 20-year life cycle.

Microgrids come into play in the battlefield, too, in the form of mobile units that can be quickly installed. Because they often use renewable energy or batteries, mobile microgrids reduce the need to ship fuel to remote outposts. Afghanistan revealed why saving fuel means saving lives. Vulnerable to attack, one in every 24 US fuel supply convoys resulted in a casualty there, according to an Army study.

The military also is installing microgrids to improve cybersecurity through energy independence—as are utilities. **Ameren Illinois** has developed a 1.475-MW project that is one of the most technologically advanced utility-scale microgrids in North America. Developed by S&C Electric, the Ameren microgrid was the first to install a military-grade cybersecure microgrid controller. In addition to advanced controls, the microgrid includes wind, solar, natural gas and energy storage. The distributed architecture of a microgrid makes it more resistant to cyberattack. Should one generator be attacked, the microgrid has other power sources to rely on.

Redesign the electrical system with the future climate in mind

The Biden administration has set a goal to achieve 100% carbon- and pollution-free electricity by 2035 and achieve net-zero emissions economywide by no later than 2050. A report by the Sustainable Development Solutions Network, called the Zero Carbon Action Plan, found that the US will need to nearly triple its renewable generation capacity to achieve this, adding 100 gigawatts every year between now and 2050, mostly from wind and solar. To put the scope of that undertaking in perspective, the US added 29 gigawatts of renewables in 2020.

According to an analysis published by Wood Mackenzie, the grid can reach 25% wind and solar penetration with relative ease. But "beyond that point, operational and cost complexities progressively multiply, in large part due to the intermittent nature of renewables." No grid, the report said, has yet operated with more than 30% renewable energy.

One way to overcome renewable intermittency is by tapping into distributed energy resources, such as microgrids, that can quickly respond and provide service to the grid to keep supply and demand in balance.

In their first year of service, two microgrids installed by **Arizona Public Service (APS)** helped restore frequency within the Western Electricity Coordinating Council, which manages grid reliability for the 14 Western states, Alberta and British Columbia, and the northern portion of Baja California, Mexico.

In doing so, APS demonstrated how microgrids can do more than keep the power flowing to connected buildings during an outage; they can offer value to the broader electric grid as well. Grid frequency can go out of balance when a generator suddenly trips offline. For example, an 850-MW hydroelectricity facility could suddenly stop producing power in the Pacific Northwest, sending a ripple effect through the Western states, like a rock dropped in a pond.

Various generators respond to restore balance. Speed is of the essence. That's where the APS diesel-based microgrids excel. Acting together as a single virtual power plant, the two microgrids respond far more quickly than conventional turbines. The microgrids see a deviation, start up and energize into the grid, as well as support the critical load, in under 20 seconds. In contrast, a conventional turbine could take up to an hour to respond if it is not already running or 10 minutes if it is spinning and ready to go when needed.

The response comes thanks to an APS-designed microgrid controller—what is known as the brain of a microgrid — which monitors the grid at all times and signals to the virtual power plant that the grid needs help with frequency.

Microgrids not only help the grid manage renewables, but it also increasingly incorporates them as their primary energy sources, coupling them with energy storage and backup generators.

In **Ontario, California,** Kaiser Permanente is developing a microgrid designed to demonstrate that hospitals can incorporate renewable energy and move away from diesel generators. The hospital microgrid will also feature a fuel cell and a demonstration virtual power plant—with microgrids located in up to three different utility territories. The project includes solar, a Bloom Energy fuel cell and battery storage.

Kodiak Island, a remote community in the Gulf of Alaska with about 15,000 people, receives its power solely from a microgrid that is run on 99% renewable energy and operated by an electric cooperative. Kodiak is the US' third most productive fishing port and home to its largest Coast Guard base. Unconnected to any other grid, the island requires 28 MW, which it derives from a combination of wind power, hydroelectricity, batteries and flywheels. Once heavily reliant on diesel generators, the electric cooperative now uses the generators only as backup for its hydroelectric plant when it is undergoing maintenance. Use of the microgrid has not only brought cleaner power to Kodiak but has also lowered electricity rates on the island.

