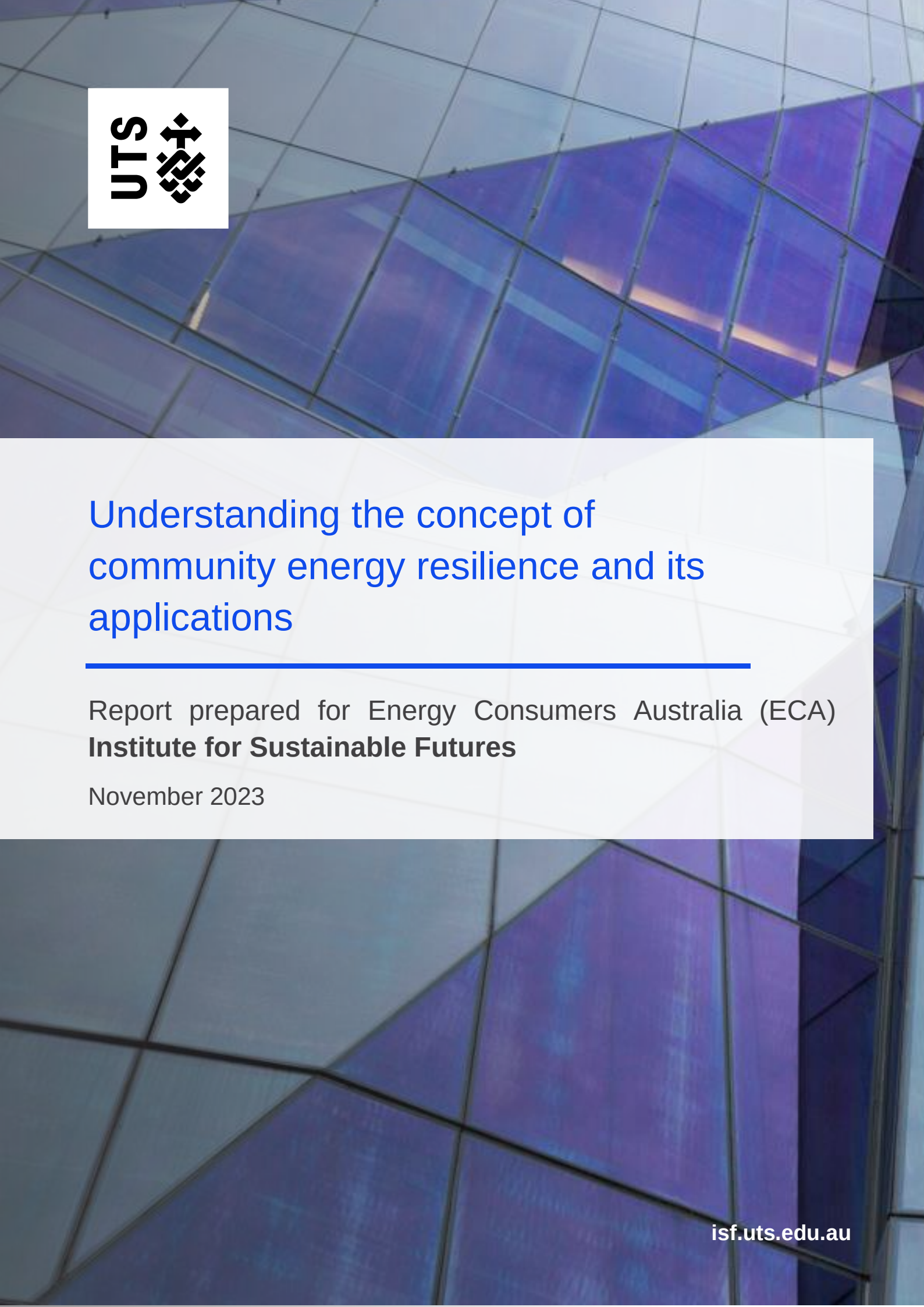
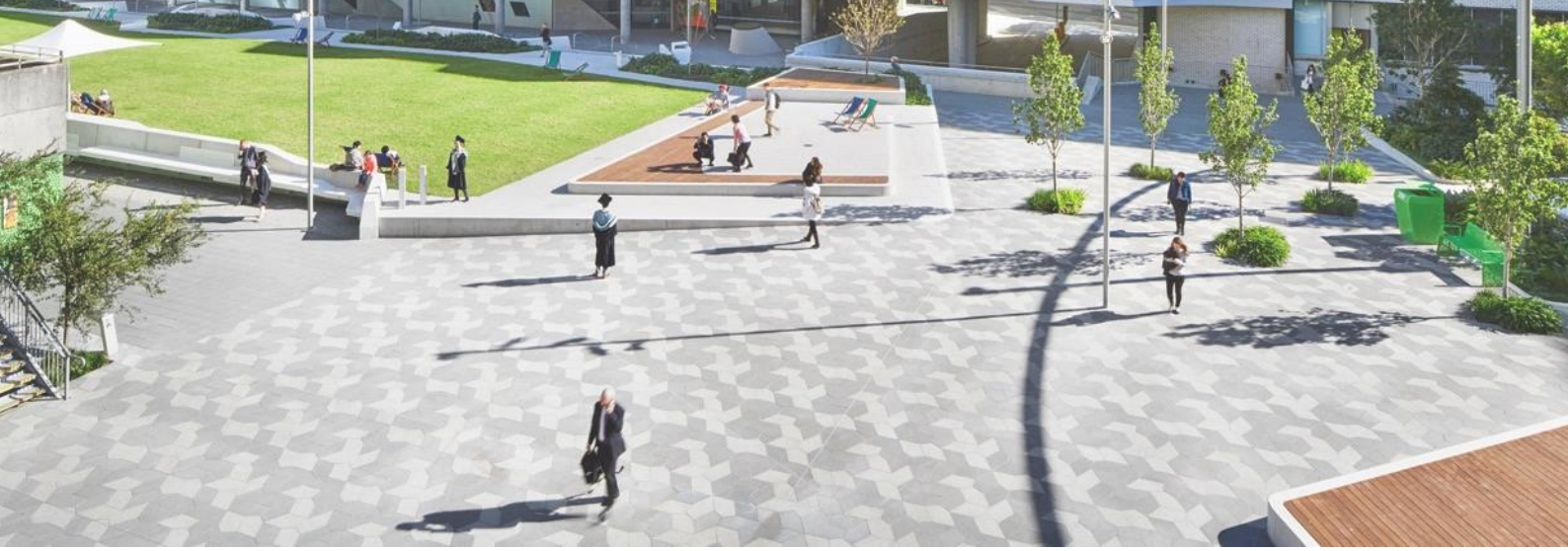


