DOCKETED	
Docket Number:	20-IEPR-01
Project Title:	General/Scope
TN #:	237456
Document Title:	Final 2020 Integrated Energy Policy Report Update Volume II The Role of Microgrids in California's Clean and Resilient Energy
Description:	Final 2020 Integrated Energy Policy Report Update Volume II: The Role of Microgrids in California's Clean and Resilient Energy Future, Lessons Learned From the California Energy Commission's Research
Filer:	Raquel Kravitz
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	4/15/2021 7:34:49 AM
Docketed Date:	4/15/2021

CALIFORNIA
ENERGY COMMISSION

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COMMISSION REPORT

Final 2020 Integrated Energy Policy Report Update

Volume II: The Role of Microgrids in California's Clean and Resilient Energy Future, Lessons Learned From the California Energy Commission's Research

Gavin Newsom, Governor

April 2021 | CEC-100-2020-001-V2-CMF

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ABSTRACT

The *2020 Integrated Energy Policy Report Update* provides the results of the California Energy Commission's assessments of a variety of energy issues facing California. Many of these issues will require action if the state is to meet its climate, energy, air quality, and other environmental goals while maintaining reliability and controlling costs.

The year 2020 was unprecedented as the state continues to face the impacts and repercussions of multiple events including the COVID-19 pandemic, electricity outages, and statewide wildfires, while keeping on track to meet the state's long-term greenhouse gas goals. In response to these challenging events, the *2020 Integrated Energy Policy Report Update* covers a broad range of topics, including transportation, microgrids, and the *California Energy Demand Forecast*.

Keywords: microgrids, resiliency, distributed energy resources, public safety power shutoffs, equity

Please use the following citation for this report:

Bailey, Stephanie, David Erne, and Michael Gravely. 2021. *Final 2020 Integrated Energy Policy Report Update, Volume II: The Role of Microgrids in California's Clean and Resilient Energy Future, Lessons Learned From the California Energy Commission's Research*. California Energy Commission. Publication Number: CEC-100-2020-001-V2-CMF.

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EXECUTIVE SUMMARY

The year 2020 brought many challenges but also hopes for a better future. The *2020 Integrated Energy Policy Report (IEPR) Update* identifies actions the state and others can take to ensure a clean, affordable, and reliable energy system. California's innovative energy policies strengthen energy resiliency, reduce greenhouse gas (GHG) emissions that cause climate change, improve air quality, and contribute to a more equitable future.

The *2020 IEPR Update* is divided into three parts:

- **Volume I** focuses on California's transportation future and the transition to zero-emission vehicles. Transportation is the focus of the *2020 IEPR Update*.
- **Volume II** examines microgrids, lessons learned from a decade of research investments by the California Energy Commission (CEC), and stakeholder input about the potential of microgrids to contribute to a clean and resilient energy system.
- **Volume III** provides an update on California's energy demand outlook, updated to reflect the global pandemic and help plan for a growth in zero-emission, plug-in electric vehicles.

The following summarizes the highlights of Volume II.

The Role of Microgrids in California's Clean and Resilient Energy Future: Lessons Learned from the CEC's Research

Background

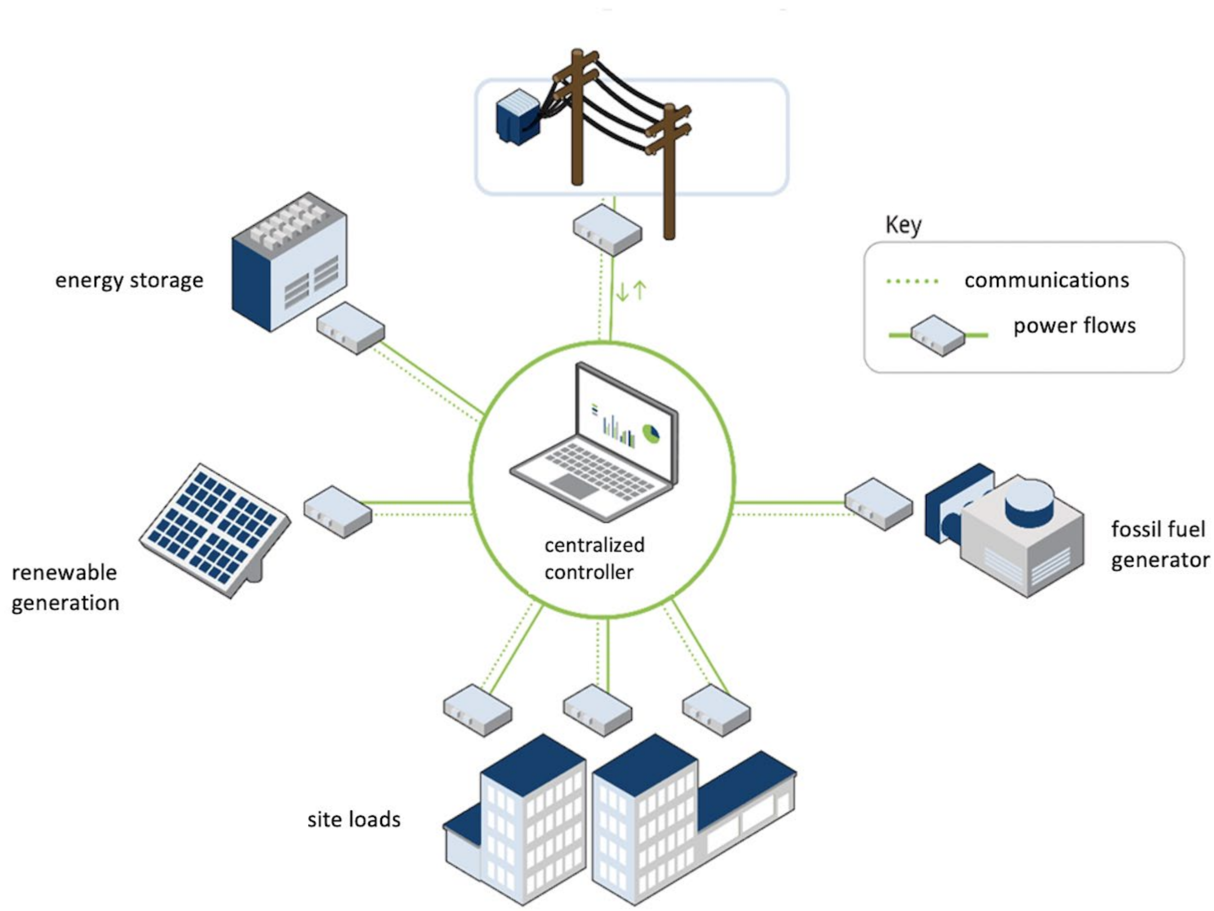
This volume examines microgrids and the lessons learned from a decade of CEC investment in microgrid research resulting 58 microgrids, nearly $180 million invested, and more than $143 million of matching funding. It addresses the potential role of microgrids as one of a suite of solutions to ensure a clean and resilient energy grid in California.

Typically, the key components of an energy microgrid are a power source, energy storage, a centralized controller, and end customer site loads that normally receive their power from the utility grid. (See Figure ES-1 for a simplified diagram of components that are typical for a microgrid.) Some clean energy microgrids include fossil fuel-based emergency generation when longer-duration protection is needed than can be provided with the renewables and energy storage contained in the microgrid. The long-term aim is for clean energy microgrids to be deployed rather than microgrids with fossil fuel-based back up power.

The microgrids discussed in this IEPR are connected to the grid. CEC has focused its grant funding for the advanced development of microgrids that are interconnected and can provide services to the grid. For example, although these clean energy microgrids normally operate using power from the grid, they can be islanded to reduce load and pressure on the grid if needed. Microgrids can be powered by renewable energy (such as solar, wind, or bioenergy) and energy storage for several hours, relying on fossil fuel back up generation when renewables are not available and energy storage has been exhausted. For example, today's microgrid can island from the grid and maintain operations during a grid outage for 4 to 6 hours before relying on fossil fuel back up generation. The long-term goal is to develop clean energy microgrids that are 100 percent renewable.

In California, utilities are working to maintain and improve reliability and resiliency of the grid for all customers. In certain cases, microgrids may provide a cost-effective solution to meet the individual needs of some end users in the event that they cannot be served by the grid. However, microgrids are not appropriate or cost-effective to address every problem, rather they must be deployed strategically.

Figure ES-1: Common Components of a Microgrid



Credit: Developed for the CEC by Frontier Energy, Inc.

The California Independent System Operator (California ISO), California Public Utilities Commission (CPUC), and the CEC are taking concerted action to meet the state's clean energy goals and maintain and strengthen the reliability and resiliency of the electric grid through increased procurement of zero-carbon generation and energy storage assets for customers across the state. Microgrids may provide an option for some customers to individually pursue these clean energy and resiliency objectives. Even though the state has recently used Public Safety Power Shutoffs (PSPS) as a calculated wildfire mitigation strategy, these events are anticipated to steadily decrease due to the significant investment in wildfire mitigation, including vegetation management and grid hardening, by utilities. Microgrids can potentially provide a strategic opportunity to make the grid more resilient. However, they are relatively expensive and are not appropriate for all situations. (See the *2020 IEPR Update, Volume I* for opportunities to enhance energy reliability with electric vehicles.) Additionally, like back-up generation options for grid services, microgrids that provide longer duration protection usually require fossil-fuel back-up power, which also comes with harmful air quality and climate impacts.

In recognition of the potential benefits microgrids can provide customers and California in meeting its future energy goals and manage their individual energy uses, in 2018, the Legislature passed the first state-level policy for microgrids in the country, Senate Bill (SB) 1339 (Stern, Chapter 566, Statutes of 2018). SB 1339 requires the CPUC, in consultation with the CEC and the California ISO, to "take action to help transition the microgrid from its current status as a promising emerging technology solution to a successful, cost-effective, safe, and reliable commercial product that helps California meet its future energy goals and provides end-use electricity customers new ways to manage their individual energy needs." The statute also requires the publicly owned utilities' governing boards to develop standardized processes that support microgrid deployment.

Addressing Challenges to Deployment

Through its research programs, the CEC has provided ratepayer funding to support the development of 58 microgrids statewide over the past decade, including 47 funded through its Electric Program Investment Charge (EPIC). EPIC-funded microgrids include:

- 6 in elevated and extreme fire threat areas.
- 41 in disadvantaged (as defined by high exposure to pollution) or low-income communities.
- 7 in Tribal communities.

Through these projects, the CEC has advanced the science of microgrids and worked to address market barriers to deployment that will benefit electricity ratepayers. Examples of CEC-funded microgrid projects serving various end uses are shown in Figure ES-2.

Figure ES-2: Research Microgrid Projects by End-Use

Credit: Images provided by microgrid grant recipients and demonstration site owners

Over the last decade, the CEC's research programs have sponsored microgrid research that has identified key values microgrids can offer their owner and the grid. Further, this research has allowed the industry to develop a better understanding of how to design, build, and demonstrate a microgrid. While this research has continued to show the potential of microgrids, microgrid costs continue to be one of the challenges to rapid commercialization. This challenge remains despite declines in the cost of solar and storage, which are typically part of a clean energy microgrid.

Another challenge to deployment is that while microgrids may include clean energy technologies such as solar paired with storage, most microgrids also include fossil-fueled backup power if they are expected to provide backup power that lasts several hours or days. The microgrids of the future must rely on zero-carbon solutions in support of SB 100 (de León, Chapter 312, Statutes of 2018), which establishes a goal of 100 percent zero-carbon electricity by 2045. Ongoing research is needed to advance solutions that can provide resiliency that relies exclusively on clean energy resources, to customers expecting to isolate from the grid for longer periods of time. Such solutions are needed if the microgrids of the future are going to meet the requirements of SB 100. Some customers may be considering the appropriate role for microgrids as a resiliency solution for the multiday outages from PSPS events experienced in recent years. However, these events are expected to steadily decline in the near future due to significant investments in wildfire mitigation — including vegetation management and grid hardening — to make the grid less vulnerable to high windspeeds and other wildfire conditions.