A school district in **Santa Barbara, California,** is installing 14 solar facilities, including six solar microgrids, along with battery storage. The solar panels will produce about 90% of the district's power needs and are expected to save about $7.8 million in electricity costs over 28 years. It also expects to reap $6.5 million in resiliency costs that it would have had to spend on backup generators.

The school district may also be able to earn money by participating in wholesale markets run by the California Independent System Operator. The project meets the school district's sustainability goals by avoiding greenhouse gas emissions while providing community shelters during emergencies.

Make these changes in an equitable fashion

When disaster strikes a community, it is often the disenfranchised that are hardest hit. Homeless families or those without transportation, for example, cannot easily evacuate during hurricanes, leaving them to suffer the worst consequences of power outages and the lack of services that ensues.

The geographic region served by the microgrid can become an island of power. The neighborhood can become a place of refuge, where community members shelter, get a hot meal, buy groceries, get clean water, charge cell phones and gas up cars. Vital services—hospitals, police stations, fire departments, communications centers and wastewater treatment plants—stay up and running.

Some communities provide microgrids for public housing where residents are restricted in their ability to evacuate during an emergency. Others protect power supply to direct care providers such as homeless shelters, nursing homes and medical satellite facilities.

Microgrids also foster economic equity. With the power flowing, people are able to work and collect their paychecks. And because of their high level of efficiency, microgrids can help dampen energy costs, putting downward pressure on electricity bills. As a form of local energy, microgrids keep energy dollars in the community and support local employment.

And, last, they help bring about greater environmental equity by offering a lower emissions, more efficient alternative to fossil fuel plants that so often dominate urban settings.

Chicago's Bronzeville microgrid is not only a social equity project but also one of the most innovative microgrids in the nation. Its innovation comes from its connection to a second microgrid at the Illinois Institute of Technology. The project offers a glimpse of what microgrid futurists see ahead—the potential for even greater microgrid reliability and efficiency by connecting several of them together and perhaps eventually creating a grid of microgrids.

Located in Bronzeville, a largely African American section of Chicago, the solar-plus-storage microgrid includes solar installations on 660 residential units in the Dearborn Homes Community.

The project is a partnership between Exelon subsidiary Commonwealth Edison (ComEd), developer VLV Development Solutions and the Chicago Housing Authority. For VLV Development, which specializes in sustainable projects, the effort is the first in what the company hopes will be a series of low-income solar housing projects linked to microgrids. In fact, the company's goal is to develop 50 MW of solar-plus-storage for at-risk residents, or one microgrid in each of the 50 Chicago wards, according to Van Vincent, president and CEO of VLV Development.

"Often we find with the more advanced technologies, the benefits go to more affluent communities; they don't reach low-income communities," said Vincent. These communities are also more vulnerable to being stranded or isolated during power outages, he said.

VLV Development is delivering a portion of the solar to the Chicago Housing Authority at a cost that will yield about $1 million in savings over 15 years.

Under development by ComEd, with Siemens and Enchanted Rock acting as vendors, the Bronzeville microgrid covers the area with about 7 MW of load, and it includes more than 1,000 mainly residential and small commercial customers who typically can't afford systems to provide heightened grid resiliency. The Chicago Police and Fire Departments' headquarters are among the critical infrastructure within the microgrid.

The project is helping to reinvigorate the Bronzeville neighborhood while providing the highest level of resiliency.

In **Tampa, Florida,** the Metropolitan Ministries Foundation saw how much its community suffered when the city lost power for four days during Hurricane Irma in 2017. The foundation, which offers services to 30,000 families and homeless individuals, attracted lines of people looking for hot meals. With no electricity, its workers were forced to prepare food in the dark using a mobile kitchen in the parking lot in order to feed community members and residents.

