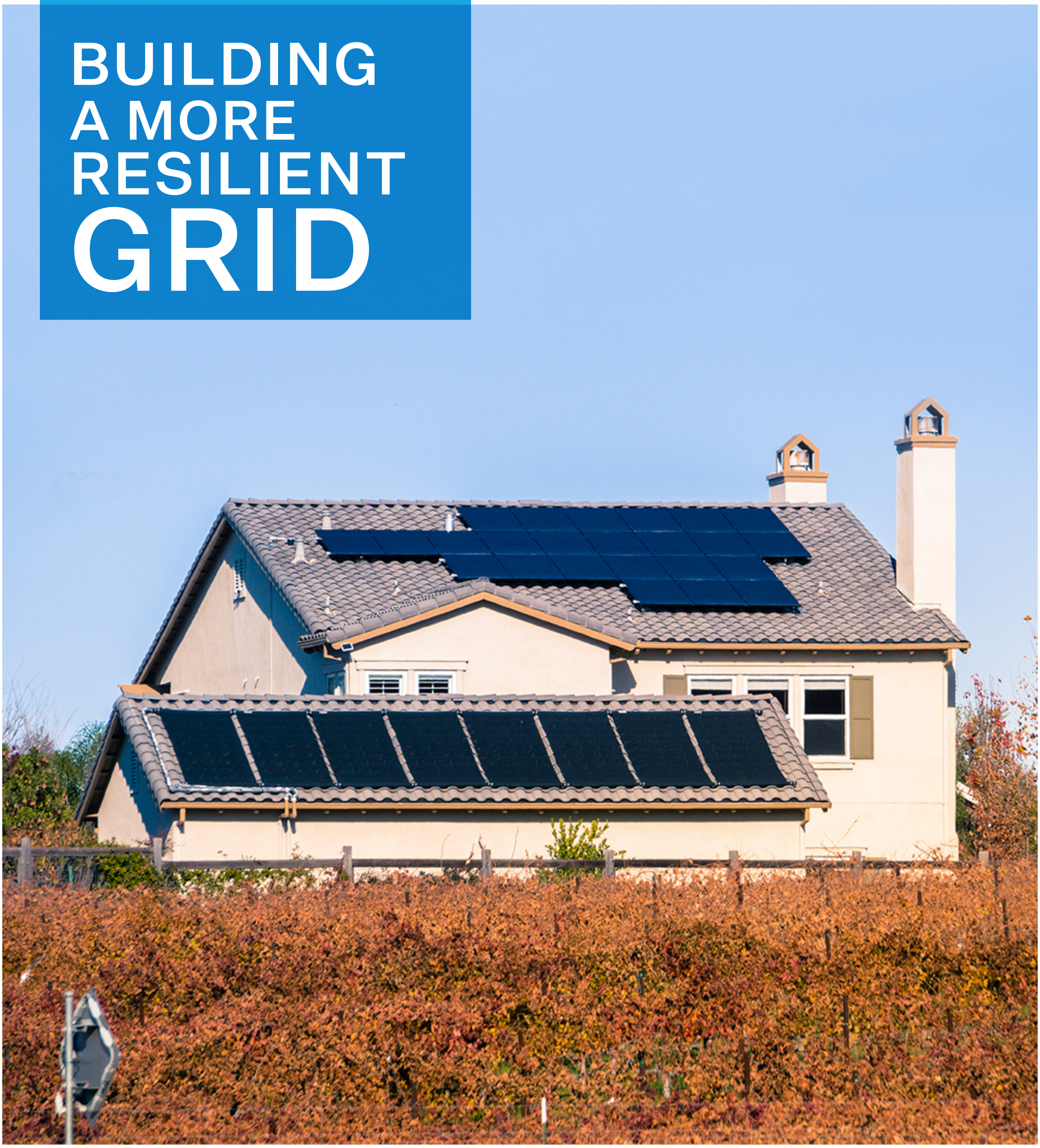
BUILDING A MORE RESILIENT GRID



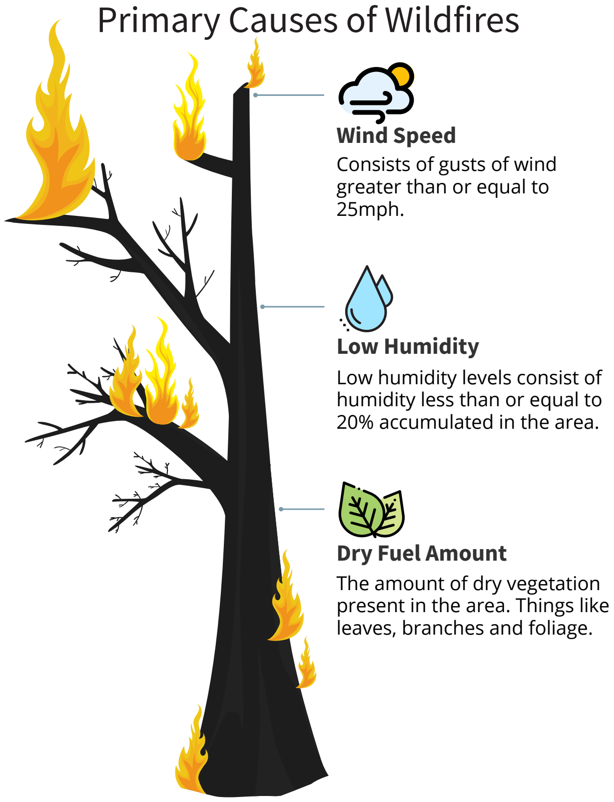
Home Solar & Storage
Mitigate Wildfire Impacts

March | 2019

Rethinking the Electric Grid

Extreme weather events are becoming both increasingly common and destructive. Over the past 40 years, fire seasons have grown significantly longer[1] and large fires are five times more common than they used to be.[2] Today, higher temperatures and prolonged dry weather are testing our existing energy infrastructure and threatening the condition of our environment.

