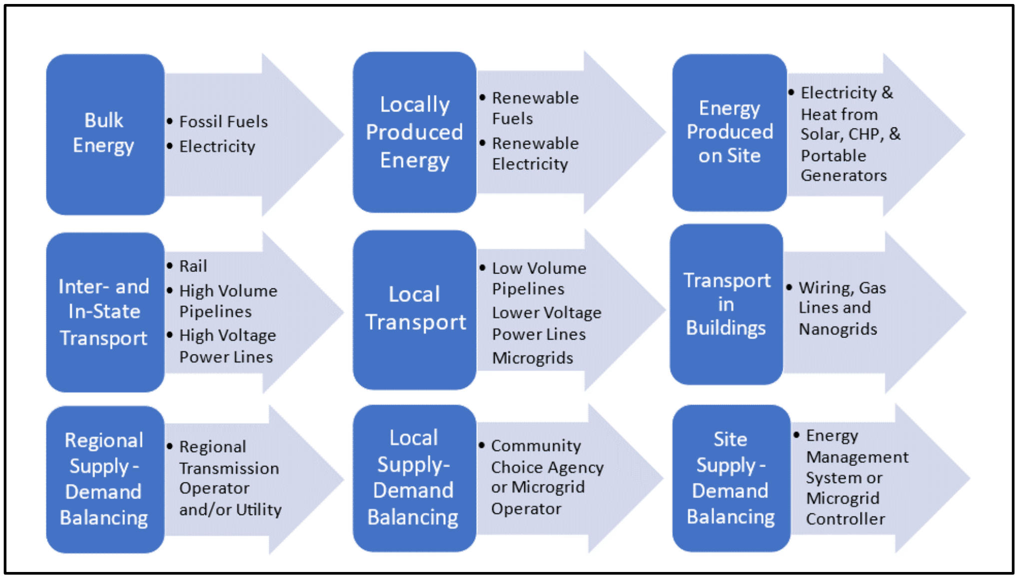
INVENTORY AND INTEGRATION OF CALIFORNIA'S LOCAL ENERGY RESILIENCE ASSETS

Integrated
Renewable
Energy
Systems
Network
www.iresn.org

Gerald
Braun, Project
Manager

GG



August
2021

Local Climate Action and Adaptation Planning
Second Year Report – Final

Abstract

The global energy transition is a transition to renewable energy. Are there renewable energy transition pathways that lead to both decarbonized electricity and gas usage and energy resilience as well? California's gas and electric energy resilience eco-system attracts massive non-utility investment but is integrated only at the site level. The current inventory of on-site energy resilience assets has accumulated over time to the point that its collective supply capacity is a major potential supplement to power plant fleets around the state. Emerging supply capacity in the form of electric vehicles and stationary batteries, inter-operable with fast growing on-site solar capacity will create an opportunity for many California communities to become fully energy resilient over the next five to ten years. Yet there are challenges to overcome and new methods of strengthening local energy resilience to implement as the energy sector transitions to reliance on renewable resources. A fundamental challenge is integration of local electricity supply with imported electricity supply - for example using microgrids to aggregate local supply and make it available when electricity imports are disrupted. Success in meeting the challenge depends on engagement and collaboration among energy resilience stakeholders, with local governments playing a leadership role empowered by state action to clear away roadblocks.

Acknowledgements

IRESN's Local Climate Action and Adaptation Project Advisory Committee supported preparation of the project work scope and met to review progress. Keith Davidson, Geoff Danker, Larisa Dobriansky, Ron Edelstein, Tanya Peacock and Byron Washom provided thoughtful and insightful guidance and/or review.

Cover illustration: Figure 1 shows three tiers of energy production, transport[1] and operations. The left tier includes inter-state energy sources, transport systems and operations responsibilities. The middle and right tiers include local and on-site energy sources and nanogrids, gas and electric distribution systems and microgrid operation and control responsibilities. While integration and inter-operability are inherent at the bulk level, inattention to integration of local energy resilience assets results in vulnerability to local disruption and economically sub-optimal energy resilience asset utilization. Deployment of operational local energy resilience assets, already massive, is rapidly being supplemented by even more massive deployment of solar PV and co-located batteries and electric vehicles. Because these additional available assets already have a beneficial and quantifiable effect on local economies, their current under-utilization is a growing concern. Microgrids address the problem by providing a platform for integration and inter-operability between local assets and regional energy grids and transport systems. The microgrid platform both enhances the resilience of regional systems and unlocks on-site resilience asset benefits to neighborhoods and communities.

About IRESN and the project manager: IRESN is a registered California non-profit dedicated to pragmatic local energy integration and collaboration. Gerald Braun is an energy utility and solar industry veteran who also, at other times, directed national, state, utility and university-based renewable energy RD&D programs.

Inventory and Integration of California's Local Energy Resilience Assets

PREFACE

Are California's energy resilience assets being used to provide energy security for diverse and important groups of individual electricity customers? Yes, but not for most residential and commercial groups. Has deployment of on-site energy resilience assets in California over many decades enabled numerous energy resilient communities. Not yet. Are energy resilience assets being integrated with grid assets to maximize local energy security? Not yet. They are not called on to feed electricity into the regional grid when it is under stress. Two strategic opportunities are being missed. First, the opportunity to use local resilience assets to back up the state's electricity system during times when the combination of California power plants and imports from other states falls short of meeting aggregated demand. Second, the opportunity to isolate and continue to serve local areas cut off from the state's electricity system due to regional or localized blackouts.

Will the doubling of operational on-site energy resilient supply assets expected in the next five to ten years materially improve energy resilience in California? Not to the extent it could. Nor at minimum societal cost. Optimally effective asset use can only be achieved when there is more flexible local electricity grid operation that enables aggregation of local decarbonization and resilience assets. The cost of local energy resilience can either be high or modest, depending on whether low carbon on-site energy supply and storage assets are used fully and effectively. Resilient decarbonization is maximized when a portion of these assets rely on negative or zero carbon fuels.

Community microgrids enable aggregation and integrated operation of local resilient decarbonization assets. They are not primary targets for utility investment and rate-base building. The urgent question is whether other stakeholders - cities, counties and states - will overcome utility and regulatory resistance and lead the way on an energy resilience path that serves all energy users, not just those who have backup on-site.

Resilient decarbonization is an urgent local need requiring local initiative and leadership. It cannot be completely outsourced, because the best pathway is unique to each city or county. Among currently inactive stakeholders, local governments and utilities have crucial future roles to play if energy resilience is to be achieved at the community level as well as the site level. Utilities have the technical and economic resources to facilitate economic integration of energy resilience assets but as yet have no obligation under state law to do so. Cities and counties have the most at stake economically and will need to add energy management staff to engage promptly and effectively. State governments can facilitate local leadership and engagement and reward energy utility engagement and investment. Until currently inactive stakeholders step up, energy resilience will depend on individual energy user choices. Many users currently have no choices, or ineffective ones.

Local Energy Resilience Assets and Integration

1. Introduction. Energy resilience is the ability to restore energy supplies quickly even when they are severely disrupted. California now finds it necessary to shut parts of the state-wide electricity grid down where and when high winds, power lines and dry vegetation threaten to cause wildfires. Prompted by wildfire experience and anticipating further and more severe wildfires, an energy resilience conversation is beginning in California. Robust energy resilience minimizes costs and economic dislocation in the wake of natural disasters. [1] It is made possible by on-site and community managed electricity sources and control systems. The following sections will refer to them as “local energy resilience assets”.

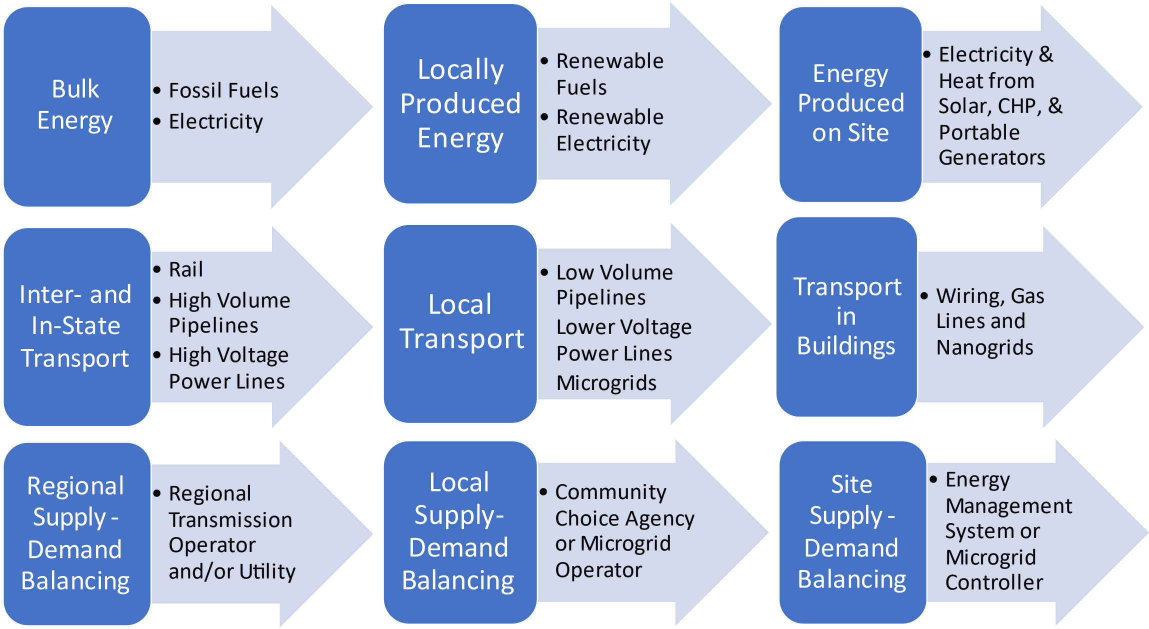


Figure 1. Bulk, Local and On-site Energy Supply, Transport and Supply/Demand Balancing