# Understanding the concept of community energy resilience and its applications

Report prepared for Energy Consumers Australia (ECA)

**Institute for Sustainable Futures**

November 2023



**UTS and ISF acknowledges the Gadigal People of the Eora Nation, the Boorooberongal people of the Dharug Nation, the Bidiagal people and the Gamaygal people upon whose ancestral lands our university stands. We would also like to pay respect to the Elders both past and present, acknowledging them as the traditional custodians of knowledge for these lands.**

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## About the authors

ISF is an independent research institute within the University of Technology Sydney. We conduct transdisciplinary, project-based research in line with our vision of creating positive change towards sustainable futures.

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# Executive Summary

Communities around the world are at the forefront of the worst and most destructive impacts of climate change. The summer of 2019/2020 was Australia's worst bushfire season on record, where an area equivalent to the country of South Korea burned. The following year saw record high floods in Eastern Australia, the worst in 60 years. Both events saw the affected regions declared natural disasters zones.

During such events, communities rely heavily on the energy infrastructure to ensure continued access to essential services, such as clean water, refrigeration, telecommunications, transport, medical equipment, and payment services.

Many service providers and organisations are working to ensure that these services are resilient. Energy utilities are pursuing technical and engineering improvements to their infrastructure so it can withstand or recover quickly the worsening effects of extreme weather. Government and public bodies are seeking ways to help empower communities through the provision of supporting services, programs, and policies. Meanwhile, communities are seeking to build their own energy resilience but have different levels of disaster experience, planning, and management.

This review accessed the academic and grey literature related to resilience, energy resilience, and community energy resilience. It spanned the current body of research, from the theoretical concepts to the practical insights. It found that by developing a better understanding of perspectives and lived experience with a focus on social and cultural aspects, community energy resilience can be built to find suitable solutions together.

If a community's needs are to be fully understood and met in the context of impacts from extreme weather, they must be empowered and confident in communicating with service providers on their energy resilience concerns and priorities. In the context of this project, the study provides the foundation to undertake empirical work with disaster-affected and at-risk communities across Australia. The findings will be translated into an accessible visual guide to support these conversations, while building a better understanding of what community energy resilience means for all stakeholders. In a broader context, the study provides market bodies and electricity distribution networks with a much better understanding of how energy (network) resilience is intertwined with community resilience. The study, in this sense, can support networks in their own community consultations and participatory engagements, as it does provide the rationale to place communities in the centre, when developing resilience plans and priorities. Network businesses placing communities at the centre of their strategy design, will enable households and local businesses to share their own perspectives, better understand community needs and concerns, and adopt co-designed strategies to improve community energy resilience.

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# 1. Introduction

Resilience has received increasing recognition as a critical factor in environmental disaster response and emergency management (Masterson et al., 2014), as a notion of a system's capacity to recover, namely "bouncing back" to its initial condition (Pimm, 1984). As a key adaptation strategy, there is a strong focus on the ability of communities to become (more) resilient in the context of climate change.

Resilient communities are considered those that are best prepared for coping and recovering from the direct and indirect effects of climate change (IPCC, 2014; Koliou et al., 2020). An important dimension is energy infrastructure and communities' interdependencies related to essential energy-related services and facilities during and after disasters. As the pace of climate change accelerates, energy resilience of local communities is of growing concern. At the same time, the ongoing transition to renewable energy sources, distributed energy technologies, and alternative processes support new opportunities for communities to adapt and withstand emerging challenges.

Many Australian communities have experienced one or more major events caused by natural hazards in the last years. Indeed, the scale and frequency of environmental disasters, including bushfires, floods, cyclones, and droughts have magnified resulting in devastating impacts for Australian communities. However, such disasters and their impacts are extremely contextual and are influenced by factors such as their timing, intensity, geography, socioeconomics, infrastructure, and community preparedness. Climate change is exacerbating the severity of these events in the foreseeable future, reinforcing the case for increased focus and action on climate adaptation and resilience.

