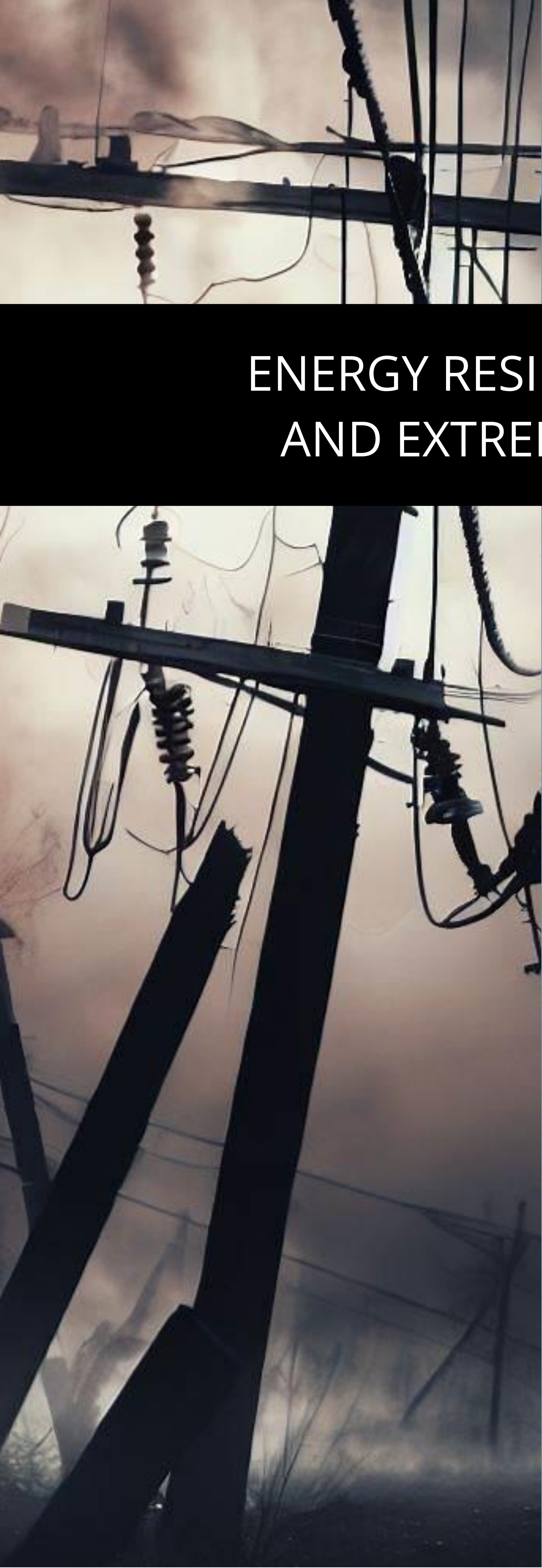

ENERGY RESILIENCE IN BUSHFIRES AND EXTREME WEATHER EVENTS

Summary of Findings

from the

ESKIES project

August 2023

Collaboration on Energy and Environmental Markets

UNSW SYDNEY

About the authors

The UNSW **Collaboration on Energy and Environmental Markets (CEEM)** undertakes interdisciplinary research in the design, analysis and performance monitoring of energy and environmental markets and their associated policy frameworks. CEEM brings together UNSW researchers from a range of faculties, working alongside a number of Australian and international partners. CEEM's research focuses on the challenges and opportunities of clean energy transition within market-oriented electricity industries.

Effective and efficient renewable energy integration is key to achieving the energy transition and CEEM researchers have been exploring the opportunities and challenges of market design and policy frameworks for renewable generation investment, and investment in the necessary flexible resources to facilitate its integration, for 20 years.

As distributed energy resources (DER) such as solar PV, batteries and demand response are deployed at increasingly high penetrations, their successful integration into electricity industries will be critical. CEEM studies emerging markets, regulatory approaches and business models for DER integration, and their technical, economic and social outcomes.

More details of this work can be found on the CEEM Website: www.ceem.unsw.edu.au
We welcome comments, suggestions, questions and corrections on this report and all our work in this area.

