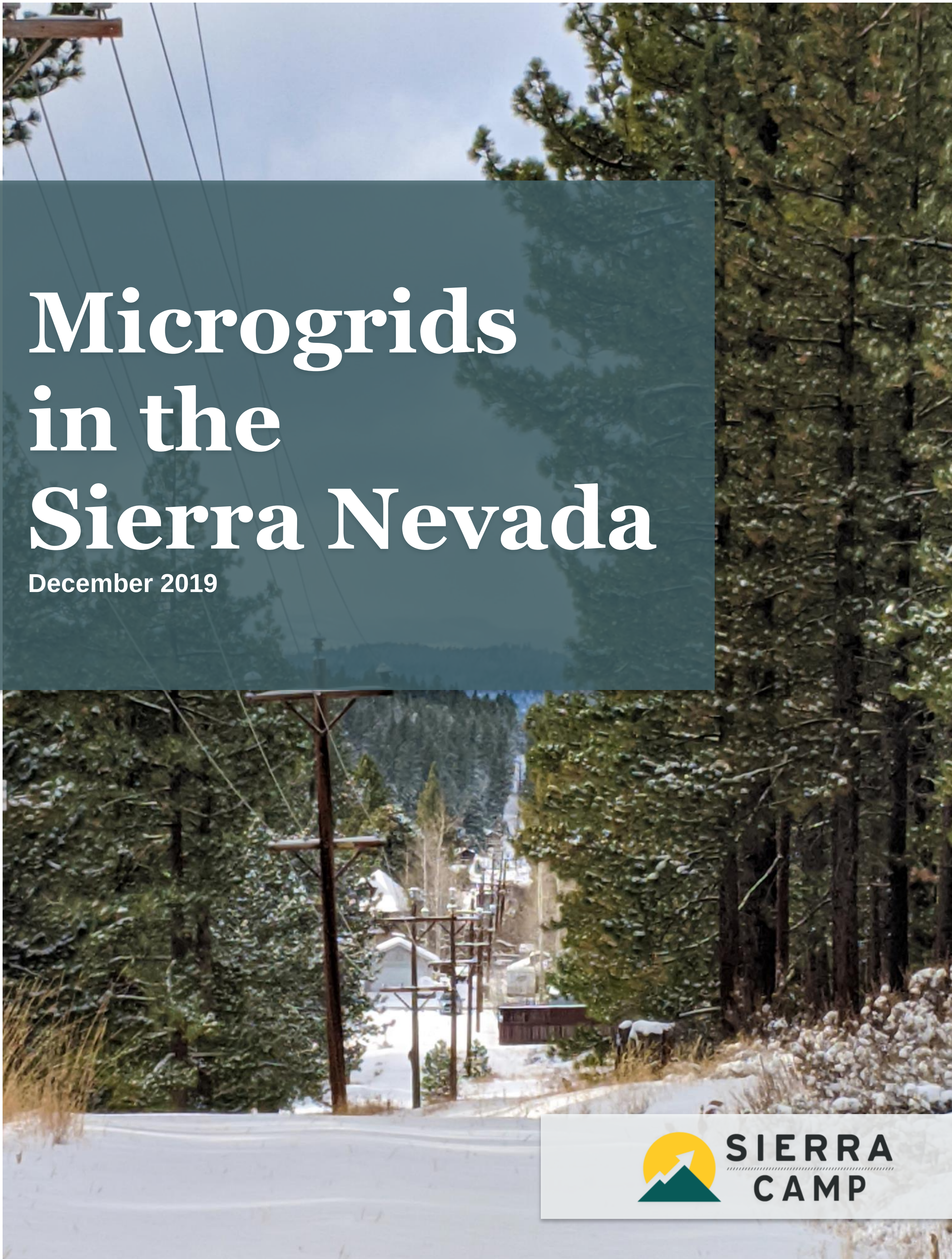
Microgrids in the Sierra Nevada

December 2019



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Microgrids in the Sierra Nevada

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Increasing scale and frequency of Public Safety Power Shutoffs (PSPS) and other power outages across the State of California highlight the need and opportunity to manage energy at a localized level. Integrating microgrid technologies into Sierra Nevada communities can reduce the risk of power outages while increasing renewable energy resources to meet and exceed state mandates and promote climate resiliency.