Figure 1 shows three tiers of energy production, transport[1] and operations. The left tier includes inter-state energy sources, transport systems and operations responsibilities. The middle and right tiers include local and on-site energy sources and nanogrids, gas and electric distribution systems and microgrid operation and control responsibilities. While integration and inter-operability are inherent at the bulk level, inattention to integration of local energy resilience assets results in vulnerability to local disruption and economically sub-optimal energy resilience asset utilization. Deployment of operational local energy resilience assets, already massive, is rapidly being supplemented by even more massive deployment of solar PV, co-located batteries and electric vehicles. Because these additional available assets already have a beneficial and quantifiable effect on local economies, their current under-

---

[1] The costliest disasters to which California is prone, earthquakes, have occurred infrequently enough to be incidental to routine energy policy and planning.

utilization is a growing concern. Microgrids address the problem by providing a platform for integration and inter-operability between local assets and regional energy grids and transport systems. The microgrid platform both enhances the resilience of regional systems and unlocks on-site resilience asset benefits to neighborhoods and communities.

Over-reliance on bulk electricity supply systems is also a concern. Vulnerabilities to extreme weather and to cyber and physical attack make regional electric systems a double edged sword. Their relative reliability and operational flexibility provide a fundamental level of adaptability under normal circumstances. But when flows of fuels and bulk electricity are disrupted, local energy resilience assets sustain economic activity, critical services and life support.

Building and transport electrification is an important pathway to energy sector decarbonization but not necessarily to greater energy resilience. Nevertheless, a suite of synergistic pathways, including but not limited to electrification, can lead to "resilient decarbonization". The suite includes integration of local zero or negative carbon resources to accelerate decarbonization and community-wide energy resilience.[2]

Resilient decarbonization is enabled by a number of technologies just now gaining traction in energy markets. Under-investment in their timely deployment and integration with existing infrastructure is the primary barrier to resilient decarbonization. See Appendix A for additional detail on resilient decarbonization enablers and barriers.

2. California's Energy Resilience Assets. On-site assets that produce or store energy cost-effectively offer the additional benefit of operating independently of local grids in an emergency. Unlike sources on which routine service depended in the past, energy resilience assets typically operate independent of energy transport systems and provide backup power to electricity customers who own them. On what local supply assets does energy resilience depend? How do they work to deliver resilience? In what amounts have they been deployed and what is their current rate of deployment? How can new asset types be added and integrated in the mix?

Table 1. California's Energy Resilience Assets

Resilience Asset	2020 Capacity (est.) (GW)	Annual Market Growth (%)	Projected Capacity in 2025 (GW)
Currently Operational Assets			
Combined Heat and Power	**8.6**	**5**	**11.0**
Standby Power	**10.4**	**4**	**12.6**
Additional Assets Available for Use			
Solar PV	**9.3**	**14.5**	**19.5**
Electric Vehicles	**41.4**	**22**	**108**
Enabling Assets			
Campus Microgrids	**0.2**	**19**	**0.5**
Community Microgrids	**No est.**	**No est.**	**0.5**

Deployment status and trends for major energy resilience asset categories are

---

[2] A 2020 white paper (Ref. 1.a) identified synergistic pathways to greater use of locally produced renewable electricity and gas.

summarized in Table 1. Local energy resilience assets deliver energy security by backing up electricity and gas transport systems. They serve selected on-site energy uses when regional or local energy transport systems are disabled. They include publicly and privately owned systems that convert fuels, waste materials or renewable energy to electricity for local use. With the exception of standby power assets using diesel fuels[3], almost all energy resilience assets are also decarbonization assets.

The asset categories summarized in Table 1 are detailed in later sections. They encompass a diverse menu of modular fuel and renewable energy conversion technologies - combustion engines and turbines, on-site and community PV arrays, batteries, fuel cells and more. Their reliance on secure local fuel and renewable energy sources enables to automatically fill in when bulk electricity transport systems are temporarily disabled. Their energy resilience benefits are typically captured by transferring building circuit connections from the local electricity grid to on-site generation or energy storage when there is a grid outage.

Unlike the sources on which routine grid electricity service depends, <u>currently operational local energy resilience assets</u> typically are not directly connected to energy transport systems. Most are owned and operated independent of electric utilities. Most are permanently installed but some are portable or mobile. They provide backup power to one of eight California electricity customers. Thanks to non-utility investments over decades, California's currently operational on-site energy resilience asset capacities add up to 20GW. Their cumulative capacities are still growing at modest annual rates. For a sense of relative scale, total in-state grid electricity supply capacity, 80GW, is only four times greater.[4] [5]

<u>Additional available on-site energy resilience assets</u> are being deployed at much faster rates than CHP and standby generators. They include on-site solar PV arrays and batteries charged by the arrays. Battery storage must be available on-site if solar PV is to enable sustained 24/7 energy resilience. On-site solar arrays can charge vehicle batteries that both power the vehicle and feed electricity into the local distribution grid. Solar plus storage systems relying on stationary or vehicle batteries can increase the current operational on-site asset total by a factor of two over the next decade. This fact should invite policy attention to the opportunity for more effective use of all resilience assets, currently operational and yet-to-be exploited.

---

[3] Standby generators rely on diesel fuel storage that enables up to three days of operation following a loss of grid service. They have long been an antidote to local outages that might otherwise be costly for their owners. Diesel generators designed to use natural gas have long been commercially available and can provide backup indefinitely until grid service is restored. For health, safety and GHG emissions reasons, where extreme weather events may result in outages that last weeks, not days, the state has an interest in fueling new and replacement standby generators with gaseous fuels already available on-site.

[4] Almost three-tenths of California's electricity comes from outside the state, enhancing on both California's vulnerabilities and buffering against disruption of in state sources. Source: US Energy Information Administration.

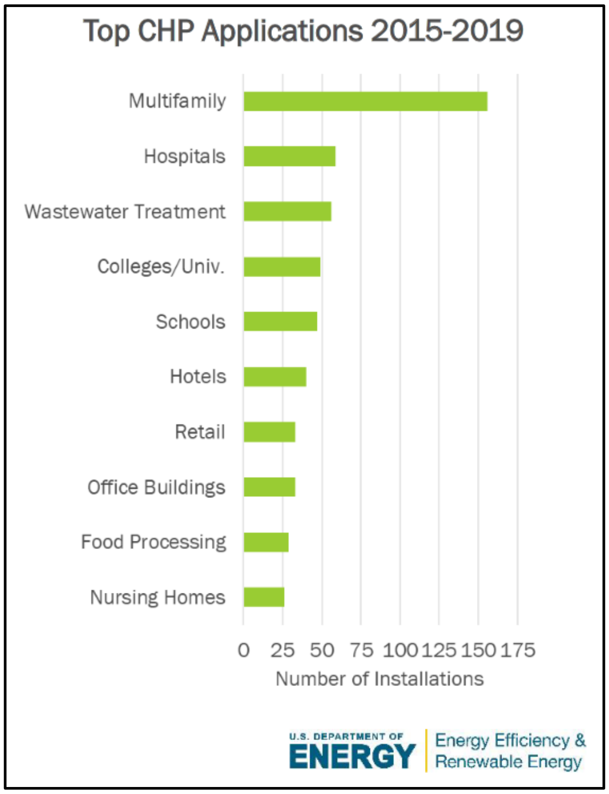
[5] Unlike the sources on which routine grid electricity service depends, local energy resilience assets typically operate independent of energy transport systems and provide backup power to only a small fraction of electricity customers.

Microgrids can bring operational energy resilience assets into play when needed to back up neighborhood, community and campus grids. Currently deployed microgrids play a relatively small energy resilience role because of rules that prevent electricity from flowing from one electricity user to another. This limits microgrid applicability to university and industrial campuses where electricity metering is at the campus boundary and the campus owner distributes electricity to campus energy uses.