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The full version of the ESKIES Final Report can be found at https://energy-resilience.com.au

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Collaboration on Energy and Environmental Markets

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EXECUTIVE SUMMARY

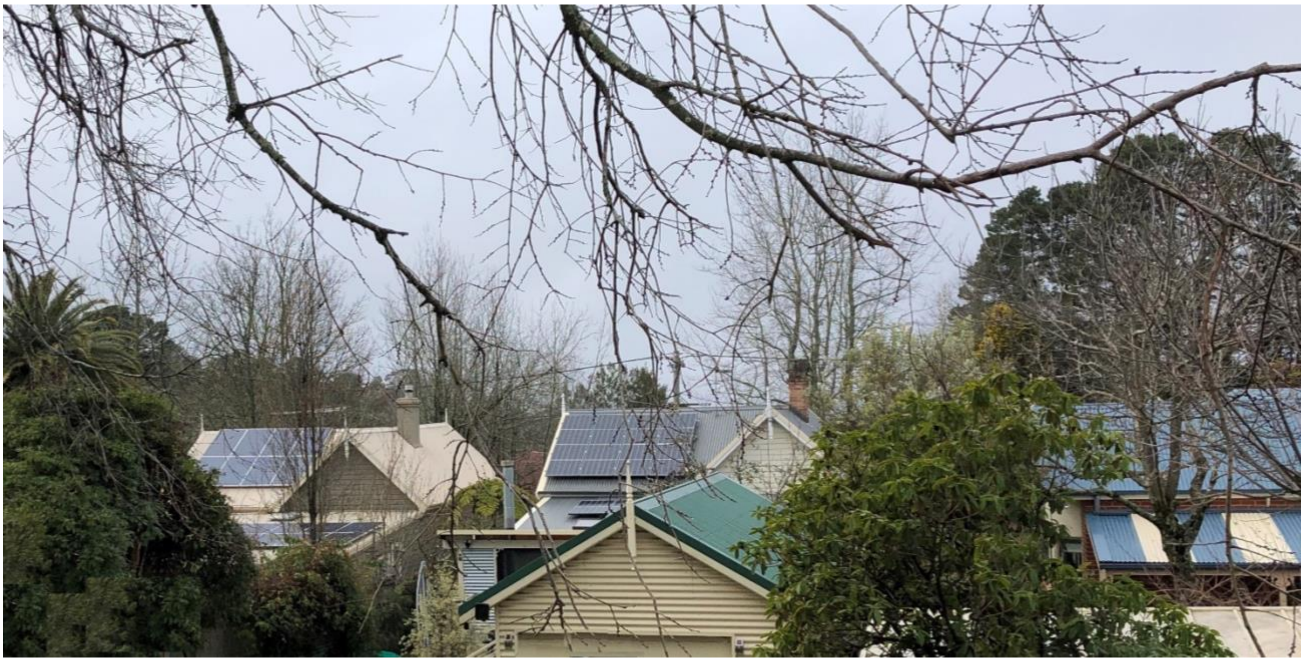
In recent years devastating bushfires and other extreme weather events have seen communities across New South Wales (NSW) lose access to power from the electricity grid and, with it, a range of critical energy-dependent services. With new technologies being developed in the transition to renewable energy that enable households and communities to generate, store and use energy locally, there is an opportunity to ensure that people have alternative means of accessing power for essential activities when the grid is affected.

The ESKIES project was funded by NSW Reconstruction Authority's Bushfire Community Resilience and Recovery Fund (BCRRF) in the wake of the Black Summer bushfires of 2019-2020. The project's primary aim is to explore the options for enhancing the resilience of households and communities during weather-related power outages and to share the learnings with communities affected (or likely to be affected in the future) by these disruptions, as well as with policy-makers and other stakeholders.

We have sought to develop an understanding of:

- how households and communities have been impacted by power outages
- how they have used Distributed Energy Resources (DER) and other resources available to them to manage during these outages, and
- how DER and other resources could be used to achieve greater energy resilience in future.

As a team of social science and engineering researchers in the Collaboration on Energy and Environmental Markets (CEEM) at the University of New South Wales (UNSW), we have taken an interdisciplinary approach to investigating the potential and limitations of DER and other technologies within their social contexts of the home, the community and broader society.