Infrastructure plays a crucial role in resilience building of communities, providing the essential services and resources that are needed for daily life, such as water, energy, communication, and transportation. Recent events such as the flooding in the Northern Rivers region of NSW (2022), the bushfires in the East Gippsland region in Victoria (2019-2020), and the South Australian power outages after a severe storm (2016), have highlighted the vulnerabilities of infrastructure and the communities they serve in Australia. Energy resilience and the functioning of essential services, such as hospitals, emergency services, and water treatment facilities, during and after major disruptions is critical for public health, safety, and economic stability. The profound incorporation of energy resilience in disaster preparation and management planning will support recovery and rebuilding processes at the community level.

Local actors, civil society, and government agencies have been working to activate and increase community energy resilience as a response. Initiatives comprise of those technical, regulatory, and social in nature. This has seen increased interest in community microgrids and neighbourhood batteries, led to discussions about further regulating the national electricity networks under the National Electricity Rules (NER), and resulted in the formation of new grassroots community groups.

However, there is both a need and an opportunity to increase the understanding of energy resilience, going beyond infrastructure fixes and technology performance (AER, 2022; The Royal Commission into National Natural Disasters, 2020; ACOSS, 2015), rather than solely focusing on community-based initiatives. Despite the increased attention on the topic and the growing body of literature, there is a lack of qualitative empirical work from the bottom-up perspective on the incorporation of communities when discussing the topic of energy resilience.

This literature review is part of the Collaboration Grant funded by Energy Consumers Australia: (*Em)powering communities on the journey to energy resilience*. It provides an overview of the multifaceted dimension of energy resilience, with the aim being to enhance understanding of the concept in the context of disaster-affected communities and communities which are at risk of experiencing greater climate impacts in the future.

## 1.1 Scope of this report

This literature review is a starting point for the project and for developing discussion guides on the concept of energy resilience with communities. It provides a platform for stimulating questions and conversations for workshops delivered under the project. It is important to acknowledge that the literature review is neither intended nor able to provide an exhaustive picture of energy resilience in the context of community. It is also

not an assessment on how communities become energy resilient, nor a deep methodological analysis for approaching communities on the topic. While these are worthwhile endeavours, this is out of scope for this research project.

## 1.2 Project background

The project *(Em)powering communities on the journey to energy resilience* investigates communities' perspectives on energy resilience with the aim to initiate a societal dialogue on how the concept could be viewed and acted upon from a consumer-first perspective.

This report constitutes the basis for the empirical work that seeks to answer the following research questions:

- How do communities understand energy resilience?
- What priorities do they see in building local energy resilience?
- What are the drivers for community members to engage in energy resilience?
- What do communities consider as necessary steps to reach energy resilience?
- How do communities view their own role in energy resilience building?

## 1.3 Structure of this report

This report is structured as the following, first the key concepts that form the notion of 'community energy resilience' are defined in Section 2, and the drivers behind energy resilience are discussed in Section 3. Then, the report unfolds the dimensions of energy resilience and infrastructure, covering the individual and household, community, and utility level in Section 4. Next, social factors of energy resilience are explored in Section 5, which includes agency and leadership, social capital, connectedness, and trust, as well as social dynamics and communication. Section 6 provides case studies of energy resilient communities and outlines lessons for and from communities, including lessons learned from practical guides and handbooks, from communities directly, and explores how communities can become energy resilient. Finally, Section 7 concludes with a working definition of community energy resilience.

The research questions listed in Section 1.2, have been addressed by questions which appear in the form of grey boxes below corresponding report sections, as the content is progressively discussed. The questions explore potential interactions between communities and other players in the energy sector, for example networks providers. The main intention is to remind the reader about the report's relevance for empirical research with communities, and its aim to bridging the desktop findings and real-world fieldwork.

# 2. Key Concepts and Definition

The fundamental notions of ‘resilience’, ‘community resilience’, and ‘energy resilience’ need to be fully understood if ‘community energy resilience’ as a concept is to be defined.

## 2.1 Resilience

Resilience has become an established term in recent years applied across various academic disciplines, industry sectors, and in public policy. While the concept has proliferated, there is still a lack of an unequivocal definition leading to varied interpretations and understandings. Most prevailing is its notion of “absorbing” and ‘bouncing back’ to a state of ‘normal’ after a shock (Holling, 1973), see Table 5 in Appendix.

This idea firstly emerged within the realm of natural science, placing emphasis on the adaptive capacity of ecosystems and species to effectively respond to alterations in their environment. Over the years, a stronger focus on social factors and agency emerged, with Folke et al. (2002) emphasising the intimate link between human and natural systems. Acknowledged was that learning and adaptation feature as critical components of resilience. Table *6* in the Appendix shows the various definitions of the term resilience and how the term is applied in different contexts, including disaster resilience and energy resilience.

Over the last decade, the United Nations (UN) played a significant role in further promoting the concept of resilience at global, regional, and local levels. It stressed the importance of resilience in addressing complex challenges such as poverty, inequality, conflicts, and other humanitarian crises.

The concept was rapidly adopted for use within the context of climate change and environmental disasters. The United Nations Office for Disaster Risk Reduction (UNDRR) defined resilience as “*the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management*.” This definition has been promoted in the Sendai Framework 2015-2030, which is the international agreement to reduce global disaster losses.