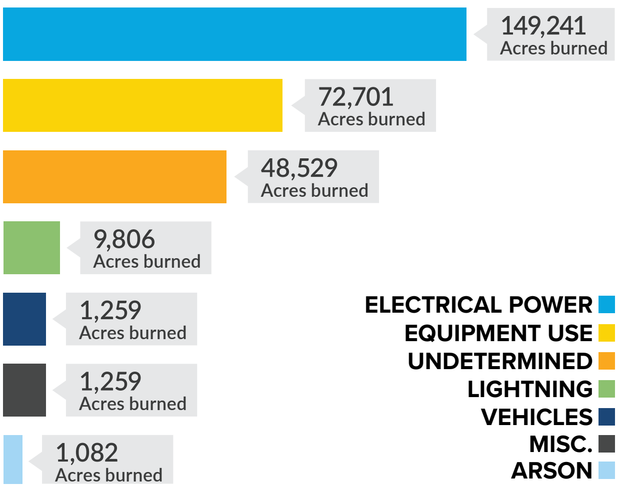
According to the Fourth National Climate Assessment of November 2018, "climate change and extreme weather events are expected to increasingly disrupt our nation's energy and transportation systems, threatening more frequent and longer-lasting power outages, fuel shortages, and service disruptions, with cascading impacts on other critical sectors."[3]



Source: Switching on the Big Burn of 2017, University of Colorado at Boulder

Destructive Power

Wildfires sparked by power lines and electrical equipment burned the most acreage in California in 2015.