(Image courtesy of Renate Egan, APVI)

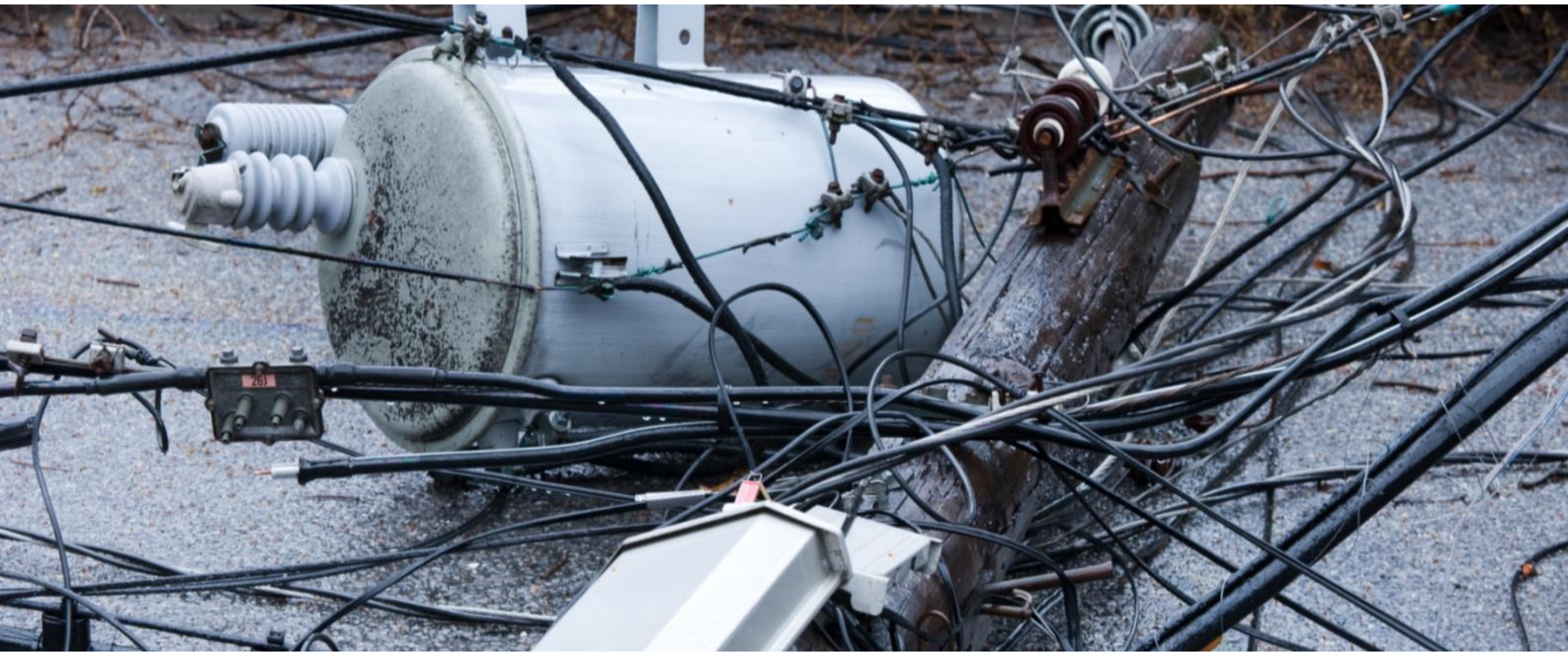
Research approach

Learnings and insights from this research project were developed through:

55 household interviews	conducted with participants across 21 local government areas (LGAs) in NSW to gain an understanding of participants' experiences with electricity supply disruptions during bushfires and other extreme weather events.
13 expert interviews	including Community Recovery Support and other council officers, solar and battery system designers and installers, engineers from distribution network service providers (DNSPs), officers from the Rural Fire Service (RFS) and consultants with knowledge of microgrids and stand-alone power systems (SAPS) and community leaders.
3 online workshops	to develop a deeper understanding of the potential roles of DER in increasing resilience to grid disruptions due to extreme weather events from a household and community perspective.
3 case studies	which involved interviews with, and ethnographic observations of, key actors across three community projects focused on increasing future energy resilience.
64 solar systems	analysis of solar generation data from households in bushfire-affected areas to develop understanding of the impacts of bushfire smoke on generation and the implications for energy resilience.

This document presents a high-level summary of the insights developed from the project, as well as the policy implications. More detail can be found in the ESKIES Final Report, available here.

IMPACTS AND RESPONSES



The impacts of electricity supply disruptions during extreme weather events can be far-reaching and people use a variety of strategies to maintain access to critical energy-dependent services.