Microgrids can also be deployed to economically serve new neighborhoods and communities and can enable on-site generation and storage and community renewables projects to be cost and operationally effective community energy resilience assets.[6] However, their applicability to existing neighborhoods and communities will depend on adaptation of existing utility owned distribution infrastructure and compensation of utility owners for its conversion and use to collect and distribute locally generated electricity.

The relatively small current microgrid capacity identified in Table 1 can grow much more rapidly than current projections when/if California makes such adaptation possible. Until then, additional energy resilience "enabling assets" will be limited to campus microgrids, microgrids serving new neighborhoods and building "nanogrids" relying on micro CHP, on-site solar arrays and electric vehicle batteries. Local energy resilience in California is currently financed by individual energy users.

There is and will be no shortage of available energy resilience assets. Many energy users already invest in energy resilience. But can local assets deliver energy resilience benefits to communities as well as to asset owners? They can. What will it take? First, new non-monopolistic models for local energy service. Second, local government engagement with energy service providers to make full use of available local energy resilience assets.



2.1 Combined Heat and Power (CHP). California and US policy targeted combined heat and power because it results in more efficient fuel use and lower emissions than non-integrated production of power and heat. The US relies heavily on combined heat and power (CHP), with 80.8 GW of installed CHP at more than 4,600 industrial and

---

[6] On-site solar plus storage configurations can also be operationally effective when connected to local electricity distribution grids operated by municipal utilities, but only if local decentralized production suffices to meet local demand.

commercial facilities accounting for 7% of U.S. electric generating capacity and 13% of electricity supply capacity supporting manufacturing. 82% of existing CHP capacity is located in industrial areas, with natural gas fueling 72% of the total and biomass, biogas and municipal and process waste fueling 15%.[7] As shown in the US Department of Energy's breakdown of recent applications (sidebar – previous page), top applications have been multifamily buildings in high population density areas where demand exceeds what on-site solar sources can supply.

CHP applications also include critical facilities – hospitals, wastewater treatment, schools and nursing homes. Over a dozen case studies of CHP-enabled public safety and recovery operations during Hurricane Sandy and other recent large-scale power outages were documented.

Texas and Louisiana require that all state and local government entities identify which government-owned buildings are critical in an emergency. They also require that a feasibility study on CHP is conducted prior to constructing or extensively renovating a critical government facility. New York educates emergency managers about the benefits of CHP systems in emergency facilities, incentivizes CHP and has higher incentives for projects serving critical infrastructure, including facilities of refuge.

Many industrial and commercial energy users rely on combined heat and power systems to save energy costs. They reap a collateral energy resilience benefit when electricity service is disrupted and gas service is not. Efficiency benefits depend on significant consumption of low grade heat, preferably all or most of the 24 hour day, as required by many industrial processes.

CHP and CCHP (combined cooling, heating and power) systems deployment has long been supported by California policy because California electricity use is driven by cooling as well as heating, and even greater fuel efficiency can be attained by producing both hot and cold water for distribution on industrial and university campuses.

Residential energy use typically results in low on-site equipment utilization factors, especially in temperate zones, resulting in less attractive CHP economics in the absence of significant incentives. Table 2 shows that deployment of "micro-CHP" systems is still dwarfed by deployment of larger systems. However, micro-CHP growth in the next decade could accelerate as small fuel cell electricity generators converting renewable hydrogen are mass produced for vehicular power and migrate into stationary power applications. Micro CHP can also have a key role in powering neighborhood and community microgrids, as it provides reliable capacity that complements the seasonally variable

Table 2. California's CHP Resilience Assets[8]

Resilience Asset	**Est. 2020 Capacity (GW)**	**Market Growth (%/yr.)**	**Est. 2025 Capacity (GW)**
CHP	**8.6**	**5**	**11**
Industrial	4.1	3	5
Commercial Other	4.5	5	5
Micro CHP	0.3	20	1

---

[7] Source: DOE CHP Installation Database (U.S. installations as of July 31, 2020).

[8] Industrial and commercial installations as of 12/31/2016: Reference 2.c. Source for micro CHP: Reference 2.a.

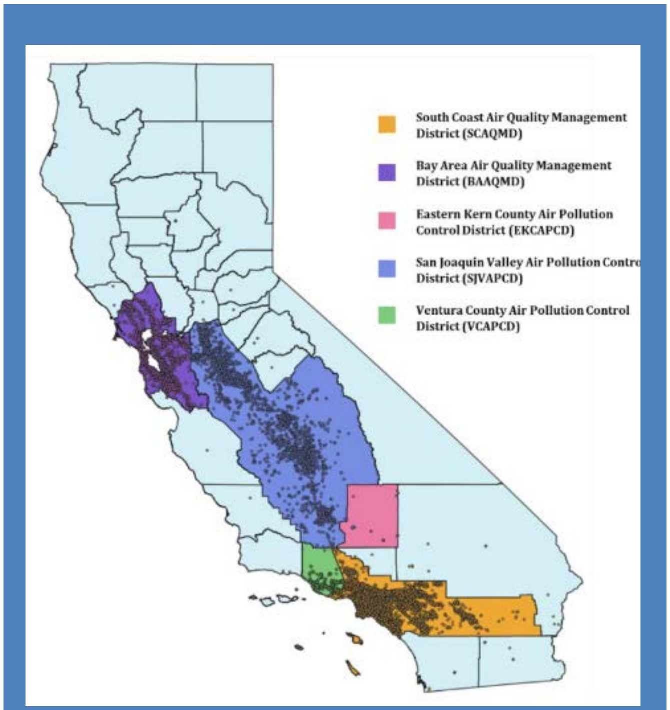
capacities of solar plus storage. In this application, micro CHP can use renewable fuels, allowing such microgrids to have a net zero carbon environmental profile.

Some level of mutual reliance and coordination among nanogrids, microgrids and local electricity distribution systems will likely result in the overall lowest cost of service and overall maximum reliability and resilience. However, compartmentalized thinking about energy resilience and decarbonization poses a major barrier to technical and economic integration that maximizes community and energy user benefits and equitable sharing of benefits and costs.

2.2 Standby Power. The most diverse and pervasive energy resilience resources are back-up generators (BUGs) engine based “gen-sets” and micro-turbine generators. Converting diesel fuel stored on-site or natural gas from local gas distribution systems, they allow critical industrial and commercial electricity uses to be restored

Table 3. California's Standby Power Resilience Assets[9][10]

Resilience Asset	Est. 2020 Capacity (GW)	Market Growth (%/yr.)	Est. 2025 Capacity (GW)
Standby Power	**10.4**	**4**	**13**
>25 hp Rental	3.7	>4	4
>25 hp other	2.4	>4	3
<25 hp	4.3	4	5



Across five of 35 California air quality districts, roughly 25,000 back-up and emergency generators in the size range above 50kW are permitted, most to run less than 500 hours per year with nearly reliant on diesel fuel stored on-site. Comparable numbers of standby generators in the 10 to 50 kW range serve residential and small commercial emergency and back-up needs. (Source: reference 4.a) According to the California Air Resources Board “of particular concern are the health effects related to emissions from diesel back-up engines Diesel particulate matter (DPM) has been identified as a toxic air contaminant, composed of carbon particles and numerous organic compounds, including over forty known cancer-causing organic substances. The majority of DPM is small enough to be inhaled deep into the lungs and make them more susceptible to injury.” (Source: reference 4.c)

Their (hard to monitor and quantify) pollutant and GHG emissions are a concern as noted on and discussed in reference 4.b.

---

[9] Existing California asset capacity is inferred from data in CARB analysis in Ref. 4.b. Analysis of > 50kW BUG standby power capacity in Ref. 4.a results in a higher proportion of >25kW capacity and a lower proportion of <25kW capacity, but the total current capacity is consistent with both analyses. Growth rate source for North America: Global Market Insights.

[10] Regarding <25kW, one of 8 houses in CA has an average 3.5 hp generator. 13.16 million households in CA in 2019

quickly. Capacities span a three order of magnitude range. Table 3 shows that capacity growth is expected to continue.

Diesel fuel is used in 95 percent of large BUGs (unit sizes greater than 50kW) in the air districts highlighted in the sidebar on the previous page. Each BUG technology/fuel option has significant advantages and limitations. Generally, gas fuel (natural gas and propane) is preferred in the lower size ranges where it avoids the complication diesel fuel storage and where grid-connected generators provide additional services as well as back-up and so have higher reliability and lower net costs due to more frequent operation. Natural gas generators pose a risk of a loss of gas pressure, while diesel fueled generators pose a risk of running out of fuel in situations where resupply is not possible. Fuel-related risks are highest for widespread, long outages, especially in areas prone to natural disasters. Anecdotally, based on cases where data is available, natural gas provides additional reliability compared to diesel for regions that face high risks of long outages.[11]

2.3 Solar PV. California electric utilities allow on-site solar electricity to spill over into their local grids when production exceeds usage. Net usage and net production are metered. Property owners are credited for solar electricity that feeds into the local grid at the same price they pay for electricity they get from the grid. They are currently not allowed to size their solar arrays to produce more electricity annually than they got from the grid in the past.[12]

Table 4. California's On-site Solar Resilience Assets[13]

Resilience Asset	Est. 2020 Capacity (GW)	Market Growth (%/yr.)	Est. 2025 Capacity (GW)
Solar PV	**9.3**	**14.5**	**19**
Residential	6.1	17	13
Non-res.	3.2	14	6

More than 7% percent of California's electricity usage is supplied by more than a million net metered solar arrays. Their cumulative

The California Public Utilities Commission (CPUC) is considering utility proposals to make on-site solar much less economically attractive to property owners. This makes it very hard to predict whether and to what extent on-site solar installations will continue to be part of growing base of energy resilience assets, disciplined by competition and commitment. Also, whether a retail solar industry will remain that has strength and capacity to respond to property owner interest in battery storage. Currently, because of energy resilience concerns, interest in battery storage is growing. But its capital costs are greater than those of standby generators.