Assessing Strategic Locations for Clean Energy Microgrids

Given the limited availability of grant funding, especially in the wake of the COVID-19-induced recession, providing high-level guidance on the most strategic applications for microgrids is useful to decision makers. The CEC staff suggests prioritizing microgrid applications to:

- Respond to PSPS events as addressed the CPUC's deenergization decision D.19-05-042.
- Support lifesaving services that require uninterrupted electricity supply.
- Deliver community services such as fire, police, emergency response, and overall community management.
- Support low-income, tribal, rural, and disadvantaged communities that are disproportionately impacted by grid outages.
- Enable critical military installations and state infrastructure operations such as ports, water delivery, and water treatment.
- Serve other unique energy demands where energy reliability is key.

Fully realizing the potential of microgrids to be part of California's clean energy future will require ongoing work by the CEC, CPUC, California ISO, developers, communities, utilities and other load-serving entities, as well as others. This volume of the *2020 IEPR Update* provides a review of some of California's most successful microgrids and lessons learned. It recommends specific actions to expand consumer awareness and create market tools to help advance microgrids in a way that supports California's energy goals for a cleaner and more equitable future.

CHAPTER 1: The Regulatory Framework

State Law Calls on the Energy Agencies and the California Independent System Operator to Advance Microgrids

In recognition of the promise of microgrids, the Legislature passed the first state-level policy for microgrids in the country, Senate Bill (SB) 1339 (Stern, Chapter 566, Statutes of 2018). The bill requires the California Public Utilities Commission (CPUC), the California Energy Commission (CEC), and the California Independent System Operator (California ISO) to "take action to help transition the microgrid from its current status as a promising emerging technology solution to a successful, cost-effective, safe, and reliable commercial product that helps California meet its future energy goals and provides end-use electricity customers new ways to manage their individual energy needs."[1] SB 1339 directs the CPUC, in consultation with the CEC and California ISO, to facilitate "the commercialization of microgrids for distribution customers of large electrical corporations" by developing methods to reduce barriers for microgrid deployment without shifting costs between ratepayers.[2] The bill also requires the publicly owned utilities' governing boards "to develop standardized processes for the interconnection of customer-supported microgrids, including separate electrical rates and tariffs."[3]

CPUC Rulemaking Addressing SB 1339 and Resiliency Strategies

The CPUC established a rulemaking proceeding (R.19-09-009) to address the actions required in SB 1339 and consider additional technologies and activities that may improve resiliency for customers, particularly those faced with potential Public Safety Power Shutoffs (PSPS) outages. The CPUC established three tracks in the rulemaking:

- Track 1 develops and implements short-term actions to accelerate the deployment of microgrids and related resiliency solutions in time for the 2020 wildfire season and outages. A subset of the actions considered in this track were adopted by the CPUC in Decision (D.) 20-06-017 on June 11, 2020.

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1 Citation for Senate Bill 1339, Stern, Chapter 566, Statutes of 2018. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1339.

2 Ibid.

3 Ibid.

- Track 2 develops and implements actions to ease the commercialization of microgrids following SB 1339. Track 2 resulted in D.21-01-018 on January 14, 2021.
- Track 3 includes ongoing implementation requirements of SB 1339 and resiliency planning.

In Track 1, the CPUC addressed critical near-term needs to support resiliency. The actions taken by the CPUC included streamlining interconnection processes, allowing energy storage systems to import from the grid before a PSPS (to ensure they could provide maximum service during a PSPS), and directing investor-owned utilities (IOUs) to collaborate more closely with local and tribal governments on developing microgrids and other grid resiliency projects.

The CPUC's Track 2 decision ordered six primary actions from the IOUs:

1. Southern California Edison (SCE) to revise its Tariff Rule 2 to permit installing added or special facilities microgrids.
2. SCE and Pacific Gas and Electric (PG&E) to revise their Tariff Rule 18 and San Diego Gas & Electric (SDG&E) to revise its Rule 19, to allow local government microgrids to service critical customers on adjacent parcels.
3. SCE, PG&E, and SDG&E to each create a renewable microgrid tariff that prevents cost shifting for their territories.
4. SCE, PG&E, and SDG&E to jointly develop a statewide Microgrid Incentive Program with a $200 million budget to fund clean energy microgrids to support the critical needs of vulnerable communities impacted by grid outages and test new technologies or regulatory approaches to inform future action.
5. SCE, PG&E, and SDG&E to develop pathways for the evaluation and approval of low-cost reliable electrical isolation methods to evaluate safety and reliability.

The CPUC's Track 2 decision also adopted an interim approach for minimizing emissions from back up generation at safe to energize substations during PSPS events with a transition to clean temporary generation in 2022 and beyond.

The CPUC is working on Track 3 of the rulemaking through a Resiliency and Microgrids Working Group that is tackling issues including standby charges, multi-property microgrids, the value of resiliency, microgrid interconnection, and continuing to develop the renewable microgrid tariff.

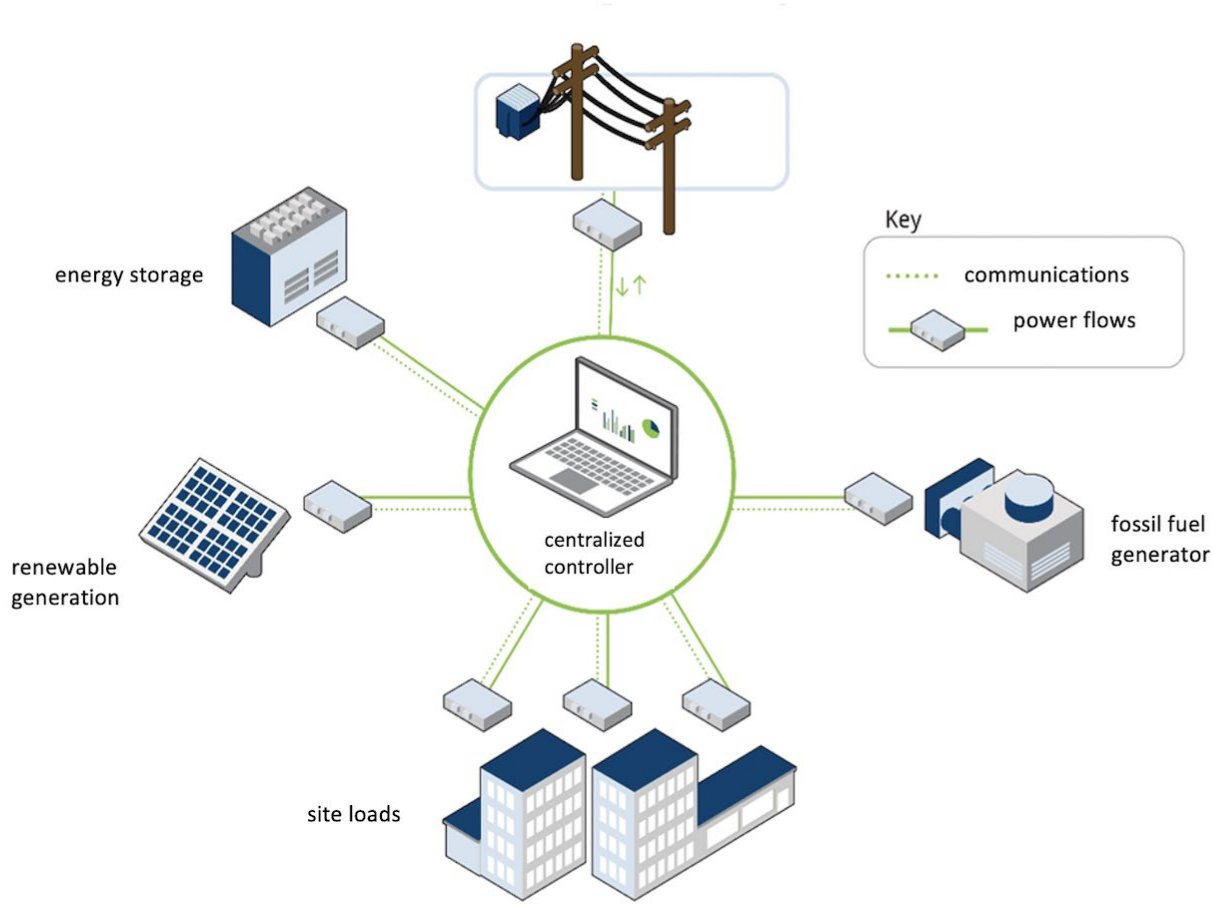
SB 1339 Microgrid Definition

"An interconnected system of loads and energy resources, including but not limited to, distributed energy resources, energy storage, demand response tools, or other management, forecasting, and analytical tools, appropriately sized to meet customer needs, within a clearly defined electrical boundary that can act as a single, controllable entity, and can connect and disconnect from or run in parallel with larger portions of the electrical grid, or can be managed and isolated to withstand larger disturbances and maintain electrical supply to connected critical infrastructure."

What Is A Microgrid?

The California Legislature codified a definition of microgrids in Senate Bill 1339 (Stern, Statutes of 2018, Chapter 566). (See side bar.) The primary intent of SB 1339 was to establish a commercialization pathway for microgrids in California. While definitions may vary nationally, they all have similar components as illustrated in Figure 1. Typically, the key components of a clean energy microgrid are renewables, energy storage, a centralized controller, and end customer site loads that normally receive their power from the utility grid. Some microgrids include fossil fuel-based generation when longer-duration protection is needed than can be provided with the renewables and energy storage contained in the microgrid. The long-term aim is for clean energy microgrids to be deployed rather than microgrids with fossil fuel-based back up power.

Figure 1: Microgrid Components



Credit: Developed for the CEC by Frontier Energy, Inc.

The Clean Energy Microgrids of Today and the Future

The concept of a clean energy microgrid implies that all the elements of the microgrid uses clean energy. As shown in Figure 1, today's microgrids in many cases use a fossil fueled backup generation system. For example, the microgrids defined in this IEPR typically have energy storage that can support 4 to 6 hours of backup protection without the use of fossil fuels. Once the limits of renewable energy production and energy storage are exceeded, the microgrid can transition to a backup generation system that uses fossil fuel.

In the future, backup power protection is expected to increase such that most microgrids will not need a fossil fuel system for backup power. In 2020, the EPIC Program funded eight grants to demonstrate backup protection that will exceed 10 hours. In 2021, the EPIC Program plans to provide funding to demonstrate microgrids systems that can provide 24 to 36 hours of protection without the need for fossil fuel backup power. Further research is ongoing on emerging clean energy storage technologies that can cost effectively provide up to 100 hours (more than 4 days) of continued backup protection. Therefore, while there is currently a technology limit on the amount of time microgrids can provide protection without the use of fossil fuel generation systems, future microgrids are not expected to rely on fossil fuel backup power.

Most microgrids have three characteristics:

A microgrid is local. Microgrids include a form of local electricity production, meaning they create electricity for a building or a small cluster of buildings (such as a neighborhood, campus, industrial complex, or small community). The generation is either on the building(s) or adjacent to the user(s). Onsite fossil-fueled generation has often been used to provide the power consumed in a microgrid, typically diesel backup generators. Microgrids powered by solar, wind, or bioenergy generation and coupled with a fossil fuel back up generator[4] sited locally, however, are becoming more common.