These include:

Telecommunications	Grid outages often impact use of mobile phones, landline phones, television, radio, internet and social media, either or both due to power outages within households and through disruption to broader communications infrastructure. People responded by relying on face-to-face communication, using back-up options such as satellite mobile phones and battery-operated radios, and sharing access to communications technologies.
Water	Water supply can be affected where it depends on electric pumps on individual properties or at community pumping stations. Strategies to ensure access to water include using fuel pumps, gravity feed systems or electric pumps powered by solar and battery systems, as well as keeping stocks of drinking water on hand.
Fuel	Access to fuel can be affected as petrol stations may not be able to pump fuel due to lack of electricity, or as people may be unable to reach petrol stations due to blocked or flooded roads. Those reliant on fuel generators tend to make sure that they stock up on fuel where they have advance notice of an outage.
Refrigeration	To prevent loss of refrigerated food and medicine supplies, people keep fridges shut, consolidate supplies into one rather than multiple fridges, share fridges between households, or use eskies.

Energy resilience means different things to different people.
For some, energy resilience means having alternative sources of electricity to ensure undisrupted access to a service (e.g., using a generator or solar and battery system to run a refrigerator) – in other words, to be able to continue life more or less as usual. For others it means using non-electrical energy sources to access the same service (e.g., using an esky for refrigeration), or adapting to not having access to the service (e.g., doing without refrigeration) – in other words, to be able to cope when life is not 'normal.'

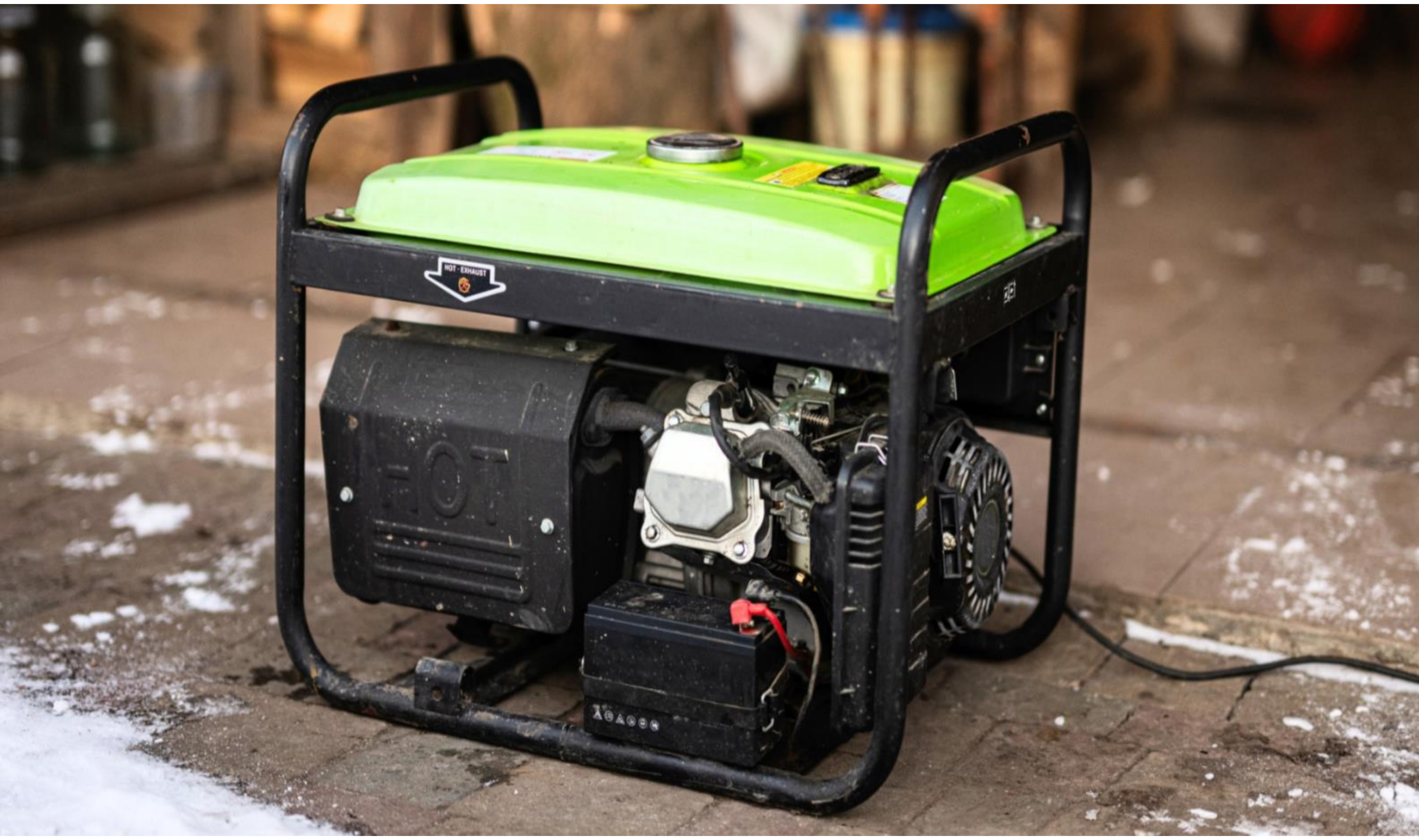
Diversifying the options available to access services is an important way of increasing energy resilience.
This means that when one form of technology is unavailable, others can be counted on. On the other hand, depending on one type of technology to achieve an outcome – or being dependent on electricity in general – may leave people more vulnerable. Multiple alternative options can be maintained in a household or within the broader community.