Rather than limit on-site solar deployment, regulators can recognize, enable and reward the benefits of on-site solar plus storage integration for local grid operation and resilience. Solar plus storage integration will be throttled if solar deployment is throttled. Solar plus storage systems have potential benefits for local grid operation that must be shared with their owners before rapid adoption can be expected. Until then, deployment of solar plus storage systems that provide backup in an emergency will be limited.

---

[11] Cf. Ref. 4d.

[12] This impedes rapid energy resilience progress. Local electricity systems must enable net positive on-site solar electricity from existing arrays to be distributed to energy users lacking on-site solar supply.

[13] Residential and non-residential installations as of 12/31/2020 and 1/31/2021 respectively. Source: Ref. 3.a

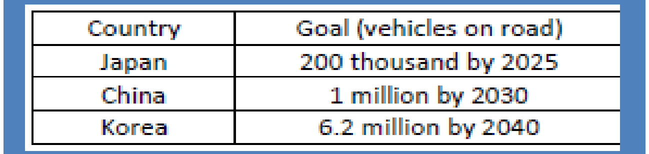
production capacity has been increasing at more than 16 percent per year. Installed system costs, that plummeted in the past ten years, are leveling off and have become more predictable.

Table 4 quantifies the result of tens of billions of dollars in California home and business owner solar investments and the expected doubling of on-site electricity production capacity over the next five years. On-site solar PV systems account for nearly 50 percent of the solar electricity generated in California and about 7 percent of all electricity consumed, though the latter percentage can be as high as 15 or 20 percent in specific cities and counties. At current market growth rates, cumulative capacity will exceed that of any other available on-site non-vehicular energy resilience asset.

Residential and small commercial energy users have been deploying on-site solar arrays in recent years but use of arrays to back-up local grids is at best limited to daytime hours if the arrays are not coupled on-site battery storage and cannot continuously match on-site demand.[14] Energy resilience concerns and time-of-use utility rates could result in significant on-site storage deployment by 2025. The combination of solar PV, battery storage and fuel cell electricity generation has potential to allow microgrids to provide resilient electricity service at electricity prices below rates those offered by electric utilities.

<u>2.4 Electric Vehicles.</u> Unlike battery electric vehicles (BEVs), FCEVs do not require an on-site electricity source to be effective resilience assets. In the longer term, their energy resilience asset value can be exceptional, because they rely on hydrogen, a fuel that can be produced, stored and distributed locally

California's battery electric vehicle market is expanding in response to state policies and incentives. Nissan is ready to launch vehicle models having V2G capabilities in 2021 that can respond to local grid demand and/or shift on-site solar usage to high demand periods. Tesla will continue to market stationary battery systems as well as EVs and opines that vehicle based energy storage would not be sufficiently convenient for effective demand response or grid backup purposes. V2G capabilities will see greater or lesser use depending on time of use rate differences. TOU rate differentials typically suffice to influence customer behavior but not to stimulate customer investment. Even so, a combination of energy resilience concerns and greater usage shifting benefits may lead to vehicle purchaser interest in models having V2G functionality.



Country	Goal (vehicles on road)
Japan	200 thousand by 2025
China	1 million by 2030
Korea	6.2 million by 2040

<u>National Fuel Cell Electric Vehicle Deployment Goals</u>

Fuel cell electric vehicles are conceptually superior for V2G purposes because of their higher power ratings and greater on board energy storage capacity. Sales will expand fastest in smaller markets, such as long haul transport, that do not require extensive fueling station coverage. Toyota plans to adapt the on board fuel cell power system for the Toyota Mirai to stationary power applications, creating a faster ramp to high volume production. Green hydrogen supply and distribution is a gating issue as well. Japan, Korea and China have aggressive goals to expand domestic FCEV production, likely hoping thereby to secure larger shares of the global FCEV and green hydrogen markets they expect to emerge

---

[14] Modern grid-tied solar inverters are capable of supplying on-site usage during a grid outage, but the property owner must know this feature exists and install transfer switches that allow it to be used when daytime backup is needed. The number of solar homeowners that have taken this extra step is probably quite small.

and converted to electricity in amounts that exceed on-site demand.

Table 5 quantifies the result of tens of billions of dollars in California vehicle owner investments and the expected rapid increase of vehicle based electricity production and storage capacity expected the next five years. BEV charging on vehicle owners' property is a current norm that creates an opportunity to power a home 24/7 in the wake of a short term (day or two) grid outage. Once BEV use in on-site demand management and load shifting is demonstrated, vehicles (BEVs), can add to the resilience benefits of on-site solar and on-site solar plus storage systems. However, complete, continuous back-up over an extended period in the wake of a disaster will be subject to seasonal and daily variations in solar electricity production.

Table 5. California's Electric Vehicle Resilience Assets[15]

Resilience Asset	Est. 2020 Capacity (GW)	Market Growth (%/yr.)	Est. 2025 Capacity (GW)
EVs	**41.4**	**22**	**108**
BEV cars	30.0	23	84
PHEV cars	11.0	15	22
FCEV cars	0.4	35	2
FCEV buses & trucks	0.01	35	0.05

Locally fueled FCEVs and solar-charged BEVs connected to microgrids will provide energy resilience benefits to communities as well as individual energy users.

2.5 Community Microgrids. Table 6 provides a rough estimate of California's microgrid inventory measured according to generation capacity. Capacity is growing in spite of impediments to community microgrid development discussed below.

Table 6. California's Microgrid Resilience Assets[16]

Resilience Asset	Est. 2020 Capacity (GW)	Market Growth (%/yr.)	Est. 2025 Capacity (GW)
Microgrids	**0.0**	**19**	**1**
CHP, NG and Diesel	0.1	19	0.3
Solar, Battery, Other	0.1	19	0.3

Community microgrids have been deployed in parts of the world that lack regional or municipal grids. Where grid interconnection is available but service is prone to outages, microgrids can provide a significant resilience benefit. Where the grid interconnection is strong, for example where the microgrid interconnects with the higher voltage systems, there is an opportunity for mutual back-up.[17]

---

[15] Sources include Refs. 5.a and 5.b.

[16] Sources include Refs. 6.a and 6.b

[17] There are cases where the grid backs up the microgrid and vice versa. Smaller solar powered microgrids typically interconnect with less reliable, lower voltage "distribution" grid circuits and may have a greater reliability and resilience contribution. Larger microgrids reliant on gas turbine based CHP and CCHP units may interconnect with more reliable high voltage "transmission" grid circuits and may receive as well as provide back-up. In both cases California experience is limited and data may not be available for analysis.

Experience following hurricane Sandy and more recent disasters indicates that microgrids can not only carry load until grid service is restored but can help enable faster restoration of grid operations. Historically, campus microgrids deployed in California relied on CHP or CCHP. Existing campus microgrids may have limited roof and parking areas to be fully powered by combinations of solar and battery storage. In cases where on-site solar production is insufficient or in some seasons, the buildings microgrids serve can be backed up by other decentralized power sources (renewably fueled gen-sets and fuel cells).

In addition to emergency use, fuel cell and engine generators are being used to optimize the overall cost of making new microgrids fully resilient. The cost of relying exclusively on solar plus long term battery energy storage scales with the number of hours of storage capable of carrying all or a major part of daily load during days and weeks where solar electricity production is minimal or significantly degraded. Fuel cell and engine generators can be included in a microgrid's supply portfolio to avoid investment in under-utilized battery capacity. In cases where their economically optimum annual utilization factor of is more than a few percent, arrangements should be made to supply them with renewable methane or renewable hydrogen.

Image: Montgomery County Maryland Correctional Facility Powered by a Campus Microgrid

During a power outage a microgrid can disconnect from the surrounding grid and continue normal operations autonomously. Larger campus microgrids may have reliability comparable with that of high voltage grids. They have had an economic purpose enabled by highly efficient fuel conversion and thermal energy production and storage. In cases where microgrids also serve a resilience purpose, achieving the purpose depends, as it does in the case of larger grids, on a mix of generation sources, not a single source. Like gas and electric grids, microgrids serve as a resilience asset by enabling energy from assets like CHP, solar, batteries, fuel cells, and standby generators to feed in and be distributed to energy users.