Source: California Department of Forestry and Fire Protection

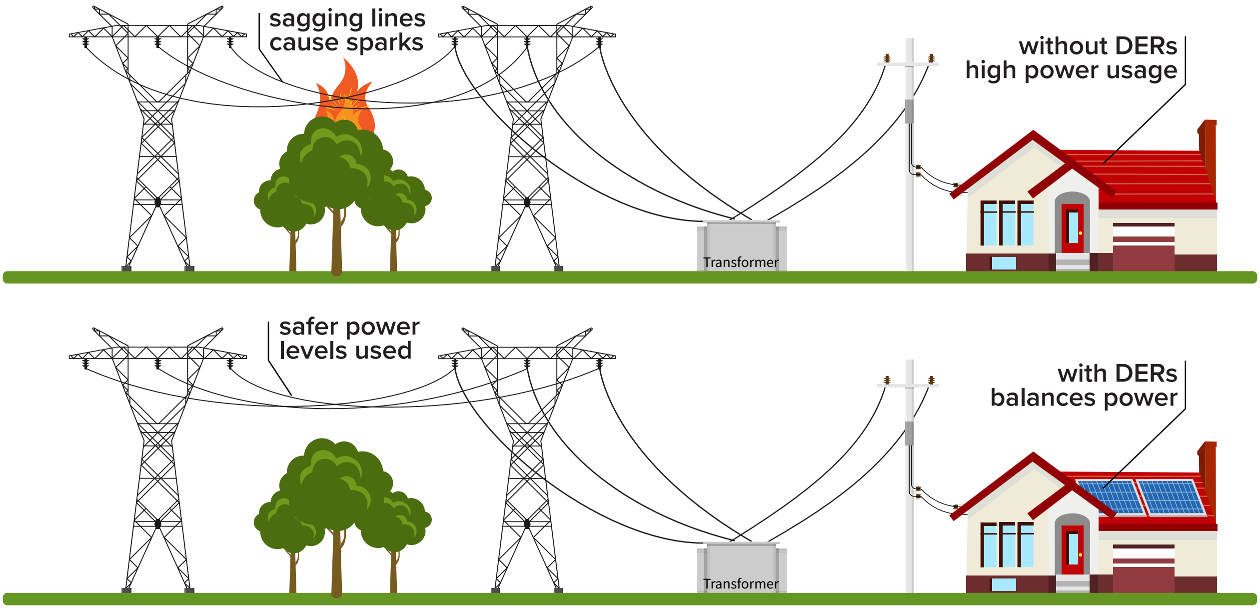
Today's electric grid is energized by large power lines that deliver electricity across long distances from centralized power plants—many of which exacerbate climate change by using harmful fossil fuels. More than 70% of America's transmission lines and large power transformers are at least 25 years old.[4] Our aging energy infrastructure is not equipped in many places to withstand the growing impacts of climate change.

Local **distributed energy resources (DERs)**, such as home solar and batteries, can provide more resilient energy solutions in high-risk fire areas that are serviced by electric lines. DERs can reduce or outright prevent power outages for homes, businesses, and other critical facilities. Home solar and batteries can provide reliable energy and keep electricity running for energy users. This technology can also reduce the chances of electric sparks caused by a problem with overhead lines, which could result in dangerous wildfires.

Impact of DERs on Circuit Loading

Electrical power flowing through circuits causes them to heat up. When an electrical circuit heats up, it will expand proportionately to temperature. This affects how close to the ground that circuit hangs, the "sag". Too much sag can bring the circuit closer to other objects or circuits resulting in sparks which have potential to cause wildfires. In addition to temperature changes, the sag of a circuit is also affected by how the circuit has been supported, the materials used in its construction (which also impacts how the circuit responds to temperature), and certain weather factors. The amount of circuit sag was a contributory factor in the October 2017 Fire Siege, as reported by Cal Fire.[5]

Power Level Optimization



Illustrative example, actual line sag changes will vary by route and number of DER systems.

Apart from the power flow, the factors that affect sag can only be changed when a circuit is constructed or modified. Some factors, like weather conditions, are outside of utility control. In order to control temperature and sagging, limits are placed on the amount of power flowing through electrical circuits. These limits are often based on a worst case scenario.

A traditional approach to managing the risk of wildfires is to switch out particular circuits entirely; this is the most established mechanism to prevent any fire causing sparks. However, this will also result in a change to the route that power takes around the rest of the network. When deciding to switch out a circuit, a utility must be sure that this does not cause any other circuits to become overloaded and sag excessively, which would cause further problems in the event of the loss of additional circuits. This may mean that some homes cannot be supplied with power at all, or that the circuit is forced to remain in service as the wider network cannot safely pick up the load. DERs help to reduce power flows by picking up the additional load around the network and keeping electrical circuits within their power limits. Usage of DERs also ensures that there is spare capacity to respond to future events without causing unacceptable temperature increases. In the event of disconnection to the main grid, DERs can directly supply energy to the disconnected homes, as discussed in more detail later in the document.

Currently static limits are the norm for limits on power flows, however the use of dynamic thermal limits, which adjust to changes in ambient temperatures and weather conditions, is a growing practice for some utilities on suitable circuits. This practice helps to maximize the use of capacity through measurement of sag and/or temperature and weather conditions.[6] Dynamic thermal limits recognize that on cooler days, the circuit can carry more power before it reaches the temperature limit due to the lower starting point while less power can be carried on hot days.