A microgrid can be independent. Microgrids may be connected to, and work in parallel with, the grid but can disconnect from the central grid and operate independently. For most microgrids, operating independently from the grid, commonly referred to as "islanding," is temporary. There are challenges associated with fully disconnecting a microgrid from the grid, including the cost and size of a system that allows full grid independence. Most microgrids island for short periods, usually hours or days, to supply power to their customers when grid

4 Localized pollutants from bioenergy generation should be considered, and the cleanest options should be encouraged.

conditions require it or when economical. Extended islanding times require larger amounts of renewable generation and batteries or fossil generation or both.

Advanced microgrids are adaptive. This adaptability in advanced microgrids emanates from what is known as the microgrid controller — the central brain of the system — that manages the generation, energy storage, and end customer energy systems with a high degree of sophistication. The controller software is often programmable to coordinate multiple resources to meet the energy goals established by the microgrid customer. For example, customers can program a controller to prioritize lowest overall energy cost, lowest greenhouse gas (GHG) emissions, or greatest resilience. The controller achieves these goals by increasing or decreasing use of any of the microgrid's resources — or combinations of those resources — much as a conductor would call upon various musicians to heighten, lower, or stop playing their instruments for maximum effect. Working together via complex algorithms, the microgrid resources create a whole that is greater than the sum of its parts. This orchestration is managed autonomously in a near-instantaneous fashion; there is no need for human intervention once programmed unless goals or tariffs change.[5]

Sometimes the term "microgrid" is inappropriately used to describe a simple generation system, such as rooftop solar panels. A key difference, however, is that a microgrid will keep power flowing when the utility grid fails; a typical solar panel alone will not. Many homeowners with only solar panels are unaware of this and are surprised to find that their solar panels cannot power household loads during an outage unless they have been specially configured to do so.

Simple backup generators, such as those used by homeowners, are also not microgrids. Those systems are single purpose and are used only when the grid power is out to back up some or all home electrical needs.

Equity Considerations for Microgrids

As discussed further below, microgrids can be appropriate and beneficial in targeted applications. The California grid must support all customers, and, in some cases, a microgrid can provide a cost-effective solution to meet the individual needs of some end-users. The upfront capital costs of microgrids do not make them a feasible solution for all customers and generally solutions that ensure all Californians have access to reliable, clean electricity are preferable.

5 Wood, Elisa. "What is a Microgrid?" Microgrid Knowledge web page. June 24, 2020. https://microgridknowledge.com/microgrid-defined/.

As California reaches for a better future, care must be taken to ensure that the public funding allocated to microgrids is equitably distributed. Public Resources Code section 25001 establishes the finding that reliable electricity is "essential to the health, safety, and welfare of the people of this state." It is therefore essential that low-income and disadvantaged communities continue to have nondiscriminatory access to a clean, reliable, and resilient source of electricity. In supporting appropriate microgrid deployment, policies that erode the responsibility of all ratepayers to share in the cost of providing universal access to electric power for all must be avoided. As microgrids are strategically deployed, the disproportionate impact of grid outages on low-income, tribal, rural, and disadvantaged communities should be a considered factor.

Under resourced communities typically do not have adequate funding for early stage microgrid research projects that evaluate and demonstrate the value and benefit of microgrids, and how to bring down costs because they have difficulty accessing private funds. The CEC's Electric Program Investment Charge (EPIC) program is required by law (Assembly Bill 523) to apply 25 percent of program funds in disadvantaged communities and another 10 percent in low-income communities. In implementing the EPIC program, 60 percent of program funding has deployed projects in under resourced communities to study how microgrids can benefit ratepayers. The EPIC program is expected to continue to support the evaluation and demonstration of microgrids in under resourced communities.

The CEC's EPIC program invests in scientific and technological research to accelerate the transformation of the electricity sector to meet the state's energy and climate goals. The CEC's EPIC program will continue to support future research and demonstration for microgrid projects in the state. Strategic deployment of microgrids using ratepayer funds is a topic within the scope of a rulemaking (R.) that was opened in 2019 (R.19-09-009) and is discussed in the following section.

In August 2020, the CPUC also opened a new rulemaking (R.20-08-022) to examine options to assist electricity and gas customers with investments designed to decrease energy use, reduce GHG gas emissions, and produce energy to support customers' on-site needs. The CPUC has a long history of using electricity and gas ratepayer funds to encourage customers to invest in energy-related equipment, through financial tools various forms. Those financial mechanisms are used to encourage investments by customers in microgrids, energy efficiency, demand response, distributed solar and other self-generation technologies, energy storage, and transportation electricity infrastructure, among others. This rulemaking is designed to examine options that encourage larger-scale and deeper investments in one or more clean energy resources at customer sites. Further, this rulemaking will examine options for multiple sources of funding by combining and leveraging ratepayer funds with private financing to support these more comprehensive investments- including among low- and middle-income customers.[6]

6 CPUC. Issued September 4, 2020. Order Instituting Rulemaking to Investigate and Design Clean Energy Financing Options for Electricity and Natural Gas Customers. Rulemaking 20-08-022. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M346/K361/346361154.PDF.

Chapter 2: Public Funding is Advancing Research on Microgrids

A Decade of Experience

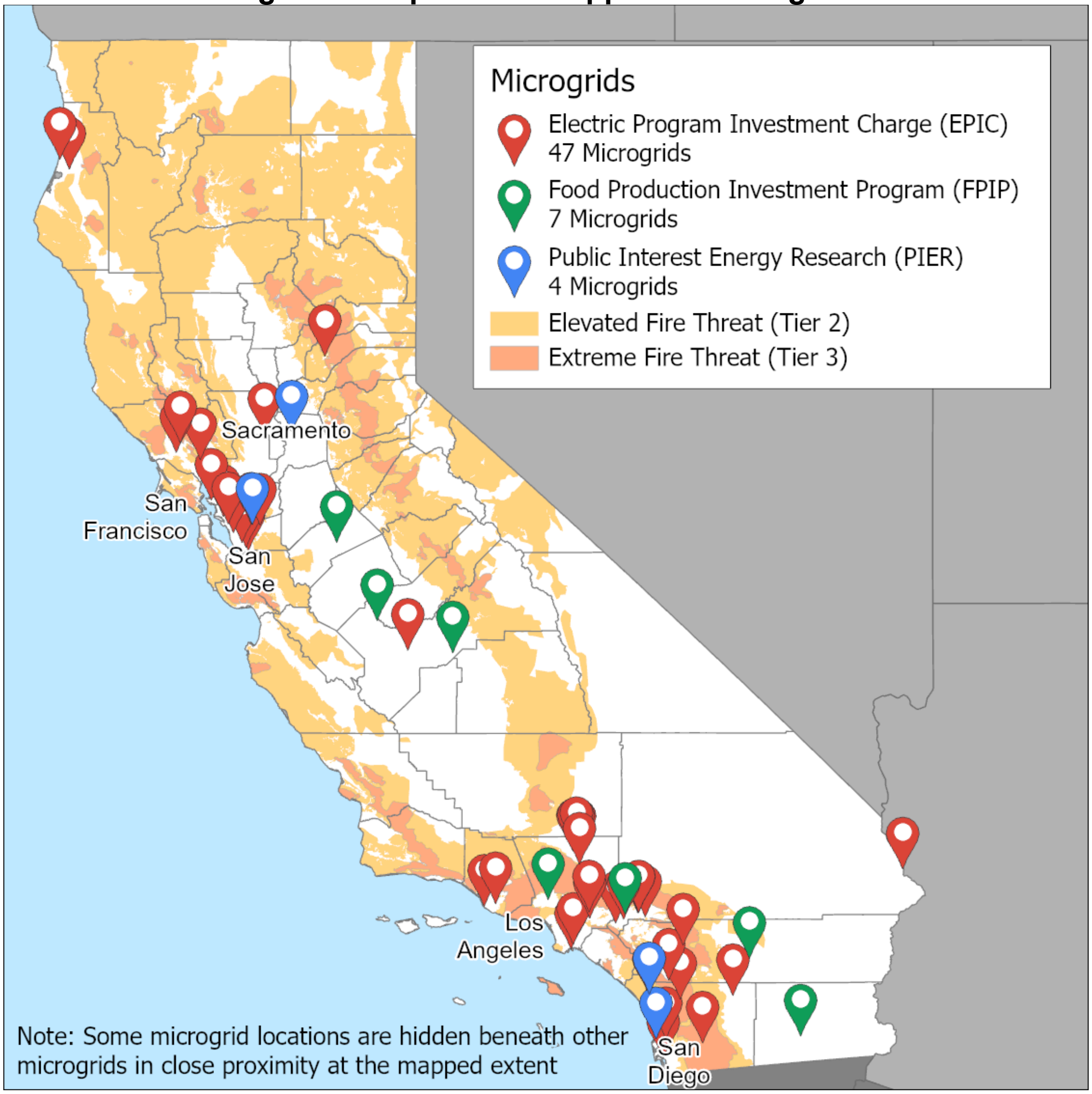
The California Energy Commission (CEC) has more than a decade of experience providing funding to advance the viability of clean energy microgrids that do not rely of fossil fuel back up generation. Beginning in 2009, the CEC provided funding for four microgrids through the Public Interest Energy Research (PIER) Program. The PIER-funded projects were early tests of how microgrids could connect and disconnect from the grid and provide services to the end user such as resiliency, reduced electricity peak demand costs, and reduced electric bills. These microgrids were located at a utility site, California prison, university campus, and military site.

The knowledge gained from these research projects helped structure the microgrid research program funded through the Electric Program Investment Charge (EPIC) program, the program that replaced the Public Interest Research (PIER) program. The EPIC program has funded 47 microgrids, the largest collection of public research on microgrids in the nation. Several of these projects are discussed in this volume of the *2020 Integrated Energy Policy Report (IEPR) Update*.

Planned or unplanned power outages can cause major disruptions to many of California's food processors, causing significant financial and product losses. The CEC has funded seven microgrids through its Food Production and Investment Program (FPIP). The projects are expected to allow food processors to continue operating during grid outages, support the resiliency of the local grid, reduce operating costs, and reduce GHG emissions.

As of December 2020, the CEC awarded more than $179 million in grants, with more than $143 million in matching funds for 58 completed or ongoing microgrid projects. (See Figure 2, Table 1, and Appendix A.) These projects include a diverse range of applications, including residential, commercial, industrial, campus, and community systems. This research has demonstrated the resiliency and customer cost savings values of microgrids and has helped identify and overcome technical challenges with microgrid development, while informing policy development, such as the California Public Utility Commission (CPUC) rulemaking. The knowledge gained from these research microgrids has assisted the CPUC in developing its Senate Bill (SB) 1339 implementation plans.

Figure 2: Map of CEC-Supported Microgrids



Credit: CEC (6 microgrids are in high fire threat areas — 1 funded by PIER, 5 funded by EPIC. 41 microgrids are in disadvantaged or low-income communities or both — 3 funded by PIER, 32 funded by EPIC, and 6 funded by the CEC's FPIP. 7 microgrids are in Tribal communities — funded by EPIC.)[7]

7 Disadvantaged communities are identified by the California Environmental Protection Agency (per Senate Bill 535 [De León, Chapter 830, Statutes of 2012]) as the top 25 percent most impacted census tracts in

Table 1: CEC Funding and Match Funding for Microgrid Projects

Funding Program	Year Awarded	Number of Microgrids	CEC Funding	Match Funding
PIER	2009 - 2013	4	$6,292,684	$5,853,007
EPIC	2015 - 2020	47	$140,584,463	$118,494,205
FPIP	2020	7	$32,822,569	$18,921,895
TOTAL		**58**	**$179,699,716**	**$143,269,107**

Credit: CEC (Agreements included if they received approval at a CEC business meeting. EPIC microgrids do not include Title 24 residential microgrids. Some projects have multiple microgrids.)