Figure 1 Tripartite view of resilience

Source: Adapted from Koliou et al. (2020) and Scott et al. (2017)

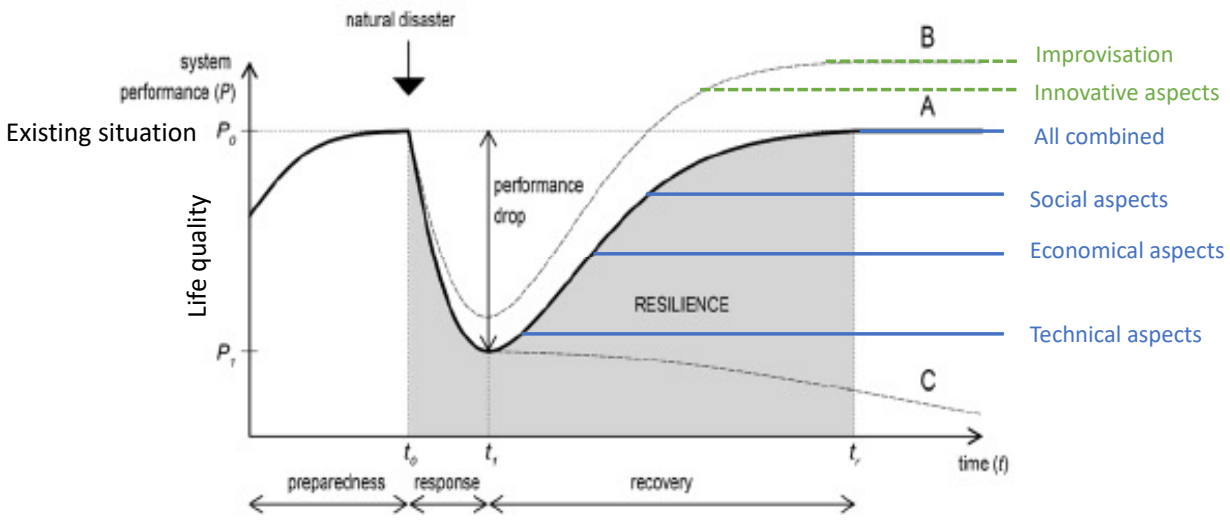
Despite different interpretations and emphasis in use, the tripartite view of resilience (see Figure *1*) – prepare (reduce vulnerabilities for future impacts), respond (reducing impacts or consequences) and recover – has

become widely applied in climate response (Koliou et al. 2020, Adger et al., 2005; Cutter et al., 2008; Maguire and Hagan, 2007; Resilience Alliance, 2015; UNISDR, 2005; Walker et al. 2004).

While this concept covers the overarching mechanisms, there are further nuances regarding the temporal and practical implications. For example, the preparation stage can comprise a short and long-term perspective – which is either in the immediate phase before a disaster or is subject to long-term planning and strategising. During the short-term perspective (pre-disaster and disaster phases, Figure *2*), communities, emergency management agencies, and government bodies implement practical measures to prepare and respond to disasters. Examples include clearing vegetation to reduce bushfire risk, elevating power outlets for flood protection, and creating emergency kits for power outages. These measures aim to minimise the impact and scale of damage from climate-related disasters.

During the long-term or recovery phase, community functioning improves as resilience aspects, such as technical, economic, and social factors, are restored (Khalili et al., 2015; Figure *2*). Through innovation and improvisation, some aspects of the community may even surpass the pre-existing situation, in the sense of 'bouncing forward' (also referred to as 'building back better') and adopting sustainability practices. Strategies may involve place-based technology solutions based on renewable energy, adopted in a process of involved community participation.

Figure 2 Different temporal phases of disaster responses




Source: Adapted from Khalili et al. (2015) and Koren et al. (2017)

Note: The event of the disaster will change the existing situation ($P_0$) of the community/ socio-economic system, and result in a drop of the system's performance ($P_1$). From a temporal viewpoint, the community's level of preparedness will influence their response to the disaster as well as their recovery time, i.e. the building of resilience. There are various levels and elements of disaster recovery and resilience building, including technical aspects, followed by economic and the social aspects (Khalili et al., 2015). Once technical, economic, and social aspects have been rebuilt, the community/ socio-economic system has returned to its initial state. However, for the community or the system to further their efforts in resilience building, innovative aspects need to be incorporated into the recovery process. This will achieve an improvisation of the system's performance / community's quality of life and will result in the ability to 'bounce back better'.

## 2.2 Community resilience

This tripartite view is also part of the narrower definition of community resilience in the context of climate action. Mileti (1999) was an early proponent who defined community resilience, stressing the capacity of a community to effectively utilise its available resources to respond to, and recover from, the impacts of environmental hazards. In his definition, he emphasised the community's ability to mobilise and leverage its resources, both

tangible and intangible, to navigate the challenges posed by disasters and to facilitate a successful recovery process.

Hence, resilient communities are those that not only prepare and respond to adversity but can also reach a higher level of functioning post-event, via adaptation (Parkhill et al., 2015). In this context, Adger (2000) proposes to consider community resilience as '*the capacity of communities to withstand external shocks to their social infrastructure*.' This perspective suggests that resilience is not something that is imposed on communities by the government, but rather relies on the ability of social systems to self-organise, adapt, and learn. It strongly relates to the notion of agency and the capacities of the community to act upon change (see Section 4.1).

Community resilience also captures the relation to 'place' and further operationalises the meaning of community (Magis, 2010; Zautra et al., 2008), as seen in

Box *1*. This includes the quality and strength of local cohesion, local networks, and community governance (including effective leadership, inclusive decision-making processes, and effective communication). Participatory approaches to enhance multi-stakeholder cooperation, social innovation, and capacity building for resilience has also been found to have an important role to play (Mahajan et al., 2022).