The Issues

The Sierra Nevada energy grid is under serious threat from climate change and its aging infrastructure. Decades of extreme drought, variable precipitation changes, and fire suppressed forests have led to increased risk, frequency, and damage from wildfires in the region[1]. Climate impacts intensify both the risk of a wildfire damaging the grid and the need to prevent future fires through power shutoffs. There are also grid issues related to the age, distance, and deterioration of the electrical infrastructure that poses significant threats to safety, reliability, and efficiency.

Recently, California utility providers have implemented preemptive power shutoffs, or Public Safety Power Shutoffs, in high-wildfire prone areas to reduce the risk of a power line causing another large, damaging wildfire. 15 of the 20 most destructive wildfires in the state's history have occurred since 2000 and 10 have occurred since 2015[2]. Although PSPS events are intended to reduce fire risk, the planned outages in 2019 left hundreds of thousands of Californians without power for days at a time[3]. On October 27, 2019, alone, approximately 3 million California residents were affected and during events like these, schools close, gas stations are unable to pump gas, traffic lights do not work, hospitals rely on generators and basic societal functionality is severely inhibited[4]. Lawrence Berkeley National Laboratory estimated the cost of these events to the California economy could be upwards of $2.5 billion, with small businesses and rural communities being disproportionately affected[5].

> "15 of the 20 most destructive wildfires in the state's history have occurred since 2000 and 10 have occurred since 2015"

The majority of United States power outages not related to preemptive power shutoffs are caused by severe weather events and cost the economy between $18 and $33 billion every year[6]. With

[1] (California, 2018)
[2] (Force, 2019)
[3] (Wikipedia, 2019)
[4] (Force, 2019)
[5] (Stevens, 2019)
[6] (President, 2013)

these events becoming increasingly common in the late fire season, local governments and communities are searching for a solution. An emerging resilience solution is to develop a community microgrid, in which energy generation and distribution are localized to maintain operational performance.

> "The majority of United States power outages not related to preemptive power shutoffs are caused by severe weather events and cost the economy between $18 and $33 billion every year."

High voltage transmission power lines sprawl over thousands of miles throughout the Sierra Nevada landscape, connecting to even more miles of smaller distribution lines. Unfortunately, the current energy grid is structured so that when a major transmission line is shut down, the smaller distribution lines are also shut down. Many rural communities are connected to the broader grid by smaller distribution lines that cut through dense forest, which become less and less efficient with age. The EPA estimates that in the Western United States, about 5.10% of electricity is lost through transmission from initial generation to consumer[7].

The United States' aging electricity grid infrastructure poses significant threats to communities. While the grid has served Sierra Nevada communities adequately for decades, nearly 70% of transmission lines and transformers in the United States are over 25 years old[8]. An upgraded electric grid is necessary for becoming more climate and energy resilient to recover from adverse events. A microgrid system could allow for an update to the existing infrastructure while reducing transmission line fatigue from PSPS events turning the entire grid on and off. By sectioning off parts of the grid during a PSPS event, crews would be able to focus on the integrity of the lines that were turned off more quickly than if the entire line was not down.

In rural communities affected by power shutoffs, microgrid systems could allow for key institutions such as hospitals, municipal utilities, schools, and government services like police departments and fire stations to continue to operate in the event of an anticipated or actual natural disaster that interrupts electrical transmission and distribution. During such events, these locations can also be used as an emergency shelter to provide clean, cool air and other essential services like warmth or charging people's electronics. Microgrids reduce the dependence on major power line transmission and distribution by offering the ability to utilize power from battery storage and co-located renewable generation during shutoffs.