Impacts and strategies can vary considerably according to the duration of the outage and may change over its course.
The experience of an outage is not necessarily linear and there may be thresholds at which the disruption becomes more difficult or requires different responses.

Some effective strategies used to cope during an electricity supply disruption may be developed as required but, in general, being prepared in advance enables people to cope better.
Participants emphasise the importance of both planning and mental preparation.

Experience from the past can be valuable in responding to grid outages, and actively learning from what worked and what didn't during recent events, such as the outages experienced during Black Summer, is considered important by the participants.

TECHNOLOGIES AND INFRASTRUCTURE



Fossil-fuelled generators are the most common DER used to provide a back-up electricity supply during power outages due to low cost, ease of access, reliability, portability and scalability, but they require regular maintenance and a sufficient supply of fuel. They also create noise, greenhouse gases and other emissions.

Rooftop solar and batteries can provide a back-up electricity supply but only if specified and configured appropriately. Most solar-only systems shut down during grid outages. Specific expertise and knowledge of household needs and the scale of anticipated disruptions are needed to design a solar-battery system for resilience.

Generators, solar and batteries should be sized for and connected to the essential loads needed during an outage. This requires consideration of instantaneous and continuous power, daily energy use, electricity supply phases, and how energy needs vary over time during an extreme weather event.

Solar generation is reduced by bad weather, smoke, ash and dirt, and both solar and batteries can be affected by extreme heat. This has implications for specifying, locating, housing, and maintaining these DER. However, the impacts of smoke are comparable to those of bad weather, which should be a consideration in resilient system design. For security of supply during very long grid outages, solar-battery systems should include a back-up generator.

The cost of investment in DER should be balanced against multiple benefits, including resilience to minor and major grid outages, reduced energy price risk and environmental benefits, as well as bill savings.