Lessons Learned from a Decade of Microgrid Research

As described above, the CEC has been funding research, development, and demonstration projects on microgrids for more than a decade. (See Appendix A for a listing of the projects.) These microgrid research projects represent the broadest combination of customer applications from any organization in the nation, public or private. The knowledge gained from these efforts provide California with unique insights into the challenges, benefits, and value of microgrid deployments.

While microgrids are not appropriate or cost-effective in all situations, they are one of many tools the state can use to improve resiliency and support SB 100 goals.[8] To support the strategic deployment of clean energy microgrids, the state needs to better understand and identify the best applications for their use.

As illustrated in Figure 3, these microgrid demonstration projects include many types of critical facilities (for example, a medical center, fire station, community center, airport, and American Red Cross shelter), California Port Authorities, military installations, college campuses,

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CalEnviroScreen 3.0 — a screening tool used to help identify communities disproportionately burdened by multiple sources of pollution and with population characteristics that make them more sensitive to pollution. Low-income communities and households are defined (per Assembly Bill 1550 [Gomez, Chapter 369, Statutes of 2016]) as the census tracts and households, respectively, that are either at or below 80 percent of the statewide median income or at below the threshold designated as low-income by the California Department of Housing and Community Development's 2016 state income limits.

8 March 2021. [SB 100 Joint Agency Report, Achieving 100 Percent Clean Energy in California: An Initial Assessment](https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349). Pages 130–131. https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349.

communities, and industrial sites. The broad range of applications and size of these microgrids provide the state with insights not only into the key elements needed to successfully design, install, and verify performance of a microgrid, but a window into understanding the cost, benefits, and overall value microgrids provide the end-use customer, the servicing utility, and the overall grid system.

Figure 3: Research Clean Energy Microgrid Projects by End-Use

Credit: Images provided by microgrid grant recipients and demonstration site owners.

At the July 7, 2020, and July 9, 2020, IEPR workshops, several EPIC-funded and private sector microgrid developers/owners discussed their reasons for installing microgrids and the benefits microgrids have provided. This input informs staff's findings on where clean energy microgrids provide the best value and where the state should work to encourage the growth in microgrids at a high level. These staff findings should be combined with distribution and transmission data to strategically deploy microgrids. Moreover, it informs where clean energy microgrids may not be the best approach to solving future grid system resiliency challenges. Based on this information, below are three observations on the deployment of clean energy microgrids.

First, it is important to emphasize that the grid is a large, complex, and highly integrated system that supports all California ratepayers. While clean energy microgrids provide services to a small subset of California ratepayers, they cannot address all the challenges that the grid faces today and will face as the state transitions to a system that can support 100 percent zero-carbon energy. Grid operators, planners, and managers must continue to improve the grid system to provide higher reliability, more resiliency, and ability to respond to future contingencies when they occur (such as wildfires, earthquakes, floods, and other natural and man-made disasters).

Second, based on the CEC's expertise from managing a decade of microgrid research projects, and considering the plans for California under SB 100, CEC staff offers the following thoughts regarding where clean energy microgrids may best serve California over the next decade, including facilities that:

- Respond to PSPS events as addressed the CPUC's deenergization decision D.19-05-042. This list is being regularly updated via the CPUC's ongoing deenergization proceeding R.18-12-005.
- Support lifesaving services that require uninterrupted electricity supply.
- Deliver community services such as fire, police, emergency response, and overall community management.
- Support low-income, tribal, rural, and disadvantaged communities that are disproportionately impacted by grid outages.[9]
- Enable critical military installations and state infrastructure operations such as ports, water delivery, and water treatment.
- Serve other unique energy demands where energy reliability is key.

Third, clean energy microgrids can provide the customers who install them with energy savings by managing their energy generation and use, but in most instances, there is not yet a clear business case for microgrids. Some of the best opportunities for energy cost savings from microgrids are associated with "peak shaving" or reducing energy consumption at the most expensive times in response to time-of-use (TOU) rates. Microgrids could also possibly offer the ability to make revenue by selling excess energy to grid operators. Until the price of key components of the clean energy microgrid such as energy storage, renewables, microgrid controllers, and other elements come down, this application is expected to be limited to a small subset of customers. However, the cost of microgrid components has decreased substantially over the last decade and is expected to continue to decrease.

With the experience gained from microgrids managed through the EPIC program, the CEC can continue tracking cost reductions and benefits provided by operational microgrids and ones in the commissioning stage. During the July 7 and July 9, 2020, IEPR workshops, several microgrid owners and third-party microgrid managers indicated that the business case is getting easier to define. With the lower component cost and the ability to finance microgrids

9 See Tracking Progress, Energy Equity Indicators, for more information about opportunities to increase energy equity, including the role for microgrids. https://www.energy.ca.gov/sites/default/files/2019-12/energy_equity_indicators_ada.pdf.

over time, it is becoming easier to make the financial case for a new clean energy microgrid. It is highly likely that in the future clean energy microgrids can provide much clearer business cases based solely on energy savings. With more creative financial options such as a power purchase agreement, future microgrids will be a good financial outlook without needing government grants to be successful.

Chapter 3: Microgrid Market Opportunities are Growing

Microgrid Ownership and Financing Structure Diversity

The growing microgrid market has expanded the options for developing systems, resulting in different ownership and financing structures. Microgrids have three common ownership structures:

- Customer-owned
- Utility-owned
- Third party-owned

In California, *customer-owned* microgrids are most common,[10] followed by third party-owned, and utility-owned. Understanding microgrid architecture, benefits, and services can help distinguish when utility-owned and -operated and customer/third party-operated microgrids are most effective. California's recent wildfires have increased interest in the use of microgrids to provide added resiliency. Following are examples of microgrids that provided increased resiliency and value to the utility or the customer.

10 Based on the information gained by the California Energy Commission's (CEC's) Electric Program Investment Charge (EPIC) staff in managing the microgrids shown in Figure 2 and Table 1, and information gained from public workshops on microgrids, more than 80 percent of the clean energy microgrids that can be estimated are customer-owned.

Figure 4: Stone Edge Farm Microgrid

Credit: Stone Edge Farm

The microgrid at Stone Edge Farm Estate Vineyards and Winery in Sonoma is a *customer-owned* microgrid (Figure 4). This microgrid was designed to support the zero-carbon goal of the 16-acre farm and provide resilience. It also acts as a living laboratory for technologies, and Stone Edge Farm supports an internship program for university students to learn more about microgrids. Its microgrid consists of multiple generation sources, including solar PV, a fuel cell, and a small generating microturbine using natural gas; it also has battery and hydrogen energy storage. The microgrid successfully islanded Stone Edge Farm for 10 days when threatened with wildfire in October 2017. Stone Edge Farm won the 2017 Governor's Environmental and Economic Leadership Award in Sustainable Practices, and, in 2018, Stone Edge Farm developed the microgrid to enable the farm to operate independent of the grid for normal operations.

Figure 5: Borrego Springs Microgrid

Credit: San Diego Gas & Electric (SDG&E)

The Borrego Springs microgrid is an example of a *utility-owned* and -operated microgrid (Figure 5). Historically, Borrego Springs had numerous outages because of severe environmental conditions. This microgrid can island an entire substation with renewable backup power for up to 5.5 hours during the day and independently provide power to about 2,800 customers. (It also has diesel backup if needed for longer-duration backup power.) The microgrid increases the community's energy resilience while reducing its carbon footprint by using renewable energy resources (a 29 megawatt [MW] photovoltaic system). The system is a combination of SDG&E assets and solar generation through a third party.

The City of Fremont fire station microgrids in Figure 6 are *owned and operated by a third party*, Gridscape Solutions (Gridscape). The city has a 10-year power purchase agreement (PPA) with Gridscape to receive clean energy from the microgrid systems at half the cost of energy from the public utility. Diesel-fired backup generation is also available on site. Overall, the project is estimated to result in nearly $250,000 of electric bill savings during the 10-year PPA term. These solar-plus-storage microgrids can also displace diesel backup generation and extend fuel reserves in the event of a catastrophe, keeping the fire station on-line longer as a viable first responder.

Figure 6: City of Fremont Fire Station Microgrid

Credit: City of Fremont Fire Department

Microgrids may also be a *combination of the above three ownership examples* previously mentioned. For example, the Redwood Coast Airport Microgrid Project is working to demonstrate the first multicustomer, front-of-the-meter microgrid with generation owned by a local community choice aggregator (Redwood Coast Energy Authority) and the microgrid circuit owned by an investor-owned utility (IOU) (Pacific Gas and Electric Company [PG&E]). The project is also evaluating the economic viability of this business case, showing how barriers to widespread deployment of multicustomer microgrids can be eliminated.

These ownership models have been used successfully to install microgrids at a broad range of commercial, industrial, and government facilities. Before 2020, home installations were rare, but microgrid installers Emera Technologies, YouSolar, and Instant On reported spikes in consumer interest to install microgrids in California residential communities.[11] Further, as solar generation is required for all new homes in California and residential energy storage prices

11 Cohn, Lisa. "Demand for Home Microgrids Surges in Response to California Fires." *Microgrid Knowledge*. October 12, 2020. https://microgridknowledge.com/home-microgrids-demand-california/.

keep declining, some home developers are beginning to install neighborhood/community-scale microgrids.

California has an active microgrid market because of a large military presence with renewable energy targets. The United States military is an early adopter of microgrids to ensure that power stays on to support mission-critical operations. Several military bases in California have built or are building clean energy microgrids by installing solar panels and storage to help achieve renewable energy goals, also making the bases more resilient. Leaders from all branches of the military are interested in microgrids to achieve the Department of Defense's national goal for improving military base resiliency.

Around the world, microgrid deployment is expected to grow dramatically as prices for distributed energy resources drop and concerns about electric reliability due to severe storms, cyberattacks, and other threats grow.[12] Guidehouse forecasts that the worldwide microgrid capacity will reach 20 gigawatts (GW) by 2028, up from 3.5 GW in 2019 with a total global market value of near $39.4 billion.[13] The growth is predicted to be centered around North America and Asia.

Decisions about the deployment of microgrids depend on the costs and benefits of the system and the services it will provide. Trends that are improving the cost-competitiveness of microgrids are discussed below.

The challenges with evaluating the costs and benefits, including the value of energy resiliency benefits, were raised by many participants at the July 7 and July 9, 2020, IEPR workshop on the future role of microgrids in California. While quantifying the value of microgrids is an important topic, it is not addressed in detail here since the topic is being considered in an ongoing proceeding at the California Public Utilities Commission (CPUC). The CEC encourages interested stakeholders to participate in the CPUC's Senate Bill 1339 (Stern, Chapter 566, Statutes of 2018) rulemaking. (See Chapter 1.)