"It took us a little bit by surprise how much the people and city depend on us," Justine Burke, the organization's vice president of marketing, said in a statement. "Many couldn't just evacuate or go to a hotel for a week because they could not afford it. When we showed up to work the next day, there was a huge line of people outside of our Outreach Center, waiting for us to help them."

The ministries got by using portable generators, some borrowed. But after that experience, the organization began looking for a more permanent solution before the next disaster hit. The board of directors found the answer in a microgrid brought to them by a partnership of PowerSecure and Tampa Electric (TECO).

The microgrid was configured for Metropolitan Ministries with a single point of contact with the grid and advanced paralleling switchgear. The system includes a Tier 4 diesel engine with the ability to isolate from the grid automatically in an outage or when it is called upon by TECO for load management.

In addition to providing reliable and resilient energy, the microgrid participates in TECO's demand response program. Having the microgrid on hand helps TECO avoid construction of additional peaking power plants. When TECO uses the microgrid, it gives Metropolitan Ministries a credit on its bill.

About 23 million people in the US live in food deserts, areas where stores that offer fresh and healthy food are at least a mile away. About half of this population is low income, and many are in urban areas, according to the US Department of Agriculture.

Urban agriculture is viewed as a way to counter food deserts, and microgrids are a natural companion to these facilities.

Vertical indoor farming, in particular, offers several advantages because it not only grows healthy food closer to consumers, but requires less land, water and pesticides than conventional agriculture.

However, vertical indoor farming is very energy-intensive.

To better manage their energy, Bowery Farming and Fifth Season have installed microgrids at indoor farming facilities in the Northeast US. Developed by Scale Microgrid, the projects use Schneider Electric software and control tools. Using solar, storage and natural gas generators, the projects bring significant environmental benefits and economic advantages. They sell ancillary services to the electric grid, which provides a revenue stream and helps offset microgrid costs and reduces greenhouse gas emissions.

Who Uses Microgrids Today?

- Health care facilities.
- Universities/research facilities.
- K-12 schools.
- Smart cities and communities.
- Ports, airports and mass transit facilities.
- Homes and neighborhoods.
- Utilities.
- Government and the military.
- Agricultural operations.
- Data centers and others focused on power quality.
- Telecommunications services.
- Retail and wholesale businesses.
- Oil and gas refineries.
- EV charging stations.
- Remote islands or outposts.
- Critical services such as police, fire and water.

Section III: How to Capture the Full Benefits of Microgrids in Climate Change Strategies and Infrastructure Plans

Achieving the full potential of microgrids requires dedicated and deliberate action by regulators and policymakers. This is an urgent issue and speed is of the essence. Climate-enhanced disasters are already upon us, causing widespread and prolonged power outages and suffering. Too often, we see that many of these impacts were avoidable. Proposals to build microgrids in New Orleans were dismissed in favor of utility investments in transmission and large generation. When Hurricane Ida came through in August 2021, those systems failed.

In this regulatory environment, microgrid development is a slow and daunting task. The component technologies can be installed relatively quickly, but outdated state, federal and utility requirements add unnecessary costs and delay projects. Regulatory reform that focuses on fair value, fair access and fair rates is urgently needed. There is no shortage of private capital ready to invest in microgrids and advanced energy solutions, but that requires more sensible price signals and tariffs. Unpredictable costs and arbitrary interconnection requirements hamper customer investments in microgrids, denying full achievement of cost savings. Rectifying these issues will help cities, towns and utility planners better understand where, when and how to incorporate microgrids into their resilience and infrastructure planning.

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Of particular importance are:

1. **Resiliency value:** Identifying reasonable and accurate ways to value the energy services provided by microgrids in both critical and everyday contexts.
2. **Rate reform:** Working to establish fair rate structures that are rooted in actual operational experience and true costs of service.
3. **Open access:** Establishing level playing fields and sensible interconnection strategies that encourage market access.
4. **Policy alignment:** Developing new, forward-looking mechanisms that recognize the value of a digitized grid and encourage development of microgrids as key solutions to resiliency, equity and climate challenges.