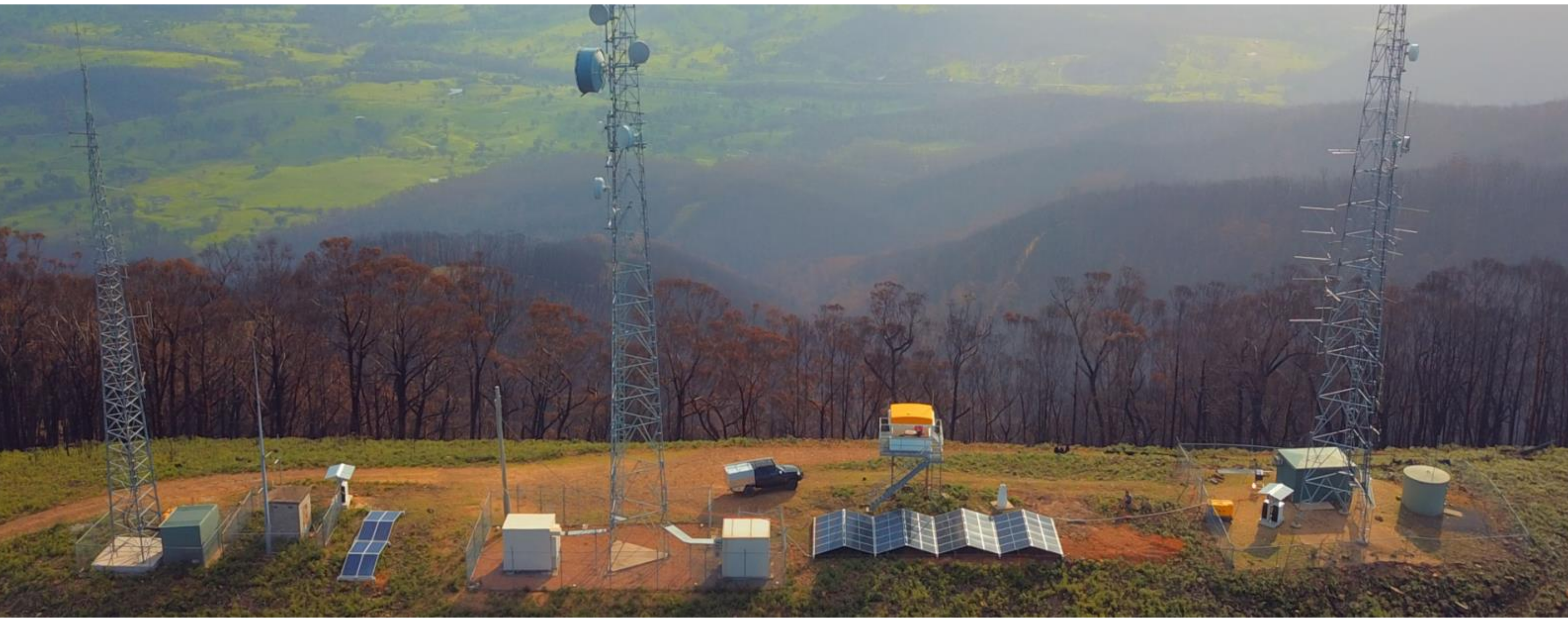
Electric vehicles have potential to provide household energy resilience through vehicle-to-home (V2H) or vehicle-to-load (V2L) but the Australian market for these technologies is undeveloped.

Managing how electricity is used (demand management) is a key component of energy resilience. Energy priorities, which depend on individual or community needs, preferences and circumstances, vary with time and must be considered at the planning and system design stages as well as during preparation for and management of extreme weather events.

Diversity of energy supply can increase energy resilience but may conflict with decarbonisation aims. Gas, biomass, fossil-fuel or disposable or rechargeable batteries can variously provide cooking, refrigeration, heat, light, water heating or communications. Appliances purchased for other purposes (such as camping or recreation) may have secondary use in providing resilience during grid outages.

Community approaches to energy resilience include shared individual DER, resilient community buildings and microgrids. Solutions are specific to local geography, distribution and demographics of households and businesses, topology of the existing distribution network, historic and potential causes of network disruption, economic factors and desired resilience outcomes.

VISIONS FOR A RESILIENT ENERGY SYSTEM



A 5B and Resilient Energy Collective project in Cobargo NSW deployed in 2020. Image courtesy of 5B, an Australian solar pioneer developing prefabricated, pre-wired ground mount technology.

Many people are interested in household DER because they offer energy independence and self-sufficiency. Being less reliant on the main grid and energy companies is seen as one way of being more resilient.

However, this vision of a decentralised energy system may also deepen inequities across society, as some people are unable to access or afford DER and may have to pay more to maintain the electricity grid as others get less of their electricity from it.

Some people see sharing DER and other resources – whether informally or more formally through models such as microgrids – as another way of being more resilient. This can mean that there is a greater quantity and diversity of DER options that a community can draw on for essential energy services.