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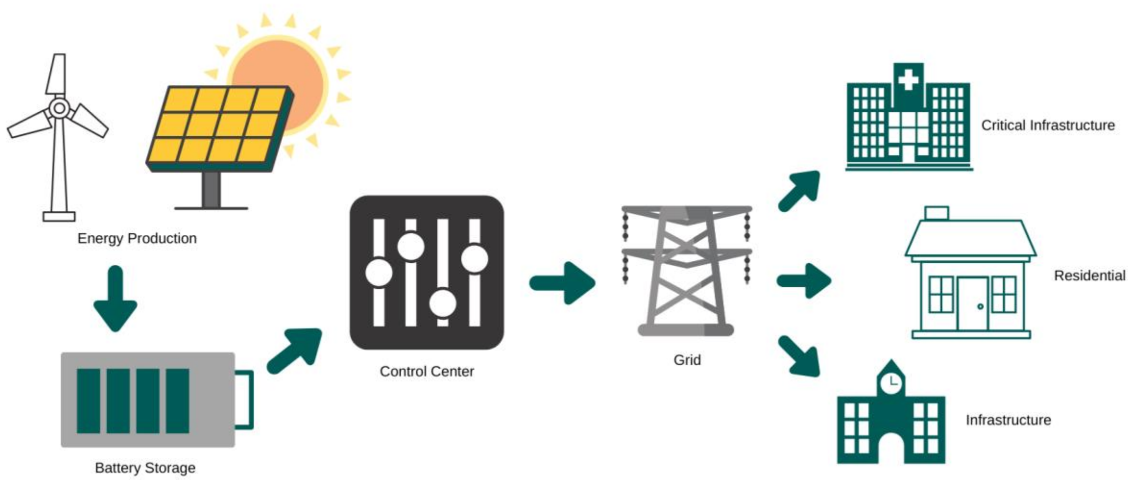
7 (EPA, 2017)
8 (President, 2013)

California legislative priorities around energy efficiency, emission reductions, and renewable energy portfolio standards increase the local government's urgency to find solutions for increasing renewable energy resources in their communities. In 2015, SB 350 was approved to expand Renewable Energy Portfolio Standards for each of the state's investor-owned utilities (IOUs), electric service providers, and community choice aggregators to acquire 50% of their electricity from renewable resources by 2030[9]. To add to this urgency, in 2018 SB 100 was passed to revise those Standards to require the achievement of 50% renewable resources target by 2026 and 100% eligible renewable energy or zero-carbon resources by 2045[10]. The state can meet and exceed these goals by capitalizing on the often large sources of renewable energy that microgrids supply through distributed energy resources.

Energy Storage
Energy Source
Control System

What is a Microgrid?

A microgrid is a local, coordinated energy system that can use renewable energy resources like wind, solar, biomass, hydro, or fuel cells to provide electricity at a smaller, more resilient scale[11]. In general, a microgrid is a miniature, semi-independent grid of its own that can island from the broader grid in times of crisis. The term "island" refers to the microgrid's ability to act independently from the entire grid and not remain connected to the entire grid. A microgrid can be as small as a single room that supplies energy to itself when the power is threatened or as large as an entire community[12].



Microgrids typically work simultaneously with the investor-owned utility grid to supply electricity but during times of crisis, microgrids can island themselves to provide energy to residents and critical infrastructure, depending on the scale. The energy provider simply views the community microgrid as another ratepayer and delivers energy as usual.

[9] (Senate, Clean Energy and Pollution Reduction Act - SB 350, 2015)
[10] (Senate, SB 100 Bill Text, 2018)
[11] (Energy, 2014)
[12] (Microgrid, Strategic Microgrid, 2019)

Microgrids are a tool that can be used in conjunction with other energy system mechanisms to mitigate the risk of preemptive power shutoffs and potential wildfire risk. A microgrid system includes three main parts: energy generation, a storage system, and a controller to monitor and manage the flow and use of that energy. Most importantly, microgrids provide a solution for economic, environmental and community resilience that can be replicated in the Sierra Nevada. It is becoming increasingly important for communities to rethink their connections to the broader grid and work to increase independence.

Mechanics of a Community Microgrid

Microgrids consist of three essential parts, energy resources, an energy management system, and some type of storage capacity. Microgrids also combine various forms of distributed energy resources (DER) which can include fuel cells and microturbines, gas or diesel cogeneration, photovoltaic modules, wind, biomass, or a small hydroelectric plant[13]. Renewable energy sources can be used to power all or a part of the microgrid system. It is important to determine what types of energy sources the microgrid system will work from to best utilize local energy sources.
Each microgrid project is unique based on the needs of the community and the resources available to the region.

Features:

- High penetrations of local renewables and other DERs that achieve desired levels of grid reliability, resilience, and power quality;
- Local balancing and load flattening that reduces costly transmission investments and load peaks;
- Ongoing, renewables-based backup power to prioritized loads;
- A scalable and replicable solution based on the substation-level building block of the electric grid.

Stakeholders:
There are many stakeholders involved in the process of making a microgrid a reality including the utility, municipalities, policymakers, residents, financers, and operators depending on the project[14]. It is important to engage with these groups with a clear message and wish to develop a community microgrid in order to build consensus and support of the project. The most important stakeholder to engage with while developing a project is the utility provider for the area because they will have the most up to date information about necessary updates to the grid. Most microgrids in the United States receive energy from the utility in the area and provide high penetrations of renewables into the system but have the ability to isolate themselves if needed.