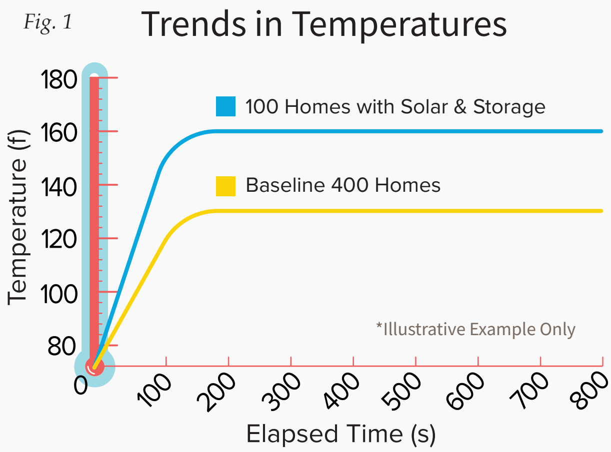
An alternative option for using dynamic thermal limits compared to how they have been applied in the industry to date could be to apply a lower temperature limit, with a corresponding reduction in permissible power flow, to meet a temporary situation where less sag than normal would be desirable. This dynamic clearance limit could be a mechanism, particularly where other options are not available, to increase the distance between circuits and other objects in the vicinity of the circuit in question. Doing so would reduce the risk of circuits and objects coming too close together. DERs could assist in taking up some of the load on the circuit, especially batteries which allow for times of high risk to be specifically targeted. Such application is worth further exploration to fully understand its application and usefulness in this context.

At today's levels of DER deployment, their impact on power flows across the whole network are limited. However, increasing uptake in at risk locations will open opportunities for these technologies to assist utilities in active network management to address fire risks in the future.

Home Solar & Storage: Strength in Numbers

Higher power flows can be acceptable for a limited time without reaching unacceptable temperatures. This time-limited additional capacity allows time for repairs to be made and other changes to the network to be carried out. With DERs present in a community supported by an electric line, both the power usage and the temperature of the wires can be reduced. This allows more time to resolve issues and maintain supplies.

Fig. 1



Consider an illustrative sample community of 500 homes, all of which are using about five kilowatts of power[7], which is roughly the profile of a significant number of homes in fire-prone areas in California. All these homes are currently connected to the wider network by a single electricity line. For a small community such as this, as few as five to ten houses with rooftop solar and batteries could assist in maintaining the power transported through the electricity line depending on the circuit.

Even in the case that this community were to require more energy and the electricity line supporting it reaches 100% capacity, this hypothetical community could only need fifty to one hundred homes with rooftop solar and storage to return to safe conditions.

Naturally, DERs are more useful as more homes have them, but the minimum threshold to be valuable to engineers can be as low as a handful of customers, depending on how the electricity system in that area has been designed and built, as well as the needs of the community.

Fig. 2

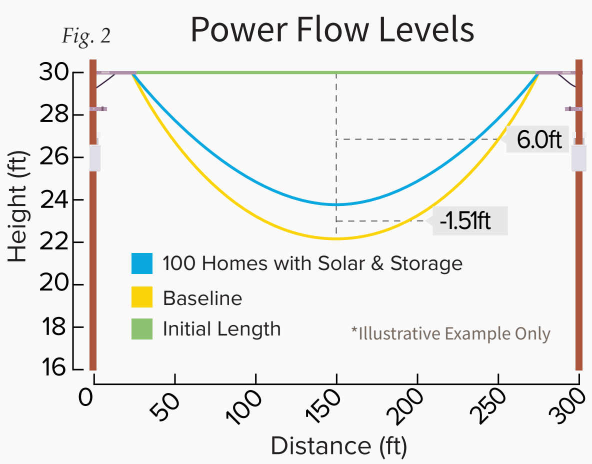


Figure 2 to the left illustrates how the sag of a theoretical line might change as power flow, and hence the temperature of the conductor, is reduced by meeting load through solar and storage rather than the distribution grid based on industry standard formula and simplified assumptions about the construction of the line. Meeting all load through the distribution grid results in a temperature of 176F and a sag of 6ft. Transferring the equivalent of 100 homes to locally supplied energy reduces the temperature to 140F and the sag by 1.5ft. Real-world values will vary depending on line construction and weather conditions.