California offers incentives and other assistance for microgrid projects. So, companies that offer microgrid design integration and controls, including Schneider, Hitachi, Siemens, and EDF Renewables are pursuing project opportunities. Microgrid implementation requires authority to distribute electricity to electricity users. Utilities have this authority because they are chartered to deliver electricity. Energy users can distribute electricity on their own property but not beyond. Local governments have the authority to own electricity distribution assets. They can set up publicly owned utilities or energy distribution cooperatives. Microgrid implementation without the exercise of above-mentioned authorities is virtually impossible.

Microgrids are assembled, not manufactured. So, there is no microgrid manufacturing industry able to replicate the manufacturing scale economies that drive growth in markets for energy resilience supply and storage assets. Rather, there are microgrid architects and system integrators who specify a mix of supply and storage assets to fit each energy usage profile. The need for each microgrid to accommodate a different suite of power source types and sizes and end use profiles may limit the benefits of standardization and scale that drive system-level cost reductions important to rapid adoption.

2.6. Locally Produced Renewable Fuels. Gas transport systems are a de facto energy resilience asset and must evolve to deliver primarily zero and negative carbon fuels. As an enabler of resilient decarbonization, locally produced negative and zero carbon fuels will have an important role regarding both decarbonization and energy resilience.

Gas transport utilities operate systems that are more flexible regarding throughput and in-line storage capacities than electricity systems. Though their systems do not need real time communication with gas users, gas utilities now face the challenge of delivering lower carbon and renewably produced gas, plus the need to ensure its compatibility with transport infrastructure. At a minimum, more complete real time monitoring of gas energy content and leakage will be required. Renewable methane can be blended with fossil methane with no technical consequences, provided it is free of contaminants, but percentages of renewable hydrogen in a blend with methane are limited by existing infrastructure that can accommodate only limited percentages of hydrogen. At current levels of renewable hydrogen production, blending is feasible, but once blended, hydrogen is costly to separate for use in fuel cells that convert it to electricity.

Gas transport systems must be retrofitted to handle low carbon fuels, upgraded to respond to real time changes in local supply and demand, and able to supply local demand when imported supplies are cut off.

Gas utilities can spur biomethane and renewable hydrogen development by investing in local infrastructure to connect gas users with local renewable sources. They can partner with local governments and developers have a pivotal role in broader use of renewable natural gas for both decarbonization and energy resilience. Leveraging California and Federal incentives, gas utilities are starting to source renewable gases, especially biomethane produced from agricultural feedstocks in other states. This step is welcome but does not address the opportunity to source renewable gases from local in-state sources while also capturing local energy resilience benefits.

The gas utility role in sourcing renewable gases from in-state sources is affirmed and clarified in a recent CPUC staff report.[18] The report recommends approval of a mandatory biomethane procurement program; state regulated gas transport utilities would be required to procure biomethane derived from organic waste at levels sufficient to meet California's statutory obligation to divert 75 percent of organic waste away from California landfills by the end of 2025.

---

[18] Cf Ref. 7.a

Incentives are available for transportation uses of renewable gas, but not for energy resilience uses. This situation exemplifies trade-offs between decarbonization and energy resilience that California will need to address.

2.7. Energy Transport Infrastructure. To minimize energy service rate increases, local energy transport infrastructure will need to operate more flexibly and at higher, more economically efficient utilization factors. Because electricity and gas usage varies more at the local level than at the regional level, local infrastructure is currently much less efficiently utilized than bulk transport infrastructure, despite demand response programs that attempt to influence energy user behavior to achieve better utilization.

More efficient electricity infrastructure utilization and more complete and inclusive energy resilience will be enabled by real time exchange of information between grid operations and building energy management systems. Capturing community resilience benefits of energy user investments energy resilience supply and storage assets will require electricity grid owners to go beyond collecting and accumulating and cataloguing energy usage information. Grid operators will need to know the status of interconnected energy production and storage systems, whether the systems are permanently interconnected at a fixed location or on a vehicle capable of interconnecting at multiple locations.

Ultimately, energy transport systems, building energy management systems and vehicle based power sources must all communicate status and economic information with one another without routine human intervention.[19] Automated dispatch of on-site resources enabled by nanogrids and microgrids may prove to be the most effective enablers of efficient utilization and energy resilience in the long term.

Achieving improved energy resilience results and asset utilization in California will require increased local engagement, including review and advice regarding local energy infrastructure investments and operations. At this time, state administered economic reward systems for energy transport infrastructure asset owners may be having a perverse effect of focusing attention on transmission assets rather than local grids infrastructure.[20] Where for-profit companies continue to own energy transport infrastructure, performance based rate setting may provide the right framework to encourage local energy collaboration.

3. Energy Resilience Stakeholders. Currently active energy resilience stakeholders include a small but growing percentage of energy users, plus backup power equipment vendors and installers. Passive stakeholders include local governments, energy product and vehicle manufacturers and retailers, energy utilities, state government, and notably, the majority of energy users that rely exclusively on energy

---

[19] The "smart" electricity grid capabilities necessary to enable greater local energy resilience have been under active discussion since the 1980s in California, along with changes in the electric utility business model would be necessary to implement them. (Will utility business models change or will new service providers simply design their business models to fit an unchanging utility business model, just as the trucking industry grew up around the railroad industry and the air travel and air freight industries grew up around both while established business models remained immutable?)

[20] California's for-profit energy transport infrastructure owners, its regional energy utilities, are incented to increase the asset base to which their profits are indexed. They enable but do not make decarbonization or local energy resilience investments. Their strategic choices, between capacity margins and efficient utilization, tend to default to centralized capacity additions. A small number of major capacity additions are easier to accommodate than large numbers of decentralized capacity additions. .

utility service. Without engagement by all stakeholders, electricity users will continue to solve energy resilience problems on their own, often after the fact of a major outage. The result will be continued uneven, uncoordinated and economically inefficient deployment of energy resilience assets.
Figure 2 outlines an energy resilience eco-system organized to implement integrated local action for energy resilience. Such action is impossible without active engagement by all stakeholders - energy users, equipment vendors and installers, cities and counties, energy utilities and state government. In a healthy eco-system:

<u>California energy users will continue to invest in resilient decarbonization by purchasing energy resilience assets.</u> They will do so in order to reduce their life cycle costs and carbon footprints while increasing their energy security. Their role is crucial, because it will continue to account for the lion's share of investment in energy resilience and decarbonization assets - for example, on-site solar plus storage systems, electric vehicles, renewable gas fueled backup power systems, and combined heat and power systems that combine with renewable sources to power microgrids.

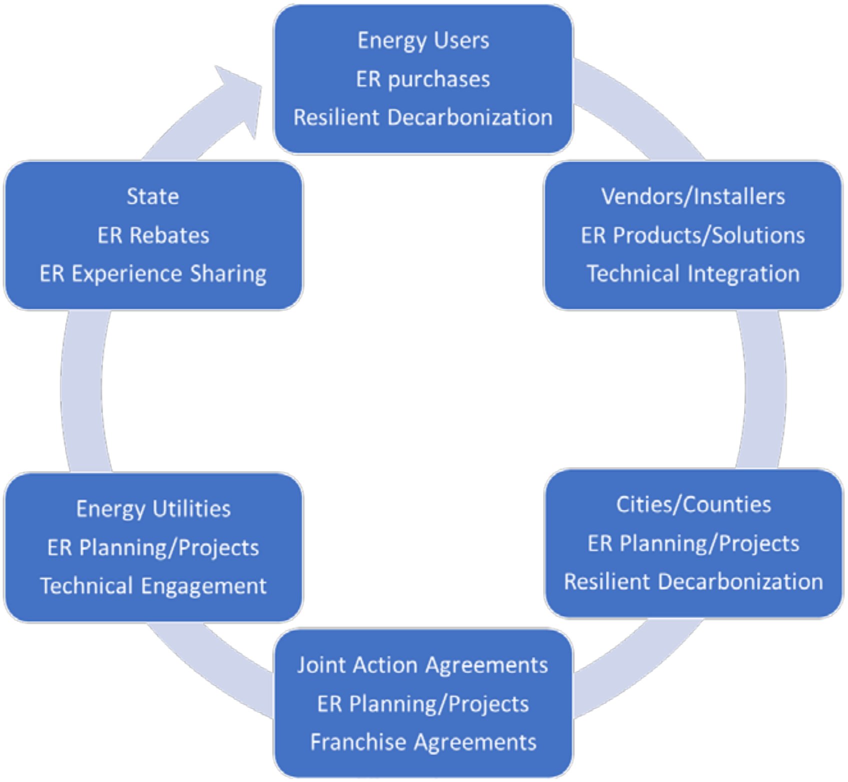


Figure 2. Local Energy Resilience Eco-system

<u>California energy equipment vendors, retailers and installers will provide increasingly integrative decarbonization and resilience services.</u> Technical and economic integration will improve as solar retailers and energy appliance installers respond to the need for technical integration of a growing array of energy resilience assets.