[13] (Coalition, 2019)
[14] (Coalition, 2019)

Case Study: *Fremont, California Fire Stations*

The City of Fremont upgraded three of its fire stations in 2017 to function as microgrids through the California Energy Commission's (CEC) Solar Emergency Microgrid Project[15]. The microgrids demonstrate a solution for maintaining operations at critical infrastructure facilities during power outage events like Public Safety Power Shutoffs or other severe weather events. Critical facilities such as fire stations and hospitals are especially vulnerable during these events, therefore integrating local, renewable energy distribution decreases dependency on the larger grid and outside sources.

The installation included 4-kW solar panels on car canopies owned by an energy innovations company called Gridscape Solutions, a microgrid energy management system and a 110-kWh battery storage system. The system provides energy cost savings while connected to the grid and at least four to six hours of clean power for critical loads during a utility power outage. The program also includes a 10-year power purchase agreement with Gridscape guaranteed clean energy system maintenance and monitoring which is projected to reduce utility bills by $350,000 and reduce municipal greenhouse gas emissions by 220,000 pounds of carbon dioxide[16].

The project's return on investment is approximately six years after an initial investment of $800,000 for the first station, and $500,000 for the second and third stations. As prices continue to drop for the cost of renewables, similar new systems would cost about $300,000 per station. The project achieved a technology cost reduction of more than 30 percent from the first microgrid to the remaining two.

The goal was for the system to be able to run independently for about three hours but the system consistently scored higher times in test with the longest islanding test lasting 13 hours[17]. As of August 2019, The project has also met the greenhouse gas emissions reduction goal of 80,000 lbs/year during the demonstration period and helped the City of Fremont meet its climate action plan objectives.

By investing in microgrids at three fire stations, the City of Fremont has increased its emergency preparedness to include critical services in the event of a power shutoff or a wildfire. This site serves as a replicable solution for energy independence which other locations across the city can convert their systems to a microgrid and act as an emergency shelter in times of crisis. This project has also given the Fremont grid an update that modernizes this section of the outdated grid system.

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[15] (Commission, Solar Emergency Microgrids for Fremont Fire Stations: Demonstrating Energy Savings and Grid Resilience for Critical Facilities, 2019)
[16] (Thurston, 2019)
[17] (Commission, Solar Emergency Microgrids for Fremont Fire Stations: Demonstrating Energy Savings and Grid Resilience for Critical Facilities, 2019)

Borrego Springs, California

Borrego Springs in Southern California is a small, rural community of fewer than 4,000 residents. The community is in a somewhat isolated area fed only by a single sub-transmission line, which makes it especially vulnerable to power outages. To build energy resilience in the community, San Diego Gas and Electric (SD&E) developed the infrastructure for a community microgrid that would allow for independent energy generation and storage if the line was damaged[18].

In 2007, a fire knocked out the main transmission line and left the entire community without power for two days. The community is located in a hot, desert area with many vulnerable populations who rely on air conditioning. Without power, there is an extreme risk of death from heat exposure. After restoring power, SDG&E received an $8 million grant from the U.S. Department of Energy to build the microgrid[19]. When an intense lightning storm hit the community in 2013, the new microgrid enabled SDG&E to restore power to the community in a matter of hours despite the main transmission line being affected.

Credit: San Diego Gas and Electric

The microgrid consists of SDG&E's air-insulated substation, a third party commercial 26 megawatt (MW) solar system located in the community, 3 MW of customer-owned rooftop solar, two 1.8 MW distributed generation resources, two substation batteries, and three community energy storage batteries to island the entire community during the day and reducing to only critical needs at night. One megawatt of electricity is about enough energy to power 1,000 homes[20]. SDG&E provides electricity to 2,500 customers in the community which means that the microgrid provides plenty of power to the community.

Credit: San Diego Gas and Electric

The results of this project have been positive. The community now enjoys its energy from renewable sources locally generated, which reduces their carbon footprint, and can also find comfort in knowing that if another large storm takes down the single power line that supplies their homes, they will be safe.

For more information on the Borrego Springs Microgrid see the 2019 CEC Report here[21]. Additional Case Studies can be found here[22].