Other interpretations of community resilience associate the concept with (i) a community's local economy (diversity and local jobs) (De Iuliis et al., 2022; Martin, 2012), (ii) people's health and psychological well-being (Norris et al., 2008) and (iii) cultural identity (Koliou et al., 2020) as sources and abilities to cope in the presence of crises and emergencies. Institutional support, funding and governance are also considered essential elements in community resilience (Cutter et al., 2010), whereby a flexible approach combining top-down and bottom-up activities is considered essential (Twigger-Ross et al., 2015). This is seen to require a broad range of different stakeholders, as each performs a different function in building resilience (Bahadur et al., 2018).

Box 1 Defining Community

> Community (*defn.*): In essence, a *community* is defined by the presence of sustained and qualitative social interaction among residents who share common ground and concerns.
>
> Past definitions focused on the patterns of social engagement bounded by geographic areas such a neighbourhoods, towns, and school districts, or what (Black and Hughes, 2001) refer to as "communities of location."
>
> In addition, social networks of people with shared identities and purposes define what Black and Hughes (2001) refer to as "communities of interest." These clusters of people are bounded by common values rather than by geography. Such webs of social interconnection determine the extent of civic engagement and social capital (Putnam 1995).
>
> From the perspective of resilience, a key domain of interest is how communities further their capacities to develop and sustain well-being and address vulnerabilities towards social and environmental threats.

## 2.3 Energy resilience

Asset-based approaches that focus on working with the resources available in communities while also seeking to enhance them are often advocated (Fazey et al., 2018). In the context of the physical built environment, it can be considered one of the most important resources in building a disaster-resilient community (Masterson et al., 2014). The provision of electricity is an essential part of the functioning of a community's built environment, while also being regarded as critical in the operation of other related infrastructure, including communication systems, water pumping/treatment, and medical facilities or lifesaving equipment (NIST, 2020).

The concept of energy resilience addresses this concern for maintaining a reliable and safe energy supply, while also withstanding disruptions or shocks to the related infrastructure. This also refers to the ability to swiftly recover from such events and adapt to changing conditions while ensuring the continued provision of essential energy services (IEA, 2022). This is one of many definitions and interpretations of the concept, which common reference to the tripartite perception of resilience.

Numerous studies have examined climate impacts on energy supply and demand, highlighting the need to strengthen resilience of the energy systems before, during, and after a disaster. Gatto and Drago (2020) identify seven different approaches and perspectives for analysing energy resilience. These include approaches which stress the concept of security and analyse possible sources of risk management with the focus on geographical aspects, modelling based evaluation and assessments, and studies emphasising government and industry interventions for energy resilience. Energy infrastructure is explicitly discussed in this context, especially concerning its role in ensuring system reliability and performance (see Section 4.3, p. 16).

A pertinent discourse in the literature concerns the objectives of energy system resilience and whether it can maintain its structures or functions. For a technical system, maintaining structures and functions can be mutually exclusive since structures often have an adverse effect on function (Jesse et al., 2019). For example, the structures of the incumbent energy system are incompatible with sustainability requirements and need to change to new conditions to retain its function. In addition, a widespread assumption is that major energy system components (such as electricity networks) should ideally return to a previous 'normal'. Instead it has been suggested that major disruptions and the risks associated with climate extremes, are a good opportunity to replace the existing infrastructure and systems with more sustainable technology in greater consideration of community benefit and needs, known as 'bouncing forward' or 'building back better' (Jasiūnas et al., 2021). Hence, energy resilience can go beyond sustaining what has already been, to being more of a forward-looking process of change that could address a wide range of environmental and social issues. In other words, rather than focussing on the notion to 'bounce back', energy resilience could rather convey a proactive message focusing on adaptation and transformation (Twigger-Ross et al., 2015). From a network or systems perspective, the transformative process centring energy resilience, challenges the status-quo of the energy sector (Greet and Barnes, 2017). Challenges include technical solutions, governance and regulatory frameworks, resource management and consumer outcomes. Developing strategies to build network and energy resilience requires the energy sector to deal with and manage uncertainty, volatility and deliver better consumer outcomes in the face of disruptive events caused by climate extremes (Cainey, 2019).

## 2.4 Energy resilience from communities' perspective

The review of definitions and key concepts in the literature shows the prevalent inclination to classify resilience under two main categories: technological units and social systems. While the literature on energy resilience is strongly associated with infrastructure concerns, as expected the literature on community resilience encompasses a broader range of dimensions, that also includes energy.

Yet, there are only a few publications exploring energy resilience from communities' or individual perspective. Those available explicitly establish a connection between new decentralised technologies and energy resilience, highlighting how individuals can benefit from this synergy. For example, Scott et al. (2017) demonstrates that energy services offered by solar household devices significantly enhance anticipatory, absorptive, and adaptive capacities crucial for resilience, especially in less developed countries. Others find that a large proportion of survey respondents are willing to share their self-generated electricity and making their resources available to others during a crisis (Knodt et al., 2023). In recent years, these synergies have been increasingly driving local initiatives to explore renewable energy opportunities, aiming to achieve greater resilience (Neighbourhood Houses Gippsland, 2022; Skinner et al., 2022).

Nonetheless, we find that community energy resilience has not been defined or captured as a specific concept yet. This also applies to more empirical investigations giving communities a voice specifying their understanding of energy resilience.

In the following sections, we delineate the drivers for energy resilience and further delve into the concept, focusing on both infrastructure and social factors. This analysis enables the identification of the primary issues and potential questions to facilitate community conversations on the topic.