Capital/Equipment Costs of Key Components of Microgrids Continue to Decline

The two largest cost components for microgrids are the solar and battery system. While the costs of solar technologies and batteries have dramatically decreased, they remain an

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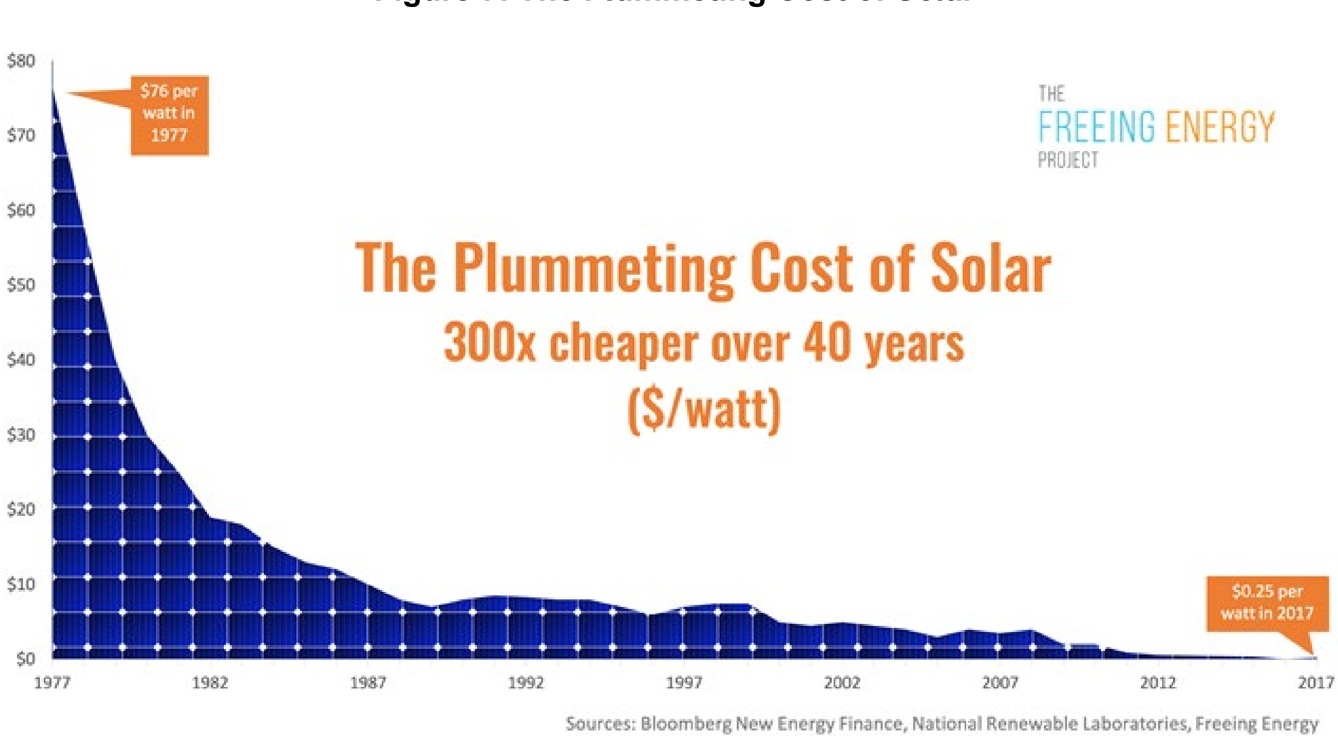
12 Business Wire. "Navigant Research Report Shows Global Microgrid Capacity is Expected to Experience a Compound Annual Growth Rate of 21 Percent Over the Next Decade."
https://www.businesswire.com/news/home/20191114005037/en/Navigant-Research-Report-Shows-Global-Microgrid-Capacity.

13 Ibid.

important consideration when estimating the future cost and value of microgrids. As Figure 7 illustrates, the cost of solar has decreased phenomenally and is expected to continue to decline. Continual improvements on the cost are also likely to increase the generation capacity for the microgrids because EPIC experience is showing that commercial customers are choosing larger solar systems so they can cover more load or island for a longer time or both.

Figure 7: The Plummeting Cost of Solar



Credit: The Freeing Energy Project, with data from Bloomberg New Energy Finance, National Renewable Laboratories, and Freeing Energy

Similarly, energy storage technologies are also following an impressive cost-reduction curve. Battery prices, which were above $1,100 per kilowatt-hour (kWh) in 2010, have fallen 87 percent in real terms to $156/kWh in 2019. By 2024, average prices will be close to $93/kWh, a 40 percent drop from 2019 prices, according to a forecast from research company Bloomberg New Energy Finance.[14] See the *2020 IEPR Update, Volume I* for more information about trends with lithium-ion batteries.

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14 Albanese, Nicholas. BloombergNEF. "Electric Vehicle Outlook 2020." June 11, 2020. https://efiling.energy.ca.gov/getdocument.aspx?tn=233410.

Based on research on more than 15 alternative energy storage technologies,[15] more than half are expected to be cost competitive with lithium-ion batteries alone once they reach commercial scale. Moreover, many of these systems provide energy storage durations of 8 to 10 hours or longer. For these longer-duration energy storage systems, the price per kWh is expected to be well below the expected future cost of lithium-ion systems. Lithium-ion alternatives also provide greater safety because they substantially reduce the fire risk and operate over a wider temperature range, making them more appealing for certain applications (for example, in hot environments).

Market Growth Brings Down Costs

A factor in cost trends is the extent to which there are a variety of vendors competing to provide microgrid solutions. Even with significant private investment, Stone Edge Farms representatives at the July 7, 2020, IEPR workshop recognized that a diversity of vendors is a key to success by driving down costs through competition. Parties with interests in smaller systems or who have limited access to capital likely depend upon a market that can present a large variety of potential vendors and project partners to create economies of scale. A stronger business case would be a motivating factor for all decision makers considering investing in microgrids, particularly those representing county and municipal entities as they must choose between a range of budget priorities and their decisions are subject to public scrutiny.

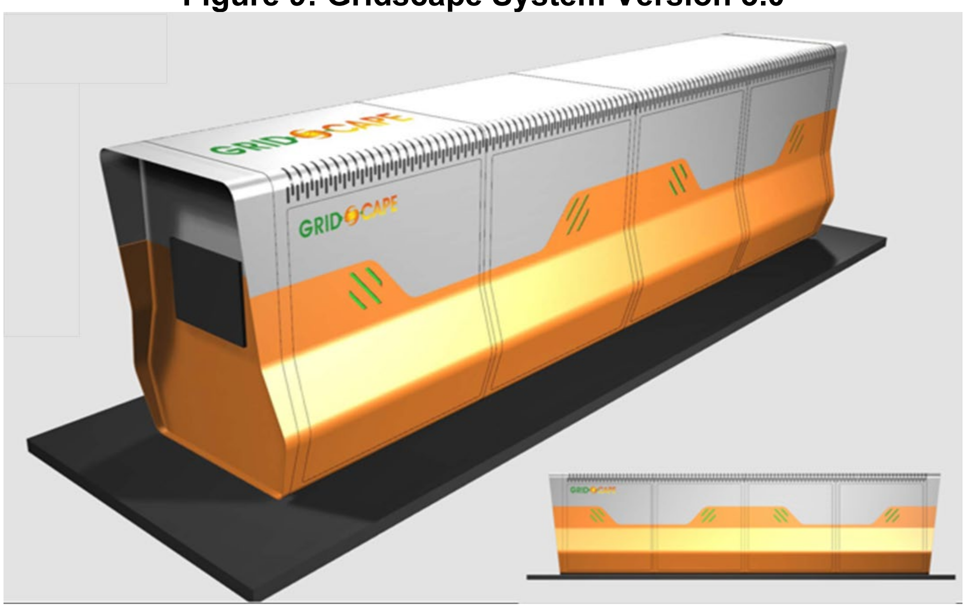
Also, business models are evolving to create building block approaches for scaling up and developing system configurations based on the customer needs. For example, as the result of a grant project to provide microgrids to three fire stations in Fremont, Gridscape was able to refine the design of its system to be modular and incrementally sized for more rapid deployment based on the size of the customer's loads (Figures 8 and 9).

15 Examples of alternative storage technologies include flow batteries; advanced chemistry batteries based on metals including zinc, magnesium, and nickel; mechanical systems such as flywheels; and thermal energy storage systems.

Figure 8: Gridscape System Version 2.0

Credit: Vipul Gore [presentation](https://efiling.energy.ca.gov/getdocument.aspx?tn=233765) at the July 7, 2020, IEPR workshop on assessing the future role for microgrids in California, https://efiling.energy.ca.gov/getdocument.aspx?tn=233765.

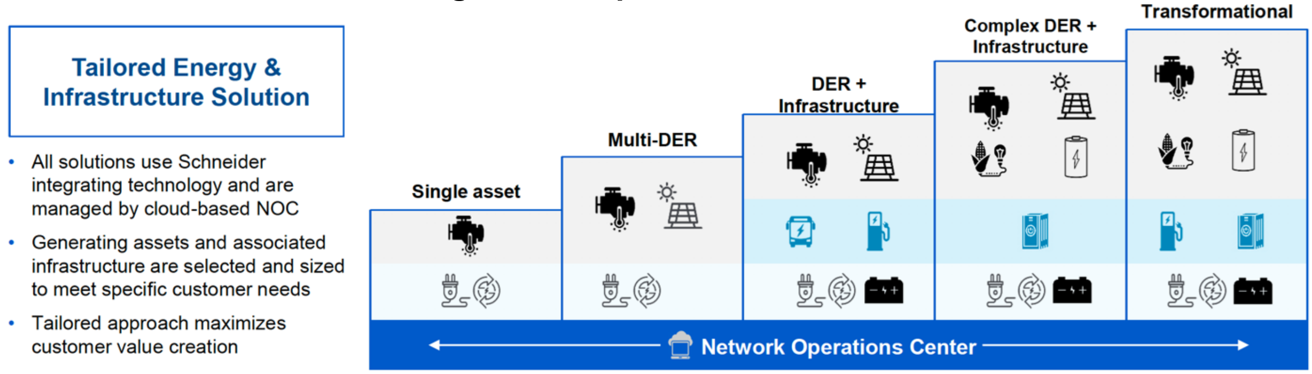
Figure 9: Gridscape System Version 3.0



Credit: Vipul Gore [presentation](https://efiling.energy.ca.gov/getdocument.aspx?tn=233765) at the July 7, 2020, IEPR workshop on assessing the future role for microgrids in California, https://efiling.energy.ca.gov/getdocument.aspx?tn=233765.

AlphaStruxure, a joint venture of Schneider Electric and The Carlyle Group, has developed a service offering that tailors microgrids to end-use customer needs (Figure 10). This joint venture represents a shift in the industry by having very large firms take interest in and offer microgrid products. This commercial venture is an example of microgrids beginning to make the transition from a purely research concept to a viable commercial product.

Figure 10: AlphaStruxure Model



Credit: AlphaStruxure web page, https://alphastruxure.com/howitworks (Accessed November 20, 2020)

One of the benefits of these business models is the ability to provide longer-term financing options for customers to use when paying for microgrids. With more stability in clean energy markets, the financial market has begun to offer new longer-term arrangements like PPAs for clean energy microgrid systems and associated key components.[16] For these PPAs to work, the financial market needs to have confidence in the long-term need for these services and the ability of the equipment to last the expected 10 to 20 years (or longer) that the PPA will be in service. Fortunately, many years of microgrid funding by national and state organizations has provided field data to assist financial institutions with predicting future performance and gaining greater confidence in PPA agreements.

Microgrids Can Provide Support During PSPS Events

The need for backup power to provide resiliency in the event of a power outage is not new. state code requires backup power for certain facility types, such as hospitals, and many commercial and industrial customers have onsite backup power to support business continuity in the event of a power outage. Most backup power is provided by stationary or mobile fossil fuel generators, primarily diesel-fueled.

The CPUC has authorized significant investment in wildfire mitigation, including vegetation management and grid hardening, which is leading to the steady decrease in the use of PSPS.

The duration of PSPS outages can substantially impact all customer types, including residential, commercial, and industrial. The CPUC reviewed PSPS events in 2019 and found that PG&E customers experienced power outages ranging from 14 to 55 hours, affecting

16 Some EPIC projects, including Gridscape, are transitioning to PPAs of 10 to 20 years once the grant timeline is complete.

nearly 1.95 million customers.[17] Southern California Edison customers experienced power outages averaging 28 hours, affecting 182,000 customers. SDG&E customers experienced outages averaging 30 hours, affecting 48,000 customers. Preliminary results from a survey of residential customers affected by PSPS events shows a 15 percent increase in the purchase of backup generators.[18] Throughout the state, impacted IOU customers experienced outages ranging from 15 to 55 hours.