[18] (Lab, 2019)
[19] (Commission, Borrego Springs, 2019)
[20] (Electric, 2019)
[21] (Commission, Borrego Springs, 2019)
[22] (Commission, Microgrid Analsis and Case Studies Report, 2018)

How Community Microgrids Could Mitigate Future Power Outages in the Sierra Nevada

Developing microgrid systems in the Sierra Nevada has the potential to benefit communities, the economy, and the environment. Microgrids provide efficient, low-cost, clean energy, enhance local resiliency, and improve the operation and stability of the regional electric grid. They provide dynamic responsiveness unprecedented for an energy resource. Beyond the benefit of keeping businesses, homes, and government services functional throughout Public Safety Power Shutoffs, community microgrids can serve to create long-lasting resilience and community independence, along with a host of other co-benefits.

Community Benefits

- Microgrids provide a more reliable energy system which can improve the operation and stability of the electric grid. This takes away the stress and panic that often is a result of power outages.
- Uses local, renewable energy, and jobs to maintain and operate the microgrid[23].
- Cybersecurity against potential grid-hackers. The current energy grid system is vulnerable to cyberattacks that can put the entire grid at risk. A microgrid would provide an additional layer of defense against an attack.
- Provides backup power to prioritize critical loads to an entire community. Critical loads are essential items that need to be powered. This could include emergency infrastructure or community evacuation shelters.
- A modern power grid with large sections of renewables included reduces dependence on foreign oil and fossil fuels.
- Incorporating smaller, decentralized power plants diversifies the energy supply and reduces the risk of widespread power outages. Most renewables cannot provide energy all day, there are limitations of the resource like the fact that the sun does not shine at night. This requires that systems have a reliable storage system like a battery. With solar combined with storage, a community can keep critical services going even during widespread blackouts.

Critical infrastructure like hospitals, fire stations, emergency shelters, or dispatch centers can be maintained in an emergency

[23] (Markets, 2014)

Economic Benefits

- The impacts of PSPSs on small businesses, whether they are restaurants forced to close and throw out spoiled food, or retail stores that cannot light their shops or process card transactions, can be incredibly damaging. Allowing businesses, the option of staying open and maintaining some level of operations can be an economic driver for small communities.
- Can attract private investment, create jobs, and keep energy dollars close to home[24].
- Generating clean energy locally keeps dollars in the community and gives residents, businesses, and institutions access to renewable energy.
    - A 2014 report showed that 1 MW (megawatt) of locally owned solar means as much as $5.7 million in lifetime economic benefits for a community[25]
- Developing clean local energy generation turns underused spaces such as parking lots, fields, and rooftops into energy-producing assets — without the controversy and cost involved in building large power plants on undeveloped land.
- Secure predictable, affordable energy prices by protecting consumers from volatile costs of fossil fuels and rising costs of delivering energy over expensive long-distance transmission lines.

Avoids expensive and inefficient long-distance transmission of power. Approximately 5.1% of energy is lost during transmission over long-distances in the Western United States.

Climate and Environmental Benefits

- Islanding capabilities when climate events occur such as shutting off certain portions of the grid during high winds (with adequate backup power from distributed energy resources)[26].
- Reduction in greenhouse gas emissions from fossil fuel energy production, as community microgrids typically utilize higher rates of renewable energy.
- Replaces the need for gas-fired plants that emit hazardous fossil fuels and reduce water and air quality, while reducing greenhouse gas emissions, minimizing water use from gas and diesel electricity generation facilities, and preserving pristine lands by siting local renewables on rooftops, parking lots, and other underused spaces within the built environment.
- Provides cleaner energy generation which improves air and water quality for residents near diesel and gas combustion sites.

Utilizes local renewable resources such as solar, wind, geothermal, biomass, and fuel cells depending on the local renewable energy resources

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[24] (President, 2013)
[25] (Coalition, 2019)
[26] (Outages, 2013)

Framework for Developing a Community Microgrid

Microgrid projects may take many shapes and forms depending on the intended purpose and economic environment of the project. However, the technical framework for a microgrid system is fairly constant across case studies. It is important to engage with the necessary stakeholders to provide technical and financial support while assessing the feasibility of implementing a microgrid system. Technical expertise is important for microgrid development and more companies and organizations are emerging as leaders in the field to help provide that knowledge base. The Clean Coalition based in California is a nonprofit organization with a mission to accelerate the transition to renewable energy and a modern grid through technical, policy and project development expertise and have a framework for creating a community microgrid.[27].