<u>California cities and counties will invest in and facilitate investment in decarbonization and energy resilience, for example by sponsoring community renewable energy projects on behalf of renters and by requiring new neighborhoods to be served by microgrids.</u> They will also inventory local energy resilience assets specific to their jurisdictions in order to identify opportunities and gaps.[21] For example, they will initiate purposeful engagement with electric utilities regarding municipal microgrids

---

[21] This will require cities and counties to create local versions of Tables 2 through 6.

and with gas utilities regarding 100 percent capture and conversion of locally generated organic waste to renewable gas. To do so they must acquire in-house energy management and engineering expertise necessary to move projects forward and make the services on which their community depends immune to energy service disruptions. In the future this will require attention to energy resilience planning and projects as well as their technical integration with waste and water management and other local government responsibilities.

California energy utilities will rethink, rescope and expand relationships and collaboration with local governments. For example, they will engage with cities and counties to rethink and rescope franchise agreements to empower energy resilience. The emerging shared focus will be on community energy projects that deliver a double benefit of increased energy resilience and greatly reduced local carbon emissions.

While states cannot mandate local energy resilience investments, California state government[22] will use proven strategies to incent energy user action – multi-year rebate programs, for example, that buy down the cost of early energy resilience projects. California state government will also: 1) encourage direct technical engagement by energy utility staff in local decarbonization and resilience program/project planning and implementation, 2) require that energy utilities create platforms for two way communication between energy transport infrastructure and energy resilience assets, 3) establish metrics for effective use of on-site or on-vehicle energy resilience assets, and 4) convene stakeholders to share project experience and lessons learned.
See Appendix B for additional detail on energy resilience stakeholder roles and responsibilities.

4. Summary. Gas and electric energy systems have been designed to maximize affordability, reliability and to minimize environmental impacts. Their vulnerabilities to disruption by natural disasters and physical attack or cyber-attack raise concerns about both reliability and energy resilience. Reliability is a measure of predictable, uninterrupted service. Resilience is the ability to recover quickly and completely from a disruptive event. Reliability and resilience relate but are not synonymous.
Energy resilience currently depends primarily on on-site generators, including combined heat and power systems and standby generators. On-site generators provide backup that may be limited or complete, temporary or indefinite, depending on fuel supply and storage. Additional energy resilience assets available for future use include on-site solar arrays, community renewable projects, on-site fuel cell generators, vehicle based batteries and fuel cells, and microgrid controllers that enable combinations of supply assets to operate in isolation from local electricity grids.

Putting available additional assets into use can double California's already massive inventory of energy resilience assets in the next five to ten years. More importantly, it can extend the benefits of energy

---

[22] Energy resilience is within the purview of the California Public Utilities Commission, though not an explicit regulatory priority. The CPUC concerns itself primarily with the reliability of the current state electricity supply and delivery system. Energy utility roles in meeting energy resilience needs may come into focus as the CPUC's effort to determine how to "prepare the electric grid for a high number of "distributed energy resources" gets underway. See Ref. 8.a

resilience to communities as well as individual energy users. But all of California's energy resilience stakeholders must work together to meet the challenge. Each has a critical role to play. City and county governments must come off the sidelines, and state government must remove roadblocks that prevent local governments from providing leadership and taking action.

5. Conclusions. Local energy resilience assets, other than diesel fueled backup generators, are also decarbonization assets, which suggests "resilient decarbonization" as a unifying theme of state and local policy. Energy sector decarbonization has the potential to degrade energy resilience if it relies too heavily on expansion of centralized electricity supply and transport infrastructure to achieve increased electrification of energy use. Resilient decarbonization implies trade-offs that coordinate and cross-leverage decarbonization and resilience investments.

California's investment in on-site and community renewable and zero emissions vehicle assets is already comparable in dollar magnitude to California's investment in bulk electricity generation and is expected to double in the next five years.[23] But energy resilience benefits are currently limited to energy users owning or leasing assets that are connected to on-site circuits. This is especially sub-optimal from energy equity[24] and community energy resilience perspectives.

At present, on-site resilience assets typically are not used to back up neighborhoods and communities. Achieving such coordination would strengthen both state and local economies. Effective coordination would require more active and purposeful attention by energy service providers and energy retailers.

Resilient decarbonization is an urgent local need requiring local initiative and leadership. It cannot be outsourced, because the best pathway is unique to each city or county. Among currently inactive stakeholders, local governments and utilities have crucial future roles if energy resilience is to be achieved at the community level as well as the site level. Cities and counties have the most at stake economically and will need to develop energy management skills and programs if they are to engage promptly and effectively. Utilities have technical capacity to facilitate economic integration of energy resilience assets but as yet have no obligation under state law to do so.

State government has the ability to facilitate local leadership and engagement and to reward energy utility engagement and investment. Until currently inactive stakeholders step up, energy resilience will depend on individual energy user choices, and many users will continue to have no choices or ineffective ones.

---

[23] The supplemental capacity in California to supply electricity in the wake of a disaster or attack that disables all or part of the state-wide electricity grid is approximately 70 GW - close to the 80 GW combined capacity of in-state utility scale power generation resources – and is likely to double in the next ten years.

[24] Energy equity refers affordable and low income and minority communities' access to clean and resilient energy service.

References.

1. Energy Resilience
    a. IRESN, Local Gas Fuel Decarbonization and Resilience
    b. BCSE, Energy Resilience Case Studies
    c. ANL, Building a Resilient Energy Future
    d. CEC, State Energy Resilience Framework
    e. SCG, Energy System Resilience
2. CHP
    a. CEC, Small Combined Heat and Power Technical and Market Potential in California
    b. NIST, Community Resilience Planning Guide for Buildings and Infrastructure Systems
    c. CEC, State of CHP in California
    d. WRI, Renewable Natural Gas
    e. Entropy Research, State of the CHP Industry and Market Trends
3. Solar PV
    a. CPUC, California Distributed Generation Statistics
    b. IRESN, Solar Power Cost, Benefit and Capacity Shifts
    c. CEG, Overcoming Barriers to Solar and Storage in Affordable Housing
    d. Utility Dive, LA Solar Plus Storage Microgrid Pilot
    e. NREL, Microgrid-Ready Solar PV - Planning for Resiliency
4. Standby Generators
    a. MC3, California's Fossil Fueled Backup Generators
    b. CARB, Additional Generator Usage Associated with Power Outage
    c. NREL, Fuel Choice for Backup Generators
    d. Million Acres, Do You Need a Standby Generator?
5. Battery and Fuel Cell Electric Vehicles
    a. GCC, BEV Sales in California
    b. FCW, California FCEV Sales
    c. Deloitte, Fueling the Future of Mobility
    d. Applied Energy, Integrating FCEV, V2G and PV Technologies
    e. APERC, Challenges of BEV and FCEV Deployment
    f. ResearchGate, V2G with FCEV as Power Plant
6. Microgrids
    a. Hitachi, Microgrid Market in the USA
    b. GMI, North American Microgrid Market
    c. Microgrid Knowledge, Fuel Cell Microgrid for Billion Dollar Data Center
    d. ICN, Microgrids Keep Cities Running When the Power Goes Out
    e. BioCycle, Biogas and Microgrids in California
    f. Schneider, Case Study – Innovative Technology to Weather the Storm
7. Electricity and Gas Transport Infrastructure
    a. CPUC, SB 1440 Implementation
    b. CPUC, OIR to Modernize the Electric Grid

Appendix A. Resilient Decarbonization Enablers and Barriers

Enablers:

1. Integration of Zero Carbon Vehicles with Local Energy Transport Systems. California energy users have funded a massive investment in energy transport systems. These systems were not intended to transport electricity and fuels for use in vehicles. Yet they can and must be used and adapted to this new purpose. The challenges are daunting in each case. Operation of electric systems and gaseous fuel distribution systems has relied on the predictability of stationary energy uses. Electric systems must now be adapted to not only deliver energy to "moving targets" but to accept energy from them. Gas transport systems must now be adapted to not only deliver an evolving blends of lower and lower carbon fuels but to source fuels locally rather than rely on interstate pipelines. These transformations require a much higher level of technical and managerial attention than before.