*Question for fieldwork: What does 'energy resilience' mean to you, what does it mean at the 'community scale'?*

*(Corresponding research question: How do communities understand energy resilience?)*

# 3. Energy resilience and its drivers

Drivers for energy resilience emerge from risks and vulnerabilities associated with social and environmental threats and the notion that adapted and prepared communities suffer far less damage than those that are not.

According to the International Energy Agency (IEA, 2022) the greatest threat to the energy system is climate change which increases uncertainties and disruptions along the entire energy supply chain. The susceptibility of the energy system to climate related shocks and disruptions has increased vulnerabilities and exposure to disasters for communities across Australia. Many Australian communities now live in an environment that is increasingly characterised by change, uncertainty, and unpredictability. The Commonwealth Scientific and Industrial Research Organisation points to increasingly frequent climate related disasters as likely to continue to be a major issue for the country in the foreseeable future (CSIRO, 2020).

Cyclones, storms, floods, and bushfires can severely damage power lines, substations, and other critical energy infrastructure (Table *1*). This can lead to prolonged power outages and in the worst cases be lethal. Since the supply of reliable electricity is the backbone for many essential services in a community, the resilience of electrical infrastructure has become a major concern for them (Government of Victoria, 2022). It also coincides with a transitioning energy system, which is becoming more distributed, digital, and decarbonised. This provides new opportunities for communities to benefit from a more local supply of energy while achieving their sustainability and socioeconomic goals. Further, conversations about energy resilience at the community level can be initiated in other contexts and include additional values, such as energy independence (Hancock and Walters, 2022), sustainability (Sharifi and Yamagata, 2015), community wealth building (Venus Bay Community Centre, 2023c), energy literacy, bottom-up learning and disaster preparedness (Erker et al., 2017).

Table 1: Climate change related effects and their impacts

| Threat | Impact on Energy Infrastructure | Impact on Community |
|---|---|---|
| Heat waves/ extremes | • Increased electricity demand<br>• Dry and warm conditions increase the risk of bushfires, which damage the soil and set the stage for subsequent landslides and flooding<br>• Aging infrastructure at risk of damage | • Physical and emotion stress<br>• Impact on health services<br>• Financial stress |
| Floods and flash floods | • Distribution and substations are subject to flood inundation, become unsafe and as a result are de-energised<br>• Aging infrastructure at risk of damage | • Loss of property, financial stress<br>• Impact on local economy (homes, livestock, crops, businesses other structures)<br>• Physical and emotion stress for community members (with health issues)<br>• Loss of health and well-being, illness or mortality, increased mental health problems<br>• Decreased air/water quality<br>• Impacts on communication infrastructure leads to delays of information-sharing in areas lacking connectivity/high-speed communication infrastructure<br>• Concern over livestock and pets often prioritised over human welfare*<br>• Limited energy backup/ resources (diesel generator) |
| Bushfires | • Distribution and substation are at risk of overheating (fire and smoke), as a result are disconnected<br>• Powerlines and timber poles are damaged or destroyed – cascading effects on water and communication infrastructure<br>• Aging infrastructure at risk of damage | |
| Storm and Cyclones | • Heavy rain can cause mud waves with damaging debris, such as boulders, large branches<br>• Powerlines and timber poles are damaged or destroyed by strong winds<br>• Aging infrastructure at risk of damage | |

Source: AghaKouchak et al. (2018), Freeman and Hancock (2017)

While energy justice and equitable access to energy goes beyond the scope of this research, the need for this is also important in the context of energy resilience. This is especially the case for vulnerable and underserved communities (see also Box 2). Vulnerabilities not only stem from environmental but also from socio-cultural factors (Tierney, 1999), increasing the risks for some communities (or parts of the community) to be more susceptible to the impacts of hazards than others. This can be due to their location or characteristics such as socioeconomic or demographic factors, as well as access to different resources and suitable housing (Ómarsdóttir et al., 2022).

In addition, rising social and economic costs of climate related disasters also play an increasing role (CutlerMerz, 2020; Insurance Council of Australia, 2022). The impact of environmental disasters on infrastructure, essential services, and communities has been estimated to cost Australians over $13 billion every year (CutlerMerz, 2020). This includes those indirect costs, which include flow on effects to businesses and networks providers, such as power outages or disruptions to supply chains.

Box 2: Excurse: Energy efficiency for community resilience.

**Key strategies to address accessibility and affordability are closely connected to energy efficiency upgrades**

There are an increasing number of projects that focus on improving energy efficiency in low-income households and social housing at scale.

With many tenants in social housing belonging to vulnerable groups, the needs of these communities have become main drivers for energy efficiency measures which can have positive knock-on effects, such as through improving health and wellbeing. This is evident from recent initiatives such as the Glebe revitalisation project [1] and the Victorian healthy homes program [2].

While not all projects are framed around or driven by a desire for greater resilience, the projects contain pathways which could also achieve this. This is through accompanying efforts to overcome challenges related to energy literacy, trust, accessibility of technical resources, and overcoming initial cost barriers.

[1] https://architectureau.com/articles/affordable-housing-project-proposed-for-glebe/

[2] https://www.sustainability.vic.gov.au/research-data-and-insights/research/research-reports/the-victorian-healthy-homes-program-research-findings

Sources: ClimateWorks (2020), Halldorsson J. et al. (2020)

Question for fieldwork: What – if anything – motivates you to pursue building more energy resilience in your community? Have there been any prompts?

(Corresponding research question: What are the drivers for community members to engage in energy resilience?)