Establish Goals	Develop desired goals and performance metrics of the targeted grid area. These goals should include renewables, grid reliability, power backup, peak reductions, etc. Example: "Achieve high penetrations of local renewables, targeting at least 25% of total electric energy consumed within the target grid area."
Perform Baseline Grid Analysis	Determine the ability of the grid to accommodate new distributed energy resources. Inventory the existing grid assets including load profiles, voltage regulation, feeder and transformer capacities, and existing generation.
Optimize Target Area's Energy Efficiency	Avoid overbuilding distribution capacity which can reduce transmission efficiency, increase renewable generation installations and ensure that the microgrid generation sources are being used as efficiently as possible. Ensure that target buildings are as water- and energy-efficient as possible. Consider upgrading high-energy use appliances and equipment to more efficient models, and invest in high-efficiency building materials to reduce the need for excess HVAC utilization during long periods of outages.
Conduct a Renewables Siting Survey	Create a comprehensive assessment of local renewable energy generation potential in the target grid area, specific to local resources.
Optimize Distributed Energy Resources	Establish an optimized combination of local renewables, energy storage, demand response (to understand community use timing), and other DER concerning cost and grid performance metrics. As part of this optimization process, test various DER combinations that achieve the Goals, building on the results of the Baseline Grid Analysis and the Renewables Siting Survey.
Complete an Economic Analysis	Conduct a comprehensive analysis of the costs and benefits associated with the community microgrid spanning energy, social (including public health), economic, and environmental benefits. This economic analysis includes assessing the energy costs for deploying local renewables and other DER, reductions in transmission and distribution (T&D) investments, and anticipated local job creation.
Develop a Deployment Plan	Design bulk procurement and interconnection processes that facilitate streamlined and scalable deployment of the local renewables and other DER, fulfilling the Goals of the community microgrid project. The Deployment Plan will often include designing a Request For Proposal (RFP), or similar requirements documentation, that allows for a straightforward assessment of proposed solutions.

[27] (Coalition, 2019)

Many companies and organizations are emerging throughout the United States who provide technical assistance and financing options for developing a microgrid. Some of these resources are located at the end of the paper.

Additional Reading:
S&C Electric, a Chicago-based electric equipment and services provider, recently published a three-part series on evaluating, building and maintaining a microgrid.

- *Is a Microgrid Right for You?*
- *How to Build a Microgrid*
- *The Short- and Long-term Care of your Microgrid*

Challenges

Utilities, businesses or municipalities might encounter challenges while developing a microgrid for the community. Depending on the regulatory framework of the city or county where the project is taking place, microgrid technology can be more difficult to implement. It is important to understand these government regulations or policies before investing in a project. There is plenty of enabling legislation at the State level that helps alleviate any potential barriers for developing this sort of system. It is important to also keep in mind the utility's contracting ability or tariffs that could be included while developing a project. Keep in contact with the utility provider while developing the microgrid system in the community.

Financing microgrid projects is often the biggest challenge that people face. Oftentimes, microgrid projects are financed through multiple funding sources and draw from the public, private or philanthropic sources. When applying for municipal microgrid funding, keep in mind the preferred ownership structure of the project or the grantor's role in the project. Microgrid financing often must cover various components of the project, such as power and energy generation systems, energy efficiency retrofits, and distribution systems and connections. Microgrids are likely to improve their bankability if they increase their value by offering thermal energy as well as electricity. For more information about financing projects, refer to Microgrid Knowledge's *Microgrid Policy Guide*[28] which outlines the process for applying to funds.

Other notable limiting factors include staff capacity and knowledge on the subject matter. Technology trends are another challenge. While our energy system is aging, there has been an influx of energy technology and it can be difficult to choose the best option. It is important to research options for microgrid implementation and find the best fit for the community.

Additional Reading:
CA Regulations are Hindering Microgrid Development
California's Critical Facility Challenge

[28] (Markets, 2014)

California Microgrid Policy

Public Safety Power Shutoffs have sparked controversy over the management of the energy utility grid. Governor Newsom was quoted saying that the way power outages were handled during the fall of 2019 was “unacceptable” for leaving so many Californians without power[29]. State policy must enable the development of more resilient energy solutions such as microgrids.