Fossil fuel backup generators pose several problems, including the generation of criteria pollutants such as carbon monoxide, nitrogen oxides (primary component of smog), fine particulates, and GHG. Further, diesel particulate matter is an identified toxic air contaminant. These systems are generally only used during emergencies and provide little value to the customer in nonemergency situations. Also, larger systems typically require permitting and periodic testing, which takes added time and resources.

In response, the CPUC has authorized temporary generation (diesel and hydrotreated vegetable oil [HVO]) for use in temporary generation in 2021 for safe to energize substations. All diesel and HVO temporary generation must receive the requisite Air Quality Management District requirements to support compliance with emissions standards. This temporary generation procurement for 2021 must be combined with a plan for clean alternatives to also be piloted at substations and a clean back up generation plan for 2022 and beyond must also be filed. These projects are funded up to $350 million.

As noted above, most microgrids are typically hybrid systems of both clean energy generation — typically solar photovoltaic — and fossil fueled backup generation. Hybrid backup systems can use the renewable generation and store it for later use — daily to reduce peak loads and customer electricity bills and in the event that power supply from the grid is interrupted—for up to 4–6 hours. When a microgrid includes renewables and energy storage, and a backup fossil fuel system, EPIC program experience has shown that these microgrids are able to operate for longer times on renewables and not rely as often on the fossil fuel backup,

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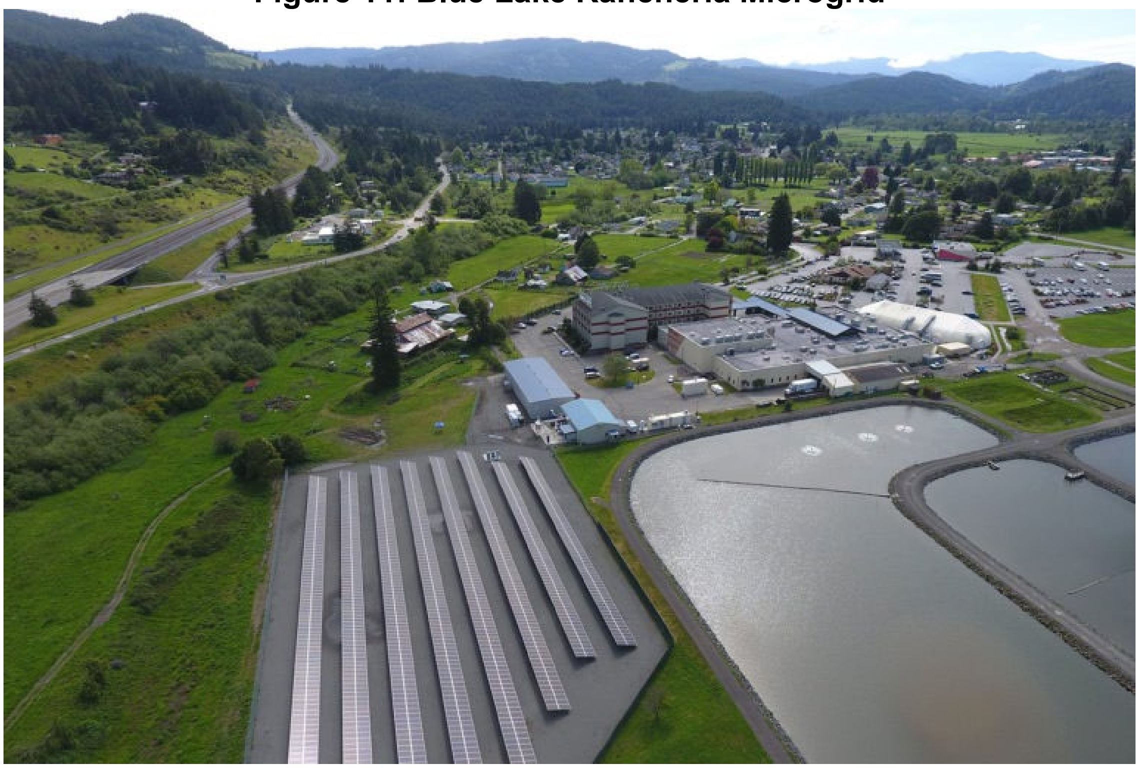
17 Anthony Noll presentation. CPUC. "Public Safety Power Shutoff Overview." https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/Infrastructure/Resiliency_Microgrids/3_BACKGROUND_CPUC%20Safety%20and%20Enforcement%20Division.pdf.

18 *Wolfram, Catherine.* "After a Long Electricity Outage, Substantial Investment in Backup Generators" *Energy Institute Blog,* UC Berkeley, May 26, 2020, https://energyathaas.wordpress.com/2020/05/26/electricity-outages-lead-to-substantial-backup-generator-purchases/.

providing an overall cleaner energy solution.[19] For example, the EPIC-funded microgrids in Fremont can island for 10 to 12 hours using only solar energy generated onsite, which is expected to reduce the use of diesel-fired backup generation at these locations. Many microgrid owners have expressed the desire to eventually eliminate the need for the fossil fuel element; however, the current clean energy technology does not provide backup generation for a long enough time. Solutions such as longer-duration energy storage technologies, which can displace the need for fossil backup generation in microgrids, are needed as the state transitions to a 100 percent renewable and carbon-free energy future by 2045.

Figure 11: Blue Lake Rancheria Microgrid



Credit: Blue Lake Rancheria

The microgrid at the Blue Lake Rancheria (Figure 11), which is in a remote region of Northern California, is an example of a system that provides reliability as well as a variety of other benefits to the community it serves. During an October 2019 event, the microgrid operated to provide 10,000 visitors to the Rancheria with access to power. This enabled individuals to use

19 Some EPIC microgrid grants recipients are measuring the GHG reductions from reduced use of their fossil fuel systems.

necessary medical equipment by staying at a hotel with power (saving four lives), the community to distribute thousands of bags of ice, and residents to pump fuel at their gas station, among other benefits. During the outage, 75 percent of the power generated came from renewable generation with the remaining 25 percent supplied by fossil fuel generation. The Tribe has added four full-time positions within its information technology and utility departments, a 10 percent increase in employment for the Tribal government. Six local small businesses and contractors worked directly for the project. In total, about $9.5 million of induced and indirect economic benefits accrued to local, regional, and state economies.[20]

Testimonial From Blue Lake Rancheria

"We have achieved improved continuity of operations across the community. ...Microgrids have [provided] lifesaving critical services for about 10 percent of our rural region. They allow us to achieve rapid decarbonization of both the energy and the transportation sectors, incorporating more solar energy and using that solar to power electrified transportation is part of the Tribe's strategy to achieve zero net carbon emissions by 2030. We have cleaner energy and less tailpipe emissions, which are lowering the pollution in the community and improving health outcomes. The microgrids reduce the cost of the electricity by about $200,000 a year. The Tribe then tracks and reinvests these savings into other projects to create a positive feedback loop. ...We're continually increasing resilient, climate smart infrastructure with more controllable costs." - Jana Ganion, Sustainability and Government Affairs Director for the Blue Lake Rancheria

Transcript, July 9, 2020, Session 2

Incentives can help accelerate the deployment of microgrids. The CPUC's Self-Generation Incentive Program (SGIP) offers rebates for installing energy storage technology at residential and nonresidential buildings to allow customers to better manage their energy needs and reduce GHGs. These storage technologies include battery storage systems that can function during shorter power outages. While not all energy storage and solar systems are microgrids, they can be upgraded by adding smart controllers. The CPUC recently authorized funding of more than $1 billion through 2024 for SGIP. This funding includes prioritization of communities living in high fire-threat areas, communities that have experienced two or more PSPS events, as well as low-income and medically vulnerable customers. The funds are also available for "critical facilities" that support community resilience in the event of a PSPS or wildfire.

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20 Carter, David, Jim Zoellick and Marc Marshall. Schatz Energy Research Center, Humboldt State University. 2019. [Demonstrating a Secure, Reliable, Low-Carbon Community Microgrid at the Blue Lake Rancheria](https://ww2.energy.ca.gov/2019publications/CEC-500-2019-011/CEC-500-2019-011.pdf). California Energy Commission. Publication Number: CEC-500- 2019–011. https://ww2.energy.ca.gov/2019publications/CEC-500-2019-011/CEC-500-2019-011.pdf.

Chapter 4: Ongoing Microgrid Research has Resulted in Progress, More Work is Needed

Driven by technological improvements and falling equipment costs, microgrids are emerging from pilot demonstration to commercial markets. Advancements in hardware equipment and control software help automate grid independence and optimize power system management based on performance metrics such as economics, carbon footprint, or reliability. An intelligent microgrid network includes control systems — such as battery management, building management, and demand response — that enable automatic load and peak demand management and also allow for energy market participation to monetize multiple value streams.

The number of hours that a given microgrid can power critical loads is an important performance measure and depends on several factors such as critical loads, energy storage size, and expected power outage duration. In 2018, Pacific Gas and Electric (PG&E) reported the average annual amount of time customers experienced a sustained outage is about 126.3 minutes (excluding major events).[21] During major events such as the Camp Fire and Carr Fire, it took days to completely restore power. For public safety power shutoff (PSPS) events, most power was restored within 1 hour to 5 hours or within 5 hours to 10 hours of the effected system being checked for safety and clearance of wildfire conditions. Microgrids can be designed to provide backup power for 5 hours to 10 hours or for multiple days), depending on the expected duration of outages.

The challenge is to provide backup power that will be resilient to multiday power outages without using fossil fuels. Using solar and energy storage, a clean solution, can provide on average 4 to 8 hours of backup power. For longer solutions (such as backup power for a multiday outage), zero-carbon options are typically cost and space prohibitive in the current market and most customers rely on fossil fuel solutions such as diesel generators.

Longer-Duration Storage, Clean-Powered Fuel Cells, and Hydrogen

Relying on diesel, gasoline, or fossil fuel gas-fired generators for backup power is inconsistent with the state's air quality, energy, and climate goals. To help meet these goals, state policy calls for other types of generators and back-up power solutions and, in some cases,

21 PG&E. *2018 Annual Electric Reliability Report*. July 15, 2019. https://www.pge.com/pge_global/common/pdfs/outages/planning-and-preparedness/safety-and-preparedness/grid-reliability/electric-reliability-reports/AnnualElectricDistributionReliabilityReport2018.pdf.

longer-duration microgrid applications building on diversified clean energy resources such as solar, wind, storage, renewable gas, or hydrogen to support community resiliency needs. (See Chapter 5 of *2020 IEPR Update, Volume 1* for more information about hydrogen.)

As discussed by Haresh Kamath, senior program manager of distributed energy resources and energy storage at the Electric Power Research Institute, and Alex Morris, executive director at the California Energy Storage Alliance, investments in research to advance long-duration energy storage are also becoming an opportunity to support microgrids. In 2020, the Electric Program Investment Charge (EPIC) program invested in new grants for long-duration energy storage demonstrations that will provide from 10 hours to 100 hours of energy storage. Many of these emerging technologies are projecting future commercial prices substantially lower than current energy storage costs. As these new energy storage technologies become available, future microgrids will be able to operate for days at a cost that will fit the customer's business case.