# 4. Energy resilience and infrastructure at different scales

Energy resilience can be facilitated through measures and infrastructure that is delivered at different scales, whether it be at the household, community, or utility level.

## 4.1 Individual level

Decentralised energy technologies have increased the opportunities for individuals to save money on energy costs, reduce carbon emissions and acquire a certain level of energy independence and build energy resilience (Roberts et al., 2023). These include solar photovoltaic (PV) rooftop systems, portable battery systems and generators, and electric vehicles (EV) with bidirectional capability (Roberts et al., 2023; CutlerMerz, 2020).

Australia now has the highest penetration of rooftop solar in the world with over approximately 3.4 million Australian homes equipped with solar PV systems (Clean Energy Council, 2023). The significant cost reduction of these systems over the last decade, along with increasing energy prices and concerns over climate change, has contributed to the rapid growth in adoption of PV (IRENA, 2022). The falling cost of battery storage has also led to almost 200,000 being installed in homes around Australia. Not all can access or afford the benefits of these distributed energy technologies (such as apartment dwellers, renters, and low-income households; TEC, 2022), while these systems don't automatically provide energy resilience (unless intentionally configured that way, which can add further cost and complexity).

The ability for a household to develop energy resilience is primarily determined by access to resources. This is closely tied to the financial, social, and housing situation. There has been found to be a positive correlation between those who own a home with solar PV and higher energy literacy (Öhrlund et al., 2020). Energy literacy encompasses an individual's knowledge and comprehension of energy-related concepts, technologies, and practices. This understanding could also play a pivotal role in fostering greater awareness and comprehension of energy resilience issues as well.

The Royal Commission into National Natural Disaster Arrangements Australia (2020), recommends that everyone should understand their natural and built environment, have sufficient insurance to cover damages, know evacuation procedures, and be familiar with emergency warnings. This therefore naturally extends to the issue of energy resilience with individuals having the responsibility to protect themselves and ensuring their energy needs can be met.

## 4.2 Community level

The community plays an essential role in all phases of resilience building, comprising localised and community approaches to increasing energy infrastructure resilience (CSIRO, 2020). As the energy system transitions to one that is more decentralised and consumer-centric, new opportunities have emerged for citizens to contribute to energy resilience at the community level (Knodt et al., 2023). For example, citizens without access to individual rooftop solar or battery storage, are being offered the opportunity to benefit from collective ownership or sharing models to access renewable energy.

In Australia, community solar investment has become a relatively common way of engaging local community members, businesses and local organisations in renewable energy. This type of model sees solar PV systems installed and operated at local community buildings, such as schools, libraries, community centres, and government facilities (CPA, 2023). There are also many examples of community and business collaboration such as the initiatives by Pingala (Pingala, 2023) or Clear Sky Solar Investments (Clear Sky Solar, 2023).

Initiatives at this level have in some cases sought to use community-serving physical spaces (such as community buildings), equipped with respective infrastructure and technology, as safe havens during emergencies or disruptions (Ciriaco and Wong, 2022). Such community facilities not only provide access to essential energy services, but also serve as a focal point for coordinating communication, as well as resource distribution during various stages of a disaster.

More complex technical solutions can include microgrids or variations on this type of local energy solution. Microgrids are like miniature versions of the main electricity grid, in which they may comprise a collection of homes and businesses that consume energy. There is some form of renewable power generation such as wind, solar or biomass. Energy storage or some other form of backup generation is typically present, as well as centralised control to facilitate the coordination of local consumption, use, and storage of energy. Microgrids should also be capable of "islanding" itself from the main grid to act autonomously when needed, such as during interruptions in power supply from the main grid. This can then ensure continuous power supply to critical infrastructure and essential services when it is needed most. Community microgrid[1] have been pursued as a way to facilitate local energy resiliency in a number of Australian examples (HeyfieldCommunity.org, 2021; Venus Bay Community Centre, 2023b; Warneryd et al., 2020). Microgrids have been deployed around the world to address energy resilience, but it is still at a very early stage for Australia. With high cost and complex legal and regulatory challenges, it requires strong engagement and commitment from the community and from the local electricity distribution utility.

Community batteries are another technology option at community level, which at the larger scales can store around 5 MWh – enough to serve 250 homes (Institute for Community Directors Australia, 2023). In terms of potential benefits, they can enable more households or businesses to connect solar PV (where otherwise they might be constrained by the local electricity grid from doing so), store excess locally produced renewable energy, generate revenue from the electricity market, or provide backup power during grid outages. While community batteries are still at a very early stage, several examples have been deployed by communities in Australia. However, the main objective is typically to absorb excess solar PV generation in the local area. The Australian Federal and State Governments have been committing additional funding for community batteries, with energy resilience likely to emerge as a key objective in at least some of these future deployments.

Energy resilience has previously emerged as just one of many different triggers and drivers for communities to have become interested in community level energy solutions (C4CE, 2015). Social and environmental drivers do often take precedent over economic ones for communities, while linking to elements of energy resilience as the above examples show. However, in recent years an increasing number of community energy groups consider energy resilience as a central aim (see Section 6.3, p. 24).

We are interested to understand what you know about energy infrastructure and how it affects disaster events.

Questions for fieldwork:

- Do you have rooftop solar and/ or battery storage? What happens to these systems in case of a disaster?
- During a recent flood event, what were the essential energy needs (that were met or missing) and why? What infrastructure – both hard (material things) and soft (processes) items were needed?
- How did you or your community respond to the disruption of electricity supply and what were they able to do to minimise the impact?
- Future proofing – what has your community done since the disaster to be better prepared?