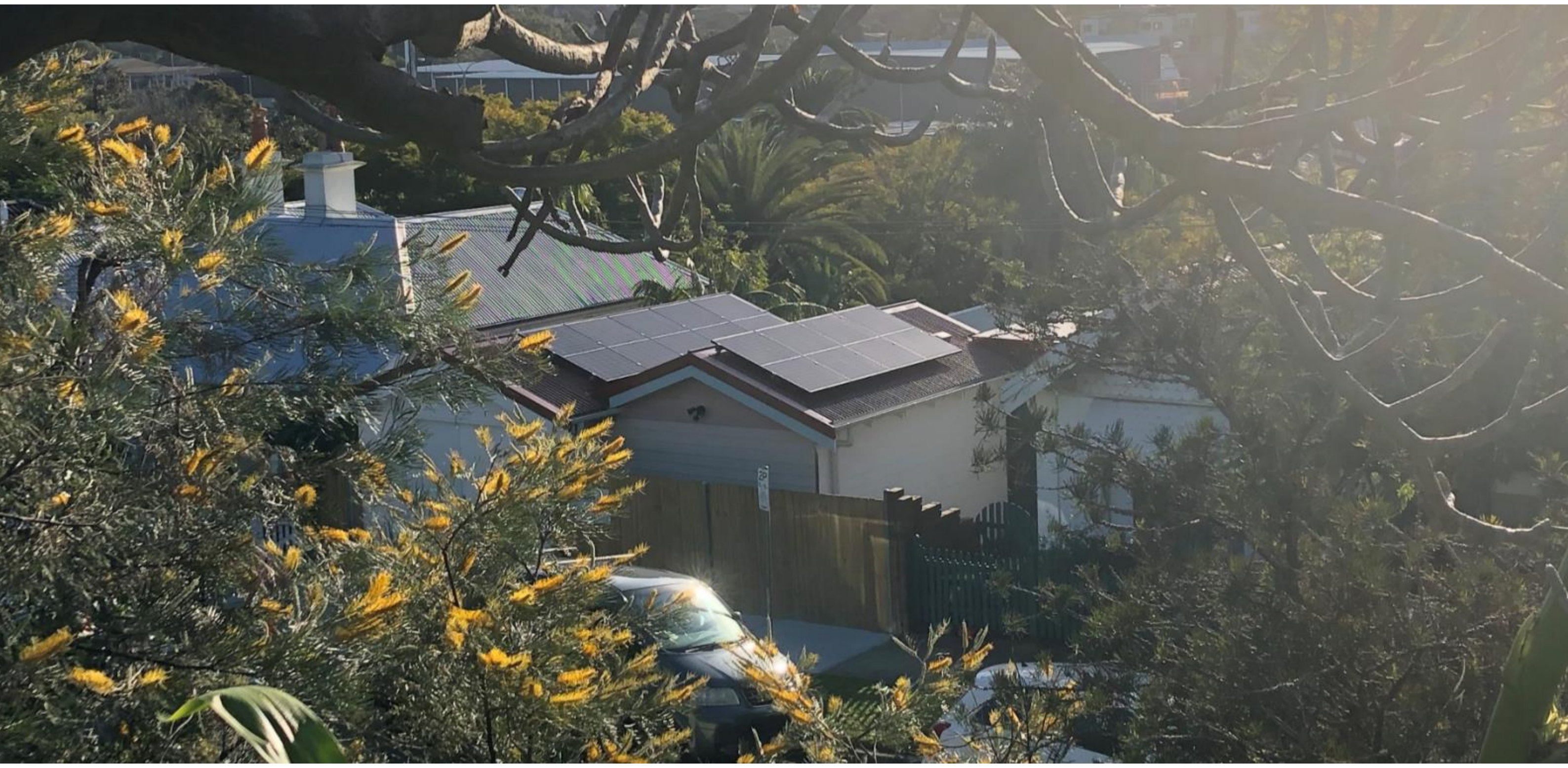
The design and management of microgrids can pose challenges, particularly with respect to how access to energy is distributed among households within the community and how contributions to the microgrid through household DER installation are divided among households.

A sense of community in responding to power outages is highly valued by many people, but local communities can have dynamics and divisions that mean that models of sharing energy locally may not benefit everyone fairly or reflect everyone's preferences.

These visions of household and community energy resilience focus on the local as the best scale to build resilience. But it is clear that these usually depend in part on support from beyond the local community. Which energy resilience options are most appropriate and feasible will depend in part on the extent to which capacity and resources are available to support them.

Depending on the specific circumstances, the energy resilience priorities of communities may or may not align with those of the DNSPs that in some instances are supporting community solutions such as microgrids.

CONCLUSION



Household rooftop solar system. Image courtesy of Renate Egan, APVI

Key findings

Our findings across this research project underscore how households and communities that have experienced bushfires and other extreme weather events in New South Wales were impacted by power outages in a variety of ways. The loss of power had significant and wide-reaching consequences for a range of energy services including access to telecommunications, water, money, fuel and refrigeration. These impacts, which varied significantly depending on the duration and extent of outages, were a source of great distress and a sense of vulnerability, leaving people literally and figuratively 'in the dark' and unable to meet basic needs.

In response, **households and communities employed a range of DER and strategies to cope with the impacts of these outages**. DER such as generators, bottled gas, rooftop solar and home batteries, EVs, microgrids, and community-scale batteries have the potential to enhance energy resilience at various scales. However, each of these DER technologies has advantages and limitations and, while there is broad awareness of their potential resilience benefits, these are complex technologies requiring a high level of expertise for appropriate design and deployment.