According to the Navigant Research report (2018), five principles should drive government programs to make microgrids a mainstream reality: (1) Shift away from sporadic grants to market-based incentives; (2) Target funds toward new clean and smart technologies; (3) Choose projects that foster new financing business models; (4) Allow for flexibility and midcourse corrections; (5) Create metrics that capture the value of resiliency[30]. Sierra Business Council recommends that this entails an examination and quantification of the co-benefits listed above.

The California Energy Commission released its Microgrid Analysis and Case Studies Report in August 2018[31]. The report includes case studies for economically viable microgrids in California, the United States and globally to better inform policymakers on how to promote and accelerate microgrid adoption in California. Each of the projects was required to be funded by at least 50 percent private investment or non-governmental grant funding, or demonstrate microgrid technology or business model innovation that offers opportunities for repeatable deployments.

In September 2018, California enacted a law, Senate Bill 1339, that requires the California Public Utilities Commission to develop regulations, standards and guidelines for microgrids by December 1, 2020, to facilitate the commercialization of microgrids for customers of large electric utilities. SB 1339 directs the CPUC to address the following key issues: (1) how microgrids operate and their value; (2) improving the electrical grid with microgrids; (3) how microgrids can play a role in implementing policy goals; (4) how microgrids can support California’s policies to integrate a high concentration of distributed energy resources on the electrical grid; (5) how microgrids operate in the current California regulatory framework; and (6) microgrid technical challenges[32].

The CPUC initiated a rulemaking to implement SB 1339 in September 2019. Public comments on the regulatory actions prescribed by SB 1339 were collected by the CPUC which included the development of guidelines to determine what impact studies are necessary for microgrids to connect to the larger distribution system currently operated by California utility providers and separate rates and tariffs to support microgrid development. A decision will be made in Q4 2020. Refer to Order Instituting Rulemaking Regarding Microgrids Pursuant to Senate Bill 1339.

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29 (Times, 2019)
30 (Research, 2018)
31 (Commission, Microgrid Analsis and Case Studies Report, 2018)
32 (Lewis, 2019)

Resources for Local Governments and Communities

Berkeley Lab	The Microgrids Group at Berkeley Lab studies customer adoption patterns of microgrid technologies as well as microgrid controllers. The Lab has been a leader in microgrid research in California.
California Energy Commission	California Energy Commission Microgrid Analysis and Case Studies Report. California Energy Commission staff in collaboration with the California Public Utilities Commission and the California Independent System Operator are developing a Roadmap for the Commercialization of Microgrids in California.
California Self Generation Incentive Program	CPUC/PG&E's Self-Generation Incentive Program provides financial incentives to help support the costs of on-site electric generating systems utilizing either solar, wind, fuel cell, micro turbine or internal combustion engine cogeneration systems. Program participants are eligible to receive incentives under this program for installing distributed generation technologies based on system type, size, fuel source and out-of-pocket costs. Only commercially available and factory new equipment is eligible for incentives. Rebuilt or refurbished equipment is not eligible to receive incentives under this program. The maximum system size is 5 MW (and the incentive payment is capped at 1 MW).
Clean Coalition	The Clean Coalition is a nonprofit organization whose mission is to accelerate the transition to renewable energy and a modern grid through technical, policy, and project development expertise.
Microgrid Institute	Microgrid Institute was established in 2013 to help energy customers, communities, technology providers, and project developers to chart pathways toward a more sustainable and resilient future with microgrids and distributed energy resources. We specialize in microgrid design, feasibility assessment, and community engagement and collaboration. We support energy customers and communities in finding qualified vendors and partners. We provide suppliers with market intelligence and project leads to support microgrid business development.
Microgrid Knowledge	Microgrid Knowledge is a resource hub for microgrid information. They regularly publish reports, white papers and news on microgrids.
Navigant Research	The Microgrids Research Service focuses on alternative distributed energy resource networks and related platforms that add enhanced resilience, redundancy, and security to the electrical distribution system. The service features research and analysis covering microgrids, nanogrids, virtual power plants, and direct current distribution networks, along with an in-depth

	examination of deployment strategies, enabling technologies, policy and regulatory factors, business and financing models, and applications for these networks in various industry verticals. Research includes a comprehensive strategic analysis of the market landscape in addition to detailed market forecasts, segmented by technology, world region, and application area.
United States Department of Energy	The Office of Electricity (OE) has a comprehensive portfolio of activities that focuses on the development and implementation of microgrids to further improve reliability and resiliency of the grid, help communities better prepare for future weather events, and keep the nation moving toward a cleaner energy future.

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