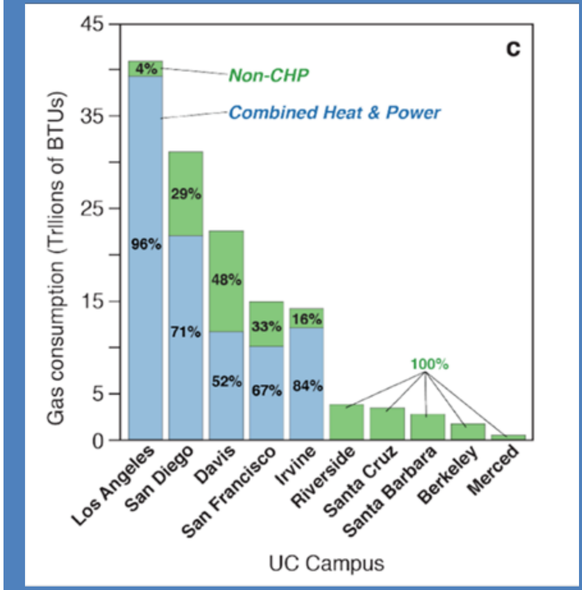
2. Storage Coupled On-site Solar. On-site solar heating installations are inherently resilient because solar water heating panels are coupled with water tanks that provide for heat storage. Likewise, solar PV arrays have inherent resiliency when coupled with battery storage. Thanks to growing demand for computer and vehicle batteries, battery manufacturing costs are trending downward. Some solar retailers are starting to gain experience providing proper battery installation and service. This trend responds to the emerging need in California to shift on-site solar electricity consumption to peak electricity usage periods. Utilities and state regulators can respond to the need by compensating energy users for energy resilience benefits they help provide as well as cost savings made possible by shifting usage to lower-demand periods.

3. Heat Pumps and Building Energy Retrofits. The accelerating impetus in California for decarbonization will have a knock-on effect strengthening energy resilience. Solar arrays and electric vehicles are decarbonization and energy resilience enablers. Electrification is one of several pathways to building and transportation decarbonization, though not necessarily to improved energy resilience, should California come to rely even more on large power plants and high voltage transmission. Where local electrification initiatives focus on substitution of renewable energy for non-renewable energy (for example, solar electrification of buildings), they may have the added benefit of opening a pathway to improved energy resilience.

4. Micro CHP. While storage-coupled solar arrays can deliver a resilience benefit when deployed on homes and low rise buildings in suburban and rural areas, demand in high density urban areas can greatly exceed their potential ability to meet cumulative local demand. Recognition of micro-CHP's reliability and resilience benefits combined with its life-cycle economic energy efficiency benefits can lead to an expansion of micro-CHP deployment in urban areas, especially in cases where renewable gas fuel is available and affordable.

5. Biomethane and Renewable Hydrogen. As described in the sidebar the University of California is moving aggressively to substitute renewable natural gas (biomethane) for "fossil" natural gas extracted from underground formations. Production of renewable natural gas is an alternative to organic waste disposal practices that result in releases of methane, a potent greenhouse gas, into the atmosphere. What are the local energy resilience benefits of renewable gas use? Gas fuel is essential to the affordability and effectiveness of neighborhood and community microgrids, but new California projects that result in increased natural gas use may be misaligned with local climate action goals. However, renewable gas can be produced as a byproduct of essential local waste management operations, greatly reducing local methane emissions and making its use in fueling CHP, standby power and microgrids a win for local decarbonization as well as local energy resilience.

6. Stationary Fuel Cells. Multiple fuel cell technologies are in commercial use around the world. In addition to fuel cell technology suitable for vehicle propulsion, technologies for stationary applications with modularity in the 250 kW and 2 MW size range and larger are in use around the world. Their energy resilience benefits are a byproduct of their ability to produce power at costs lower than retail electricity prices. Their commercial and industrial use in California faces headwinds because their cost-effectiveness depends on the number of hours per year they produce electricity. This conflicts with California's goal to minimize the number of hours per year it relies on natural gas generation. Fuel cells best fit to California's power generation needs may be as mainstays of campus microgrid supply portfolios where the campus has limited areas for solar PV deployment. In these cases, the microgrid can provide a high degree of energy resilience.



The University of California system includes 10 campuses, 5 medical centers, and California based national labs. Its primary GHG emissions sources are natural gas (63%) and purchased electricity (29%). Its decarbonization plan aims for carbon neutrality by 2025. It is halfway to its goal of substituting cap and trade eligible renewable natural gas for natural gas from geologic formations.

UC's plan aligns with California policy to emphasize substitution. For example, California has phased out self-generation incentives for CHP projects that do not use 100% renewable fuel, while supplementing incentives for projects that rely on biofuels. California has many energy programs and policies and no doubt is considering how to balance state interests in decarbonization with local interest in energy resilience and its benefits to local economies.

Barriers:

1. Under-investment in Integrated Local Electric Systems. Electric transportation and solar/battery markets are likely to be transformed by high volume product sales and resultant industry scale up. But without strategic utility investment in smarter local grids and public investment in setting up microgrids, the majority of available resilient energy supply assets will remain just building and transportation decarbonization enablers.

Barriers to economically efficient local energy resilience and decarbonization can be lowered in multiple ways. First, emerging resilience options – solar PV and electric vehicles - can be sized and integrated to provide full on-site energy resilience rather than resilience that is impaired or jeopardized by seasonal variations and cloudy weather. Second, the economic use of both current and emerging resilience assets can be enabled by their connection to independently operated neighborhood community microgrids. These neighborhood and community microgrids may share infrastructure with utility distribution systems and/or may serve to back them up. Decentralized operation as integrated energy sources allows them to deliver economic, decarbonization and resilience benefits denied under rules that only maximize electric utility revenues.

2. Under-investment in Local Carbon Negative Fuel Production and Distribution. Use of locally produced renewable methane and hydrogen[25] has potential to reduce GHG emissions from solid and liquid waste management, which comprise 2 percent of California's GHG inventory, as well as GHG emissions from livestock manure management, which comprise about 3 percent.[26] Locally produced renewable fuels are a natural complement to most or all categories of on-site power assets, enhancing their resilience benefits, and in the case of solar assets, eliminating the need for long term battery storage. Renewable fuels can be converted to low or zero carbon electricity or motive power and to back up electricity that powers buildings and microgrids.

---

[25] Renewable methane, aka renewable natural gas, is produced from organic wastes in in numerous small scale systems throughout California. Renewable hydrogen is not yet produced in comparable amounts.

[26] It also has potential to reduce the amounts of geological natural gas (NG) being produced outside of California and the related methane leakage and water consumption impacts of NG production via fracking and long distance NG transport. Though difficult to quantify and not currently included in California GHG inventories, these indirect decarbonization and environmental benefits are comparable in magnitude to those deriving from avoidance of waste management related emissions.

Appendix B. Energy Resilience Stakeholder Responsibilities.

Enabling cost saving and improved technical and operational integration will require active, mutually supportive engagement by five California stakeholder groups: 1) energy users, 2) energy equipment vendors and retailers, 3) cities and counties, 4) energy service providers[27], and 5) legislators, regulators and government agencies.

Most energy users learn from experience and are eager to avoid the inconvenience of extended power outages. They are eager to share their experience with one another, which results in better investment decisions generally and better informed transactions with equipment vendors and retailers and energy service providers.

Their opportunities in energy resilience assets depend critically on the experience and capacity of local energy equipment vendors and retailers. Teamwork among local companies can result in better integrated energy resilience and decarbonization assets. For example, retrofit packaged that combine on-site solar and heat pump enabled space and water heating can be offered by solar retailers teamed up with HVAC installers.

The combination of an unlucky event and lack of preparation can literally wipe a community off the map or leave it crippled and struggling. Cities and counties face an existential energy resilience concern. They make energy resilience investments and are primary beneficiaries of energy resilience investments by energy users and energy service providers.

Both gas and electric utilities have much to contribute to increased local energy resilience. They have learned that disasters for which they share responsibility can seriously inconvenience their customers, employees and even their shareholders and bondholders. They pay little attention to on-site energy resilience but must begin to pay a great deal of attention to energy resilience enabled by community energy supply resources, nanogrids and microgrids.

Finally, state governments in the US exercise a constitutional right to set energy policy and are accountable to voters to regulate in-state energy services in the public interest. As local California governments work to make their communities energy resilient, state policies must be adjusted to remove roadblocks.

Little will happen to significantly improve local energy resilience unless all of the above-mentioned five sets of stakeholders do their part and reach out to one another. What is the best thing each stakeholder can do to bring about greater and more pervasive energy resilience?

1.1 California energy users: Invest in resilient decarbonization. California energy users are directly reducing local carbon footprints while laying a crucial foundation for improved energy resilience.

---

[27] Energy service providers include gas and electricity transport utilities, “direct access” electricity wholesalers and Community Choice agencies.

Until now, most California energy users have out-sourced affordability, decarbonization, reliability, and resilience to state agencies and state or locally regulated energy transport utilities. This made sense when electric service reliability was high and extreme weather and natural disasters were rare. But now, public safety power shut-offs have degraded electric service reliability, and energy users face the need to backstop an electricity system that is increasingly less reliable and perhaps also less resilient. They can choose from a menu of resilient decarbonization options. They can purchase micro CHP systems or standby generators or solar plus battery systems. They can purchase battery and fuel cell electric vehicles, charge and fuel them with renewable energy, and push for changes that allow vehicles to supply electricity to building circuits when the local electricity grid is de-energized by disaster or precaution. Their energy investments will be sub-optimally rewarding until rules are enacted that maximize their cost-effectiveness.