Locational value

Recognition of resiliency value: To position microgrids in the market, it's important to define the value of their services. A key service that microgrids provide is energy resilience, a means to avoid power outages and recover from them quickly when they do occur. While resilience is embedded in utility rates, it is not compensated when it is supplied by a microgrid from a non-utility owner, such as a community, business or institution. The owner of the microgrid assumes the resiliency cost, in essence, subsidizing the local utility. How can resilience from microgrids be more accurately valued and compensated? Understanding the value of resilience will help cities and states assess resiliency needs and identify microgrid deployment opportunities.

Recognition of locational value: During blue sky conditions, a microgrid can serve as a flexible grid asset, ready to be deployed as conditions on the grid change. The exact value of the microgrid depends on its location on the grid—what pricing, for example, does congestion create at a given time and location. It's important that pricing on these nodes be clear, transparent and technology agnostic so that the least expensive asset—be it a microgrid, battery, interactive building, EV fleet or some other form of distributed energy—can be chosen to provide the service. Accurate locational values are also important because they allow utilities to weigh with clarity the value of building a conventional energy asset or using distributed energy resources to serve the need.

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One of the biggest obstructions to multibuilding and community microgrids involves what are sometimes called utility "over-the-fence" rules—prohibitions from stringing wire across utility rights of way.

Utility/microgrid relationship: Level playing field and fair market access

Rights of way issues: One of the biggest obstructions to multibuilding and community microgrids involves what are sometimes called utility "over-the-fence" rules—prohibitions from stringing wire across utility rights of way. These restrictions, born of a bygone era when multiple electric companies competed to string wires to customers, prohibit a microgrid from connecting to a building across the street. For example, if a university has a microgrid and wishes to extend its services to the fire station across the street, it is prohibited from doing so. Under existing law, the microgrid can do so if it becomes a full-scale utility, an impossibility for a small energy system. The cost and regulatory complexity of becoming a utility far exceed the microgrid's resources and serve to deeply overregulate the system.

In a Public Utilities Fortnightly article, "Peaceful Coexistence," Sara Bronin and Paul McCary point out that utility franchise laws vary widely throughout the United States. The authors use South Carolina and Connecticut as examples of two extremes. In South Carolina, the state has jurisdiction over something as basic as the sale of power from rooftop solar panels to a host. In contrast, Connecticut allows certain microgrids to sell power across public streets.

A simple microgrid, such as one serving a college campus with no intervening rights of way, could likely operate even in South Carolina without concern about franchise rules, according to the authors. However, for community microgrids—those with multiple end users on multiple pieces of property on various public streets—the over-the-fence issue arises. Community microgrids aren't necessarily precluded from being built in a state like South Carolina. But the developers depend on the goodwill of the regulators and local utility, or the utility's willingness to form a financial partnership or agreement with the microgrid, say the authors.

Aligning over-the-fence rules with 21st century technology would open the way for more communities to protect their citizens from the harsh reality of power outages caused by climate disruption.

Interconnection: In some states, rules to interconnect a microgrid to the utility grid lack clarity and consistency, which results in long project delays. While safety is paramount when interconnecting, the delays can continue long after safety is clearly established.

Forward-looking mechanisms for a 21st century grid

Given the need to hasten resilience solutions, a universal model or national guidance is sorely needed to align the distribution grid with 21st century energy technologies.

Software-based distributed energy systems, of which microgrids are the most advanced, intelligent and flexible, open up new opportunities to leverage pricing in wholesale markets. They also open the door for new pricing mechanisms on the distribution grid. Both situations create new opportunities to better manage energy to reduce costs for the customers. But proper pricing signals and market mechanisms need to be in place to do this. On the wholesale level, FERC 2222 is paving the way for allowing more market participation by microgrids. However, the distribution system, or retail market, is governed state by state. Given the need to hasten resilience solutions, a universal model or national guidance is sorely needed to align the distribution grid with 21st century energy technologies.