Research indicates that as microgrids that need longer-duration backup capability (days instead of hours) are developed, there are three technologies that can provide clean alternatives to fossil fuel-based systems and support the future Senate Bill 100 (de León, Chapter 312, Statutes of 2018) renewable and zero-carbon energy needs. These technologies should be developed in a manner that does not deteriorate air quality:

- Long duration energy storage
- Fuel cells that operate on bioenergy or clean hydrogen
- Hydrogen-based generation systems

EPIC research indicates that long-duration energy storage based on zinc metal chemistry, flow battery designs, advanced battery chemistries such as sodium, and thermal energy storage systems are expected to provide days instead of hours of protection at a cost per kilowatt hour that could be as low as one-tenth or less of current kilowatt-hour energy storage costs. This cost reduction is consistent with the dramatic energy storage cost reduction seen over the last decade as discussed above.

During the July 9, 2020, Integrated Energy Policy Report (IEPR) workshop, Mac McQuown from Stone Edge Farms discussed their plans to use hydrogen for seasonal energy storage. Mr. McQuown described how during the summer their microgrid produced enough energy that the farm could operate independently from the grid and export energy to the utility. To meet the winter demand, farm representatives found that they would need to either oversize their solar capacity quite a bit and curtail summer production or find a way to store excess energy from the summer for use in winter. They are developing this seasonal storage by hydrolyzing water (collected on site from rain) to make hydrogen. They will produce hydrogen in the summer months to meet their winter energy demand plus extra to allow for a margin of error. He noted that "it all comes at zero marginal cost and zero carbon footprint" since they generate their own solar energy to produce the hydrogen.

Julia Levin, executive director at the Bioenergy Association of California, proposed the use of waste biomass to generate biogas for use in fuel cells in microgrids. She provided examples of systems that operate using bioenergy and provide long-duration capability. Miramar MCAS and Fort Hunter Liggett use biogas generation systems that provide these military instillations with clean, long-term protection for their operations.[22] Ms. Levin noted that waste biomass comes from a variety of sources, including landfills, wastewater treatment, and vegetation control, and that these sources are broadly distributed throughout California. The technical and economic challenges associated with the use of woody biomass from vegetation control as a fuel source for electricity generation are significantly greater than the use of biogas from landfills and wastewater treatment. As noted in the *2019 IEPR*,[23] biogas is a type of renewable gas, and multiple sectors are competing for the limited supply of non-fossil gas, including heavy-duty transportation. Regardless of source, methane leakage must be addressed given the associated direct climate impact of methane emissions, the primary component of biogas/renewable natural gas, and a potent greenhouse gas.

While the new technology options like long-duration storage, fuel cells that operate on biogas or hydrogen, and hydrogen-based generation systems provide promise for California's clean energy future, the performance and cost of these technologies still need to be validated.

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22 Julia Levin comments. [July 9, 2020, IEPR workshop on Assessing the Future Role for Microgrids in California transcript](https://efiling.energy.ca.gov/getdocument.aspx?tn=234952). p. 59. https://efiling.energy.ca.gov/getdocument.aspx?tn=234952.

23 CEC staff. 2020. *Final 2019 Integrated Energy Policy Report*. California Energy Commission. Publication Number CEC-100-2019-001-CMF. pp. 47-48.

Chapter 5: Stakeholder Feedback and California Energy Commission Recommendations

Stakeholder Discussion of Commercialization Challenges

Looking forward, the future expanded use of clean energy microgrids in California depends on continued research. The ideas for further work listed below reflect input received at the July 2020 Integrated Energy Policy Report (IEPR) workshop from 21 representatives with extensive experience deploying microgrids. At the workshop, industry executives, Tribal representatives, academics, energy service providers, and microgrid developers discussed the future role of microgrids in California over two days. Policy makers are already grappling with many of the issues identified and may find the suggestions from the workshop discussions useful in considering how to focus future efforts.

- **Technology Challenges**: Currently microgrids are complex and each has its own unique design. Participants identified that these factors make it difficult to design and deploy clean energy microgrids at scale. They also highlighted that clean energy microgrids need to be designed in a simple, modular manner, and that modularity will reduce development costs by substantially reducing the labor associated with design, permitting, and interconnection. The California Public Utilities Commission (CPUC) and investor-owned utilities (IOUs) have started to implement Senate Bill 1339 (Stern, Chapter 566, Statutes of 2018), including streamlining the permitting and interconnection with single-line diagram and aligning microgrid policy with existing tariff provisions. Participants suggested that a modular design-and-build approach should be demonstrated to help the state and local governments rapidly build clean energy microgrid projects in a timely manner, when needed.
- **Business Model Challenges**: Participants suggested that for clean energy microgrids to grow at an increasing rate, the industry needs to develop and field replicable business models. This is needed to encourage the financial investment market to embrace funding future microgrid projects that do not require the specific need for added public or ratepayer funding or a requirement for the CPUC or the Legislature to change utility operating rules. Participants identified that there are ongoing challenges on how to quantify and value reliability and resiliency; how to ensure microgrid performance can be linked to expected economic outcomes; how to address departing load and standby charges in a way that does not result in costs being passed to ratepayers who do not receive any value from the microgrid; and how to make microgrids affordable to low-income communities. The California Energy Commission (CEC) has already dedicated research dollars toward solving these challenges, such as asking microgrid grantees to develop business models that address these challenges. Once completed, these examples of business models for microgrids will be shared in future public workshops. The CEC encourages industry experts who are developing and fielding clean energy microgrids without government funding to also share their results to allow others to learn from their experience and support continued market growth.

- **Incentives to Help Bridge the Gap While Business Models are Being Developed**: Participants identified that funding from the Electric Program Investment Charge (EPIC) and the Self-Generation Incentive Program (SGIP) and the federal investment tax credit have helped with microgrid deployments and should continue. They also discussed how local governments can shape the microgrid market by implementing ordinances and leveraging other funding opportunities or capital. Other state programs (such as incentives or low-interest loans) may be involved and take fleet deployment of microgrids into account, since bundles of projects are easier to finance. Participants also pointed out that permitting remains a challenge for most authorities having jurisdiction (AHJ). The state successfully implemented guidance for permitting solar installations, and the CEC is funding a project that will develop guidance for permitting energy storage. These two guides will be valuable for AHJs, but as different types of renewable generation are deployed, guidance may be needed for other technologies (for example, bioenergy systems and fuel cells).
- **Regulatory Challenges**: Stakeholder comments during and after the IEPR workshop suggested that existing and emerging regulations relating to microgrids should be updated or adjusted. In written comments, Peninsula Clean Energy Authority raised interconnection uncertainties — both cost and timing of approvals — as significant barriers to deployment of microgrids.[24] Many workshop commenters and presenters noted that costs of interconnection can be uncertain and review delays can stymie project development or becomes financially unviable.

  However, the CPUC has made significant advancements in the interconnection process over the last year. (See sidebar on CPUC efforts.) Based on research completed by the EPIC program, future microgrid grant recipients are expected to have considerably less challenges getting their interconnection agreement approved unless they have a very special and unique situation which necessitates further review.

  Additionally, many of the workshop participants identified departing load charges and standby charges as significant barriers to microgrid deployment. They did not, however, acknowledge the fundamental role such charges play in ensuring that all customers pay their fair share of grid costs or the prohibition on cost shifting in SB 1339. The CPUC is studying these issues in the microgrids and resiliency rulemaking R.19-09-009.

  Finally, many workshop participants reiterated that the rates and tariffs developed for microgrids must create a level playing field that encourages all technologies to participate.

24 Peninsula Clean Energy Authority. July 30, 2020. *Written Comments of Peninsula Clean Energy Authority*. Docket 20-IEPR-04. https://efiling.energy.ca.gov/GetDocument.aspx?tn=234061&DocumentContentId=66894.

However, the participants did not identify the specific ways in which the playing field is unfair or identify specific rate or tariff provisions that would rectify those problems. While diesel generation accounts for the majority of power backup to date, SB 1339 directs the CPUC to design microgrid tariffs and rates, as necessary, that do *not* compensate a customer for the use of diesel and natural gas generation, with exceptions for certain circumstances, such as the sources used under Section 41514.1 of the Health and Safety Code, or natural gas generation that is a distributed energy resource.

In its workshop comments, the California Alliance for Community Energy provided several recommendations on new policies that could address some of the current regulatory challenges it claims that microgrids face in California. Some of its key recommendations include developing policies to support the expansion of microgrids in underserved communities, implementing incentive programs or feed-in tariffs that will support the growth of microgrids in underserved communities that are vulnerable to wildfires and public safety power shutoff (PSPS) events, developing new fee structures that will address the impact of departing load charges on new microgrids, and requiring these microgrids be a clean energy system.[25]

25 California Alliance for Clean Energy comments submitted to Docket 20-IEPR-04. July 30, 2020. https://efiling.energy.ca.gov/GetDocument.aspx?tn=234073&DocumentContentId=66902.

CPUC Efforts to Improve Microgrid Interconnection Process

- The Interconnection Discussion Forum is an informal venue for stakeholders to communicate about implementation of Rule 21 and other interconnection rules. It was established by Resolution ALJ-347 and has been held quarterly since starting in December 2017.
- The CPUC commissioned an outside contractor to conduct an evaluation of the IOUs' interconnection processes. The final report is expected to be released in late 2020 or early 2021.
- IOUs are required to file quarterly interconnection data reports that include information related to compliance with timelines.
- Four working groups on Rule 21 issues (as called for in Rulemaking 17-07-007) have been completed and filed final reports.
- CPUC Decision (D.) 19-03-013 adopted multiple proposals from the Rule 21 Working Group One Final Report.
- CPUC Decision (D.) 20-09-035 adopted multiple proposals from the Rule 21 Working Group Two, Three, and Vehicle-to-Grid Alternating Current Subgroup Final Report.
- CPUC Decision (D.) 20-06-017 adopted short-term solutions to accelerate interconnection of resiliency projects in advance of the 2020 wildfire season. Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) must make a compliance filing to the CPUC by February 15, 2021, reporting the results of the required actions the utilities have taken, including the success in meeting Rule 21 interconnection timelines.

- **Education and Outreach Challenges**: To move the market forward and help develop clear pathways to future projects, stakeholders discussed the need for more education on the benefits and challenges of clean energy microgrids. During the July 9, 2020, IEPR workshop, John Griffiths from the EPIC project with Kaiser Hospital described presenting their experience with developing a microgrid to the California Society of Healthcare Engineers to a "packed" room where they had to "turn people away."[26] This illustrated the level of interest many organizations have in learning how to develop microgrids. There continues to be a need for educational material. The CEC will continue to inform

26 John Griffiths comments. July 7, 2020, IEPR Workshop on Assessing the Value and Role of Microgrids in California transcript. https://efiling.energy.ca.gov/GetDocument.aspx?tn=234951&DocumentContentId=67822.

stakeholders about research results through development of critically needed educational materials such as lessons learned, best practices, and challenges.

Stakeholder Suggestions for Advancing Clean Energy Microgrids

During the workshop, presenters highlighted some solutions that they suggested would help advance clean energy microgrid installations, including the following:

- Vipul Gore, president and chief executive officer of Gridscape, pointed out on July 7, 2020, "Interconnection would take us 9 months and 12 months."[27] Richard Schorske, executive director of the ZNE Alliance, recommended that "a performance standard for utilities on interconnection that requires a decision within a very short time frame would be enormously helpful ... to put some pressure on utilities around a 30-day window."[28] Many of the presenters at the IEPR workshops agreed with the recommendation. The long lead times required to gain these approvals can result in challenges and attendees expressed hope that the state would address these challenges during the SB 1339 rulemaking. The CPUC has several venues available for addressing interconnection challenges, including a formal proceeding (R.17-07-007), an interconnection discussion forum, and an expedited dispute resolution process. Emerging issues that specifically pertain to microgrids and are not being addressed in other venues may be introduced in the CPUC's microgrids proceeding.
- Departing load charges, those charges designed to recover costs stranded by a customer's decision to reduce or replace the purchase of electricity from the IOUs and to collect charges designed by the CPUC as nonbypassable,[29] are another area of concern by microgrid developers and owners. As Allie Detrio stated during the public comment period for the IEPR workshop, "Departing load and standby charges are the single largest financial barrier to microgrid deployment in California."[30] This concern was repeated by several of the workshop speakers. This challenge is difficult to address because an equitable solution

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27 Vipul Gore comments. July 7, 2020, IEPR commissioner workshop on Assessing the Future Role for Microgrids in California transcript. https://efiling.energy.ca.gov/getdocument.aspx?tn=234950.