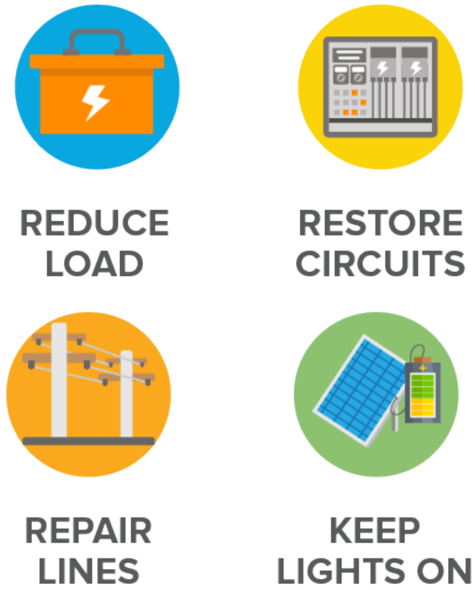
Home Solar & Storage Offer Solutions

Solar and battery technology can help maintain safe limits[8] of power flows on distribution lines if they are required to carry additional power due to problems elsewhere on the network. This could help communities maintain electricity, even after one or multiple issues occur that would typically involve turning off energy generation infrastructure or electric lines.[9]

Buying Time for Engineers

Local solar and batteries can reduce the overall strain on a community's energy infrastructure, by lowering the amount of electricity pulled from the centralized grid.

This could help keep a system operating within safer tolerances for a longer period of time, giving grid operators and line workers more time to respond to outage events. Workers need time to drive out to a site for repairs or implement other solutions to keep the lights on for affected residents.



Making it Easier to Avoid Power Outages

During the most recent wildfire season in California, Pacific Gas and Electric (PG&E) faced difficult decisions about when and if to cut electricity to entire communities as a way to ensure safety during at-risk times like red flag warnings. In October 2018, PG&E took the exceptional step of de-energizing power lines in at-risk areas across Northern California. Sadly, the recent Camp Fire may have been caused by a line that PG&E decided not to de-energize.[10]

Proactively cutting power from transmission lines is one of the safety tools available to utilities, but it should be a last line of defense due to the serious service disruptions it causes for customers who rely on the electric lines. Expanding the range of safety and resiliency solutions available to utilities and other energy managers should be a priority. DERs like home solar and batteries offer one such solution that is available today to communities as a tool to avoid power outages.

More Efficient, Clean Grid Investments

Where utilities model load growth and/or the need for new energy infrastructure investment, DERs provide a flexible approach that allows grid planners the ability to determine if more traditional poles and wire replacements are necessary and if predictions are accurate.

DERs could also reduce requirements for deployment of fossil fuel power generators during emergencies. Increased deployment of DERs can also make it easier to use simpler and cheaper electric lines, like lower capacity distribution lines.

As an example, if a utility predicts it needs to replace the wires along a route to meet forecast future loads, relying on DERs for a year or two allows grid planners more time to assess whether there is an actual need to spend on a new high capacity lines (high cost) or if a lower capacity line, or the existing line, would be suitable. The flexibility and reduced upfront costs afforded by DERs saves money to the utility and consumers.