Moreover, the capacity for these DER to confer energy resilience is far from just a technical concern; it is mediated by a host of social, economic, and situational factors, including the duration of outages. There is therefore a need for careful consideration of the DER options that might best enhance energy resilience given the different capacities and circumstances of specific households and communities.

In the accounts we heard, **there were many instances of community members supporting one another during weather-related outages.** People helped others or received help to access energy services by sharing generators, relying on neighbours or small businesses for phone charging or refrigeration, or communal cooking events such as BBQs. However, while these forms of community response should be acknowledged and supported, the feasibility of these kinds of communal responses depends on the circumstances. Communities can contain differing priorities and uneven capacities that challenge the ideal of a single coherent community response.

Helping households and communities to learn from past experiences, anticipate and prepare for power outages can enhance resilience at a local scale. This can inform household practices, the adoption of appropriate DER, and the improvement of community infrastructure to enhance energy resilience. However, some participants expressed a sense of fatigue and frustration around widespread calls for communities or individuals to be 'resilient' and pointed instead to the roles and responsibilities of governments and energy providers in improving resilience at the system level, e.g., through investments in resilient energy infrastructure and action on climate change.

Different DER configurations, at individual household and community levels, can have different meanings and implications for energy resilience. While more individual-scale approaches – including the ideal of going 'off-grid' — might help households achieve energy independence and self-sufficiency, such an approach can neglect inequities in access to DER in society, as well as the equity implications of maintaining a grid with fewer connected households.

Similarly, while collective DER configurations such as microgrids have the potential to be more inclusive, they tend to have their own context-specific political challenges with respect to ownership, leadership and decision-making. **In practice, there is no binary choice between individual and community approaches; rather, they are part of a continuum** of DER configurations that may be drawn upon in different ways to meet the needs of different households and communities. Likewise, in practice, more decentralised models do not necessarily entail a clear shift away from incumbent models or reliance on actors such as governments and DNSPs.

Our findings also surface **a tension between the imperative to decarbonise through electrification and efforts to build energy resilience**. Energy resilience can be strengthened by diversity in energy sources, with each serving different functions and conferring different forms of resilience, e.g., rooftop solar, bottled gas and generators can be used in conjunction. While decarbonisation of the energy supply is urgent, there is a need to consider its potential resilience implications, or risk creating additional forms of vulnerability in homes and communities.

A related insight from our research is that **there is a need for a richer appreciation of the multiple benefits that DER can offer** – looking beyond economic approaches such as payback periods on these technologies to consider benefits such as bill savings, emissions reduction, and resilience to outages.

Implications for policy and engagement

Our research findings point to several considerations for stakeholders:

1	There is a need for greater efforts to educate households and communities, as well as other actors such as installers, on the different types of DER available and their specific implications for resilience. For example, as detailed in this report, a correctly configured solar and battery system can provide a significant level of resilience, but rooftop solar alone is not *necessarily* beneficial during a grid outage. There is a need for more widespread industry understanding of the potential resilience impacts of DER as this has direct implications for how suppliers market specific products and engage consumers.
2	We contend that the tendency to frame the value of DER to households in purely economic terms such as payback periods is too narrow. There is a need for a wider view of the different types of value that DER can offer, such as *bill savings*, *emissions reductions* and *resilience to different types of power disruptions*.
3	The role that some forms of DER can play in energy resilience means that policies that support the adoption of DER, such as subsidies, can shape the resilience of households and communities into the future. Resilience should be considered in the design of such policies, both to evaluate potential unintended effects and to leverage opportunities to support technologies that increase resilience.
4	There is potential for the electrification of household appliances to yield negative resilience outcomes, if carried out without consideration of back-up electricity supply in areas vulnerable to grid outages. This tension between electrification and the diversification of energy sources is a dynamic that will need to be navigated in the development of policy and research.
5	Engagement with communities is necessary to understand their needs and the DER configurations that might best meet them, while also taking into account that perspectives and needs within communities differ. Partnerships between industry stakeholders and communities in microgrid and other community-scale initiatives, which tend to be asymmetrical in the interests and power that the partners bring to the engagement, will vary according to the specific context and the needs of communities. Extensive community engagement, with awareness of these existing asymmetries, is therefore essential to building partnerships to achieve resilience in forms that reflect the values of communities.