Bringing about change in all 50 states may be slow to come, but other local mechanisms exist that could be employed to hasten microgrid development:

1. Encourage resilience planning and the consideration of accurate pricing signals in utility integrated resource planning.
2. Encourage or mandate resilience considerations in all city and town master planning.
3. Investigate model microgrid tariffs, as California, Hawaii and Puerto Rico are doing.

Last, on both the state and federal level, incentives such as tax credits and renewable portfolio standards have proven to be strong drivers of renewable energy. Microgrids may benefit from the same mechanisms and Think Microgrid strongly encourages state and federal exploration of these approaches.

Conclusion

Microgrids are a unique tool for policymakers and regulators seeking to solve both immediate and long-term challenges created by climate change. The technology has already proven itself in many settings—from remote islands to dense urban landscapes—as a means to protect people from the devastation brought on by power outages caused by hurricanes, wildfires, extreme heat and cold, and other natural disasters. Microgrids also have proven to be effective in lowering energy costs and helping businesses, communities and governments achieve climate goals through use of local, renewable energy. The ability of microgrids to ensure reliable power is more important than ever as the US prepares to electrify transportation and buildings, endeavors that will increase the nation's reliance on electricity.

The truth is that the century-old legacy of energy regulation has left us with a policy landscape fraught with outdated barriers and vulnerable to manipulation. But, at the core, we established regulation to provide fair, equitable and rational approaches to building our energy infrastructure. The good news is that the solutions we need today are rooted in the same principles of open access and rational decision-making that have always guided energy regulation.

Reforming energy policy is not a political issue. It is a humanitarian issue. It is an ecological issue. It is an economic issue. It is an issue that touches our every day, our worst days and both the vibrant and turbulent days that lie ahead.

Moving forward, we need better rate design that is based on actual costs of service. We need fair interconnection rules that focus on performance and are agnostic to the component technologies. We need open markets that encourage investments from all sources, whether they are utility shareholders, private investors or direct from customers. We need to create accountability that prevents the undue influence of incumbent power and anti-competitive behavior. We need to focus on improving the distribution system of the electric grid, where customers experience the disruptions that affect their lives. We need to seek upgrades to all of these systems that will allow us to decarbonize the electric sector and, in so doing, the transportation sector. We should begin these upgrades with our most valuable and critical community and communal facilities.

We've come to expect outages from storms that last for weeks, and we often respond with a collective shrug. The fact is our electric system is very brittle. Very brittle. But it doesn't need to be. Microgrids can be the shock absorbers in this system. Every day that we delay their development in favor or outdated policies, the costs add up. We should not respond with a shrug. We should respond with urgency. Our economic well being is on the line. Our very lives are on the line. Our future is on the line.

Microgrids don't solve every problem, but they do support intelligent upgrades to our energy system and an alignment with local resources. They provide resiliency in critical moments and optimization in mundane moments. Standing side by side with every technology innovation is the need to update our archaic regulatory infrastructure, one that is too slow to act and too skewed toward macro solutions. Better market design and regulatory reform are the paths to a more resilient electric system.

Think Microgrid stands ready and dedicated to having the conversations that will lead to real change.

About Think Microgrid

Because time is of the essence in bringing greater resilience to the electric grid, a coalition of leading energy and technology companies formed Think Microgrid in 2021 to address the inherent barriers to microgrids embedded in legacy regulatory policy.

Think Microgrid:

- Establishes a common voice for the industry to heighten understanding within government and media of the critical role that microgrids play in achieving resiliency, climate and equity goals.
- Provides a coordinated approach to building relationships and leading discussions with policymakers, regulators and lawmakers.
- Works to advance pending government initiatives that support microgrid adoption and encourage new policy activity and government programs in promising jurisdictions.
- Fosters cooperation and alliances with the leading policy stakeholders.

Think Microgrid stands ready to assist government entities—cities, states and federal agencies—as they explore strategies to increase use of microgrids. For more information, please contact Cameron Brooks, executive director of Think Microgrid, cameron@thinkmicrogrid.org.