28 Richard Schorske comments. July 9, 2020, IEPR workshop on Assessing the Future Role for Microgrids in California transcript. https://efiling.energy.ca.gov/getdocument.aspx?tn=234952.

29 (Definition from Joint IOU comments on Draft 2020 IEPR Update, Volume II. Docket 20-IEPR-01. TN# 237262. https://efiling.energy.ca.gov/GetDocument.aspx?tn=237262&DocumentContentId=70444.)

30 Allie Detrio comments. July 7, 2020, IEPR commissioner workshop on Assessing the Future Role for Microgrids in California transcript. https://efiling.energy.ca.gov/getdocument.aspx?tn=234950.

will need to be reached. Departing load charges and standby charges[31] represent the cost to the utility and their customers to provide these services before the microgrid was installed. These are capital costs that are depreciated over long periods of time. By departing from the grid, such costs will shift to other ratepayers if not covered by the microgrid customer.

- During the second session of the IEPR workshop, Juan Macias, chief executive officer of AlphaStruxure, discussed the issue of interconnection challenges where there are multiple customers in a microgrid based on existing legal and regulatory requirements, including Public Utilities Code (Pub. Util. Code) § 218[32] and Tariff Rule 18/19.[33] The CPUC is working to address limitations of Rule 18/19 in its SB 1339 Proceeding. Pub. Util. Code § 218 would require a legislative change to simplify microgrid development across a right-of-way.
- Vipul Gore with Gridscape also indicated at the IEPR workshop that a standardized microgrid design that includes standard power levels, easy equipment connections, and factory-level designs to replace the one-of-a-kind designs developed to date is needed to make microgrids cost-competitive.[34]
- Many presenters claimed that being able to quantify the value of resiliency to a customer in financial terms is a key element of success for microgrids in the future. They assert that a high value of resiliency for a customer is needed to justify the development of a microgrid and expressed a desire to quantify it to support microgrid businesses. The absence of a metric for quantifying resilience also impacts the use of microgrids in low-income and disadvantaged communities. To date, development of a business case for microgrids based solely on resiliency has not been successful.

31 Standby charges are designed to cover the cost of distribution and generation capacity necessary to ensure that IOUs can serve a customer's full load when the customer's generator is not operating as intended. (Definition from Joint IOU comments on Draft 2020 IEPR Update, Volume II. Docket 20-IEPR-01. TN# 237262. https://efiling.energy.ca.gov/GetDocument.aspx?tn=237262&DocumentContentId=70444.)

32 Pub. Util. Code § 218 requires any entity who wishes to sell power to more than two contiguous parcels or across a street to become an electrical corporation, which by way of Pub. Util. Code § 218, is defined as a "public utility."

33 Juan Macias comments. July 9, 2020, IEPR workshop on Assessing the Future Role for Microgrids in California transcript. https://efiling.energy.ca.gov/GetDocument.aspx?tn=234951&DocumentContentId=67822.

34 Vipul Gore comments. July 7, 2020, IEPR workshop on Assessing the Future Role for Microgrids in California. https://efiling.energy.ca.gov/getdocument.aspx?tn=234950.

California Energy Commission Recommendations

When addressing how to advance clean energy microgrids, there are three clear forums where issues can be addressed initially: this and future IEPR proceedings, the ongoing CPUC SB 1339 proceeding R.19-09-009, and the future research efforts of the EPIC program. Many of the top issues identified in the discussion of lessons learned above are already being addressed in the CPUC's SB 1339 proceeding. With almost a decade of experience, the EPIC program has also addressed many of the top research level issues identified above. With the EPIC program receiving approval from the CPUC for an additional 10 years of funding through December 31, 2030, this program will continue addressing the challenges in transitioning from research to commercial operations as soon as possible.

- **Continue research and share information about clean alternatives to diesel generation for backup power.** Continue funding research into clean alternative technologies that can ensure future microgrids support the goals of Senate Bill 100 (de León, Chapter 312, Statutes of 2018) by expanding the research, development and deployment of:
    - Longer duration, safer, and more economic energy storage technologies.
    - Improved and more capable microgrid controllers.
    - Additional options for alternative fuels such as green hydrogen.
    - Expanded field demonstrations of green hydrogen powered fuel cells in microgrids.
    - Improved solar and wind renewable generation technologies.
    - Expanded use of microgrids that can operate on biogas produced from waste biomass, when longer duration protection is needed.
- **Continue to implement the CPUC SB 1339 Proceeding (R.19-09-009) Track 3 activities**. The CPUC has begun to address many of the challenges, barriers, and issues microgrids are experiencing in Proceeding R.19-09-009 for the implementation of SB 1339. Stakeholders should continue to address these key issues in this forum.
- **Continue to streamline distribution interconnection.** The publicly owned utilities (POUs) and the CPUC should continue to build upon the progress they have made to streamline the distribution interconnection process. Guidance should be provided to allow microgrids to complete a standard interconnection process in a timeframe that supports the overall installation and commissioning schedule of the microgrid and complies with published CPUC and utility processes to ensure public, system, and worker safety, and equitable rates.
- **Address right-of-way issues.** The CPUC, POUs, or the Legislature should work to determine the best options to allow microgrids development for larger installations and communities such that the right-of-way issues can be resolved in a manner that allows the microgrids to support all end-use customers within their span of expected and approved operation without violating current laws and public safety codes in order to ensure public, system, and worker safety and equitable rates.

- **Develop and make publicly available market information and financial tools that can be used to successfully deploy microgrids without the use of state funding.** A team from the academic community, industry, and the research community should be formed to develop and deliver publicly available information on standard business cases and financial models that can be used as tools to plan, develop, and operate microgrids. As part of this effort, the team should work with financial institutions to encourage the development and availability of long-term financing options that provide flexibility to future microgrid owners and operators so that the burden of high upfront cost can be shifted to a longer-term arrangement.

Acronyms

AHJ	authorities having jurisdiction
CARB	California Air Resources Board
CEC	California Energy Commission
California ISO	California Independent System Operator
CPUC	California Public Utilities Commission
EPIC	Electric Program Investment Charge
FPIP	Food Production and Investment Program
GHG	greenhouse gas
Gridscape	Gridscape Solutions
GW	gigawatt
HVO	hydrotreated vegetable oil
IEPR	Integrated Energy Policy Report
IOU	investor-owned utility
kWh	kilowatt hour
PG&E	Pacific Gas and Electric
PIER	Public Interest Energy Research
POU	publicly owned utility
PPA	power purchase agreement
PSPS	public safety power shutoff
SB	Senate Bill
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SGIP	Self-Generation Incentive Program
TOU	time of use

APPENDIX A:
List of California Energy Commission Supported Microgrids

Table 2: List of California Energy Commission Supported Microgrids

Location of Microgrid	Type or Use of the Microgrid	Location of Microgrid	Start Date	Estimated Completion Date
Sacramento Municipal Utility District	Field demonstration of a utility microgrid.	Industrial Facility	2009	2012
County of Alameda	CERTS smart grid demonstration with renewables and large-scale energy storage integrated at Santa Rita Jail, Alameda County, California	Industrial Facility	2009	2014
The Regents of the University of California, San Diego	Enabling renewable energy, energy storage, demand response and energy efficiency with a community based master controller-optimizer	Community	2009	2014
Camp Pendleton Marine Corp Air Station	Camp Pendleton Area 52 fractal grid demonstration	Industrial Facility	2013	2015
Fremont, CA	Fire Station #6	Commercial Building	2015	2019
Fremont, CA	Fire Station #7	Commercial Building	2015	2019
Fremont, CA	Fire Station#11	Commercial Building	2015	2019
Chino, CA	Direct current building scale microgrid	Commercial Building	2015	2019

Location of Microgrid	Type or Use of the Microgrid	Location of Microgrid	Start Date	Estimated Completion Date
Blue Lake, CA	Demonstrating a secure, reliable, low-carbon community microgrid	Community	2015	2018
Livermore, CA	Las Positas College microgrid	Community	2015	2019
Santa Rosa, CA	Laguna Wastewater Treatment Plant microgrid	Industrial Facility	2015	2019
Borrego Springs, CA	Utility-owned renewable based community microgrid	Community	2015	2018
Richmond, CA	Renewable microgrid for a medical center	Commercial Building	2015	2018
Davis, CA	Community scale low cost highly efficient photovoltaic and energy management microgrid	Commercial Building	2015	2021
Needles, CA	Community scale microgrid system at the Chemehuevi Community Center	Commercial Building	2015	2021
Blue Lake, CA	Integrated energy management microgrid demonstration in a supportive housing facility	Residential	2017	2020
Sonoma, CA	Integrated energy management microgrid demonstration in a supportive housing facility	Residential	2017	2020
Long Beach, CA	Integrated energy management microgrid demonstration in a supportive housing facility	Residential	2018	2020
Long Beach, CA	Port of Long Beach microgrid	Industrial Facility	2018	2023
San Diego, CA	Miramar Marine Air Station microgrid	Industrial Facility	2018	2023

Location of Microgrid	Type or Use of the Microgrid	Location of Microgrid	Start Date	Estimated Completion Date
Dublin, CA	Camp Parks Army integrated microgrid	Community	2018	2023
San Diego, CA	Port of San Diego microgrid	Industrial Facility	2018	2023
Fontana CA	Urban microgrid for grid resiliency and disaster readiness	Located at 5 different Commercial Buildings and final address TBD	2018	2023
Hayward, CA	Urban microgrid for grid resiliency and disaster readiness	Commercial Building	2018	2023
Santa Rosa, CA	Santa Rosa Junior College	Community	2018	2023
Bloomington, CA	Rialto Waste Treatment Facility	Industrial Facility	2018	2023
McKinleyville, CA	Redwood Coast Airport	Industrial Facility	2018	2023
Port Hueneme, CA	Port Hueneme Navy Data Center microgrid	Commercial Building	2018	2023
Lancaster CA	Advanced energy community microgrid	TBD for Locations for 5 Different Residential/ Community microgrids	2019	2024
Oakland CA	The Oakland EcoBlock, A zero-net-energy neighborhood	Residential	2019	2023
Firebaugh, CA	TomaTek solar microgrid project	Commercial Building	2109	2024

Location of Microgrid	Type or Use of the Microgrid	Location of Microgrid	Start Date	Estimated Completion Date
Van Nuys, CA	Anheuser-Busch solar microgrid project	Commercial Building	2020	2023
Ceres, CA	Aemetis Integrated Microgrid Solution (AIMS) project	Commercial Building	Pending Award	2023
Brawley, CA	Spreckels Sugar Company's solar microgrid project	Commercial Building	Pending Award	2024
Kingsburg, CA	Demonstrating a renewable energy microgrid at the Sun-Maid Raisins facility	Industrial Facility	Pending Award	2024
La Puente, CA	Basset-Avocado advanced energy community	Community	Pending Award	2025
Grass Valley, CA	Reuse of electric vehicle batteries for solar energy storage	Commercial Building	Pending Award	2025

Credit: CEC