Solar and Battery

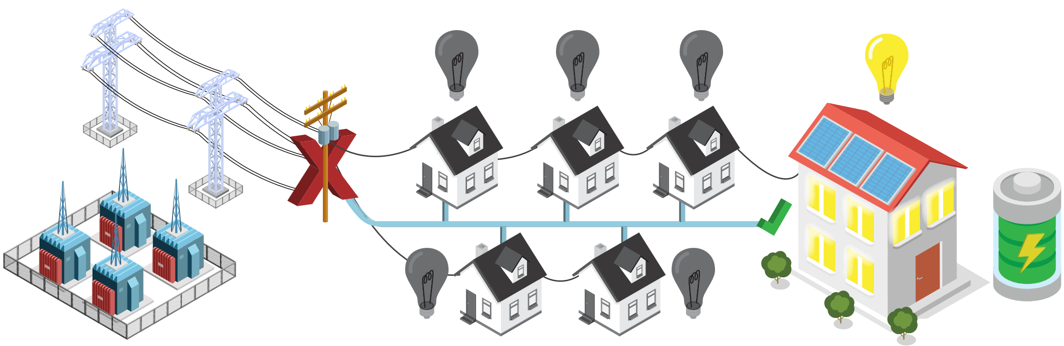
Safe Power Limit

Make Better Use of Capacity

Maintain Power

Individual Home Scenario

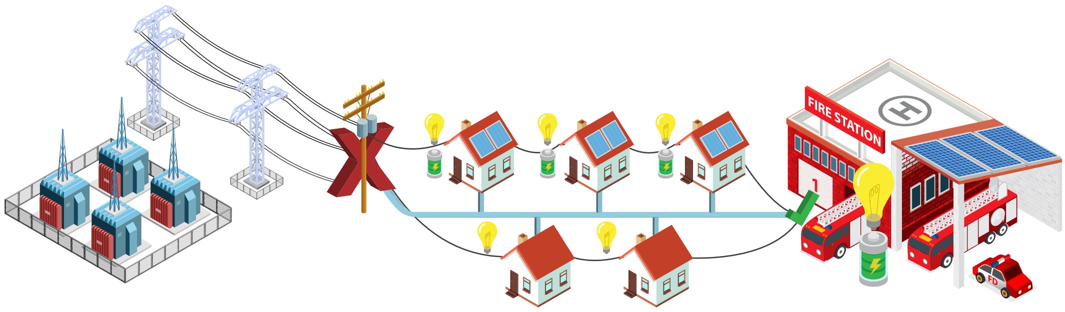
In the instance of a local power outage, the average household would be left without power. However, a house with solar and batteries would maintain continuous power.



For many communities, there is sometimes only one way for electricity to get to a neighborhood. If that path is blocked, for instance due to the circuit being turned off because of concerns about the possibility of wildfires, it will cause a local blackout. However, homes, businesses, and critical facilities equipped with solar and batteries would be able to keep their electricity running during these outage events. This is particularly important for residents who may require continuous power or backup to ensure uninterrupted use of critical loads.

Community Microgrid Scenario

With the right policy and technical support, neighborhoods could benefit from shared solar and storage.



Homes and/or critical facilities equipped with solar and batteries, such as fire stations and schools, could provide electricity to all homes sharing an islanded circuit in the neighborhood during a blackout.

Currently this is only permitted where a connection to the wider energy network exists or in specific connected microgrid campuses.[11] As technology and regulation evolve, the formation of smaller energy networks to safely supply local properties with local energy backup solutions such as home or community solar with storage may become possible. Policymakers can fundamentally change grid planning by adopting standards that enable neighbors to share power during emergencies and place limits on interruption of supply under all conditions. This could include requiring no interruption of power to critical infrastructure and setting specific time limits on permitted interruption to all ratepayers, along with action plans to address any deficiencies. By ensuring that the right standards and requirements are in place, these types of policies can build upon distributed energy solutions to create further minigrids and microgrids and improve reliability of supply for all ratepayers.

Conclusion

Home solar and batteries can provide for more resilient energy solutions in high-risk fire areas serviced by electric lines. More importantly, they can help reduce or even prevent power outages for homes, businesses, and other critical facilities.

Rate payers deserve better solutions from their utilities. Sustainable business models and partnerships with solar leaders looking to protect fire-prone communities are a start. Policy makers, regulators, the rooftop solar industry and utilities should work together to swiftly bring more solar and batteries to the communities that need them when it matters most.

About Sunrun

Sunrun is the nation's largest residential solar, battery storage and energy services company. With a mission to create a planet run by the sun, Sunrun has led the industry since 2007 with their solar-as-a-service model, which provides clean energy to households with little to no upfront cost and at a saving compared to traditional electricity.

The company designs, installs, finances, insures, monitors and maintains the systems, while families receive predictable pricing for 20 years or more. The company also offers a home solar battery service, Sunrun Brightbox, that manages household solar energy, storage and utility power with smart inverter technology. For more information, please visit: www.sunrun.com.

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7. Circuit current loading calculated with active power demand purely from sum of 500 5kW properties, less 80% for each with solar installation, with 250 kVAr reactive power demand, at 11kV. No change to ambient conditions are considered in this example. Calculations were based on industry standards, such as IEEE 738-2012 (https://standards.ieee.org/standard/738-2012.html), simplified to illustrate a theoretical single span under static weather conditions.

8. Engineers design the transmission grid to work under what is called "N-2 contingencies," as seen here in CAISO's transmission plan. That means they plan the grid to keep everyone's lights on, even when the two worst things happen at the same time. For example, the biggest transmission line could go down at the same time that a big generation plant has a problem and needs to be turned off. For some rural neighborhoods, it can be very expensive to build enough extra infrastructure to support these situations. In other words, solar plus storage could make it easier to meet N-2 standards.

9. CA ISO Transmission Plan, March 14, 2018
http://www.caiso.com/Documents/AppendixF-RevisedDraft2017-2018TransmissionPlan.pdf 10. PG&E Public Safety Power Shutoff Report to the CPUC, November 27, 2018

10. https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/PSPS-Report-Letter-11.27.18.pdf

11. Current interconnection conditions require that smart inverters disconnect from external supplies where volts or frequency fall below required levels, such as when the local network is disconnected from the wider network. These would need to be updated to allow for the formation of local grids while ensuring that the wider network is protected and those working on it are kept safe.