4.2 California clean energy retailers: Provide decarbonization and resilience services.

A California homeowner or business can purchase an energy appliance or solar array and get it installed. Retailers pass along available clean energy vendor warranties. Like energy utilities, their business models are founded on industry experience gained when decarbonization and energy resilience were not major consideration for most customers. The focus then was affordability and trouble-free long-term operation.

Now decarbonization saves money.[28] Electrification is a pathway to decarbonization. Full solar electrification that achieves net zero carbon at the building level saves more money than substitution of solar electricity for historical grid electricity use enabled by net metering rules. Solar plus storage systems have potential benefits for local grid operation that would need to be shared with system owners before rapid adoption can be expected. On-site solar plus storage systems must be “microgrid-ready” - designed and installed in ways that allow integration with neighborhood and community microgrids, when they are deployed, without major additional owner expense. Until then, deployment of solar plus storage systems that provide backup in an emergency will be limited.

These are issues that installers are typically not prepared to address. But decarbonization and resilience services that provide clean energy security at the least life cycle cost will be required. These are issues that installers are typically not prepared to address. But decarbonization and resilience services that provide clean energy security at the least life cycle cost will be required and rewarded. Until such services are available, pathways to resilient, cost-efficient decarbonization will be too hard for most energy users to navigate.

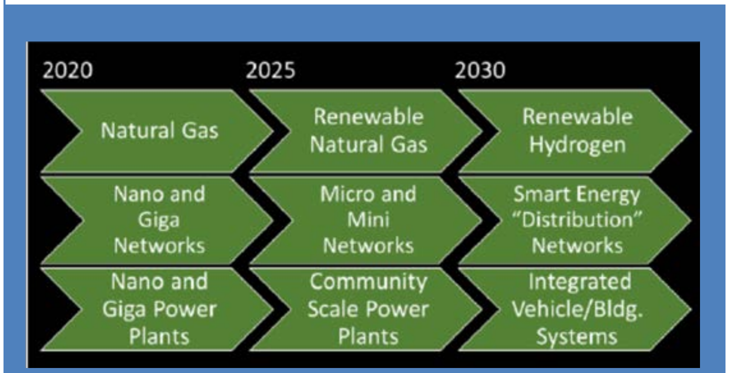
---

[28] https://www.iresn.org/news/2021/6/17/solar-power-cost-benefit-and-deployment-capacity-shifts

4.3 Local governments: Implement energy resilience projects. Lack of community investment in renewable projects continues to undermine energy resilience, making it all the more important that individual energy users know their options and make economically self-interested choices.

However, energy users that do not own real estate have limited energy resilience investment options. Specifically, low-income and minority communities and renters are at risk of not having solar or micro-grid options available. They must rely on local governments to invest in decarbonization and energy resilience on their behalf, for example by sponsoring community renewable energy projects and requiring new neighborhoods to be served by microgrids. Local energy sector decarbonization can strengthen local economies and generate revenues to provide municipal services. Local energy resilience improvements can substantially cushion the economic blow to a community in the wake of a disaster or disruption of energy supplies coming into the community from afar.

LOCAL CAAP WHITE PAPER



Technologies likely to have the greatest impact in reducing a community's carbon footprint are in most cases technologies that can be adopted by residents, businesses and public agencies. Therefore, timely local action empowered by collaboration with energy service providers will be crucial in the years ahead as California cities and counties act to reduce GHG emissions and improve energy resilience. On average, fifty percent of local GHG inventory reduction is locally actionable. Starting a decade ago many southern California cities and counties prepared and adopted Climate Action and Adaptation Plans (CAAPs). These plans addressed building energy use and opportunities to import low carbon electricity. Now cost-competitive renewable gas and electricity can be produced and distributed locally, helping insulate communities from risks of being cut off from regional energy delivery networks. An IRESN white paper identifies specific immediate opportunities to decarbonize fuel production and usage for heating, transportation or industrial and agricultural operations are identified. Emerging opportunities that will be actionable later or by the end of the decade are also identified as are potential local GHG inventory reductions that can result from taking local action are identified.

Preparing a local climate action and adaptation plan, a hazard mitigation plan or the public safety element of a general plan is an opportunity for a local government to consider taking direct local action. By focusing a major part of the local planning effort on energy resilience, local projects can be targeted that have realistic prospects for implementation. Consultants that offer local climate planning assistance are knowledgeable regarding processes for public participation in setting decarbonization goals. But they may have little or no expertise related to energy resilience. So, local governments must engage with relevant industries and experts. Planning with an intention to implement requires active participation by energy engineers and public works engineering staff in the planning process.

Some local governments are starting to engage with electric utilities regarding municipal microgrids. Others are starting to engage and with gas utilities regarding 100 percent capture and conversion of locally generated organic waste to renewable gas. In both cases, projects the engagement process sets in motion can deliver a double benefit of increased energy resilience and greatly reduced local carbon emissions.

At a minimum, every climate related local planning and energy project development initiative should draw on energy utility technical expertise. Energy utilities should commit engineering research resources to advise local planning efforts, because the focus of such efforts should be on transformation, not business as usual.

4.4 Energy utilities: Rethink, rescope and expand relationships and collaboration with local governments. Utility franchise agreements compensate local jurisdictions for the right to maintain and operate above-ground and underground infrastructure in public rights of way.[29] A broader agreement scope would give local governments and utilities context and leverage to move energy resilience project implementation forward. For example, enabling decarbonization and increased energy resilience requires locally produced energy to be more widely accessible when energy flows into a community are cut off. It requires that electricity produced on energy user property be enabled to feed into local microgrids when necessary to avoid loss of service to local areas. New local energy transport infrastructure, microgrid controllers and automated distribution system operations software, that enable access to locally produced energy could be a legitimate item on the negotiating table.

If the scope of negotiation and collaboration between local governments and energy utilities is to expand, what capabilities and assets do the two sides bring to the table? On the electricity side, cities and counties may control and be willing to lease brownfield sites suitable for solar project development, while the utility is a potential “off-taker” for any energy the local government enables to be produced locally. On the gas side, cities and counties may control organic waste streams suitable for conversion to biomethane that can be cleaned up, fed into local gas distribution systems, and resold locally by the gas transport utility.[30]

Negotiation and collaboration can focus on strategic energy resilience outcomes. For example:

---

[29] Undergrounding of local transport infrastructure is perhaps more fundamental to energy resilience than any other economically feasible measure. How well underground infrastructure is maintained also has reliability and resilience implications.

[30] Gas utilities can charge a premium for locally produced gas, just as electric utilities charge a premium price for one hundred percent renewable electricity.

- Sharing costs of cleaner and more resilient back-up generation for schools and critical local facilities.
- Sharing costs of enabling local organic waste streams to be collected and converted to biomethane.[31]
- Sharing costs of equitable access to resilient on-site solar electricity for community members unable to take advantage of net energy metering.

Achievement of such outcomes likely would start with utility leaders and elected officials kicking off and negotiations and charging negotiators to work toward win-win outcomes.

4.5 States: Buy down the cost of early local energy resilience projects.

Capturing emerging energy resilience opportunities will be a slow process until energy utilities create local grids that are inter-operable with microgrids and even smarter than those needed to take advantage of on-site solar plus storage capacities. The need is for utilities to engage and do so in a way that is collaborative, not monopolistic. States must reward utility collaboration with local governments while opening pathways to non-utility investment.

California benefits when disaster recovery in any of its local jurisdictions is accomplished quickly thanks to resilient local energy supply and services. California does not yet have quantitative energy resilience goals, metrics and investment strategies. Its cities and counties have begun to identify critical energy needs, but they lack experience and budgets.

California's most successful energy incentive programs, including the California Solar Initiative, have been designed to offer rebates that decline as experience is gained and costs come down. This design rewards timely adoption decisions. Local government expenditures on energy resilience project management and project engineering could also be eligible for rebates, as could costs of project implementation. Rebate percentages could be adjusted according to whether on-site systems provide partial, temporarily or complete and indefinite back-up.

The primary eligibility criterion should be energy resilience, the ability to provide safe and clean energy service when energy networks cannot. The focus should be on shovel-ready projects and commercially available equipment.[32] For example, community and neighborhood microgrids capable of islanding would qualify as energy resilient. So would fuel cell and battery electric vehicles equipped to serve as emergency generators. [33]

---

[31] This requires creating a blend of renewable and non-renewable gas for local use, thus simultaneously reducing the local carbon footprint and methane emissions released in fracking operations and long distance gas transport.

[32] Timely energy resilience investments are crucial. In addressing climate risks, to be late is to be irrelevant. Rebates are preferable to grants. Five years is a typical time period from California energy grant program initiation to completion of work on the first round of grants.

[33] Rebate eligibility criteria may exclude commercially available solutions already in wide-spread use, such as diesel fueled gen-sets.