(Corresponding research question: What (technical, infrastructure and strategic) priorities do they see in building local energy resilience?)

## 4.3 Utility level

At a utility level, the ownership structures of energy companies responsible for the generation, transmission, and distribution of electricity varies among states and territories, so does their vertical integration in the National Electricity Market (NEM). While some of the largest players in the energy sector in Queensland (Energy Queensland) and Tasmania (TasNetworks) are government owned or partly government owned,

[1] A microgrid is a local energy grid whose defining feature is its ability to "island" – meaning while it is typically connected to the traditional, large-scale grid that powers homes and businesses across the country, it can also disconnect and operate autonomously.

energy businesses in NSW, Victoria and South Australia are private businesses. Furthermore, the largest players in the NEM, including AGL and Origin Energy, are gentailers, i.e. they own and operate the generation and the retail component, making them powerful actors.

In Australia, these entities serve under the National Electricity Objective stated in the National Electricity Law (NEL), which places a strong focus on affordability, reliability, and security of supply. Although energy resilience is not explicitly mentioned in the NEL, the government and market bodies emphasise the role that different energy entities have in supporting communities to prepare, plan and recover from natural disasters (AER, 2022). Electricity networks, which include distribution and transmission companies, are important for communities as they provide energy services to households and businesses. Electricity network providers are obliged to undertake public awareness campaigns, which become even more essential in an energy resilience context (Ausgrid, 2022).

Australia has the longest interconnected power system in the world, spanning many different geographies and climate zones. With the frequency and intensity of storms, floods and bushfires increasing, this is leading to the interruption in community power supply more regularly and for longer periods. This puts electricity network providers under significant pressure to maintain supply as climate change accelerates. When these power outages occur, they have cascading effects that can cause multiple failures to essential services, such as telecommunications, transport, financial, and health.

Utilities have traditionally been focussed on the efficient delivery, maintenance, and operation of energy infrastructure that supports a centralised energy system, rather than other aspects that can be a high priority for communities, such as environmental or social concerns. For example, AusNet is rolling out stand-alone power systems (SAPS) to address network resilience for customers in remote Victorian locations (AusNet, 2023). While many remote energy solutions still make use of diesel generators, which are fossil-fuel powered and hence unsustainable (CutlerMerz, 2020), networks (and governments) are aware of the need to decarbonise remote communities. There has been progress in transitioning some of these communities away from fossil-fuel supply or reduce their reliance on fossil fuels. A recent example is Ergon's (Queensland's government-owned network provider) decision to invest $28 million to replace diesel generators powering communities in far North Queensland with solar PV and battery storage. This does not only save the network provider $3 million worth of diesel costs per year (Williamson, 2023), but actively reduces energy-related emissions from fossil fuel.

Previous and ongoing interactions between communities and network providers shows that there is a willingness to work together but challenges remain. Recommendations outlining the distribution networks providers' engagement with communities have been proposed by Victoria's Electricity Distribution Network Resilience Review (Government of Victoria, 2022). These included the need for networks to develop resilience investment strategies informed by community needs, ensure that vulnerable customers and critical community assets are prioritised for restoration during outages, renumerating those who have suffered prolonged power outages, and undertaking and publishing reviews of the actions taken during and after outages.

The Royal Commission into National Natural Disaster Arrangements (2020) points to the previous lack of engagement with local communities and the need to do this on a deeper level with those affected. It stated that disaster preparation, response, and recovery should be a shared responsibility. Also, that more cooperation, coordination, and education between government, industry, and local communities was needed. Energy networks will continue to have a key role in managing and maintaining their assets, as well as increasing awareness of their critical infrastructure and its role during times when it is most badly needed. This kind of engagement can better ensure that recovery after disasters is 'locally led' and attuned to the needs of the affected communities.

Questions for fieldwork:

- Have you had interactions with any institutions or power companies? If so, describe how they went.
- Who should be involved in programs/initiatives that elevate preparedness and resilience in the community in regard to energy and beyond?

(Corresponding research question: What do communities consider as necessary steps to reach energy resilience?)

# 5. Energy resilience and social factors

It is widely acknowledged that a 'system-of-systems' approach, which integrates physical-infrastructure, social, and economic aspects, is crucial for building community resilience. Just like the intricate connections among energy systems, water and wastewater utilities, communications, and transportation networks, there are also correlations with social functions in a community. Indeed, the social system is an integral part of resilience frameworks and resilience planning models (De Iuliis et al., 2022; NIST, 2020). Relevant social capacities and resources comprise agency, social connectedness, and social capital; information and communication; and the ability to learn and transform (Berkes and Ross, 2013; Chandra et al., 2011; Longstaff et al., 2010; Magis, 2010; Norris et al., 2008; Pfefferbaum et al., 2015, 2013).

However, there is still a scarcity of studies investigating the social dimension of energy resilience. Koliou et al. (2020) illustrates the limited understanding of how societal aspects, such as business disruptions, individual and community functionality, are affected by power outages, and how these impacts influence the community's recovery trajectory.

## 5.1 Agency

Despite the diversity of the concept, most definitions identify resilience as a learning process highlighting the importance of human agency (Winkelmann et al., 2020). This means that people themselves can shape the trajectory of change and play a key role in the degree and type of impact caused by that change (Bristow and Healy, 2014). Individuals and collectives are considered as proactive actors rather than merely responsive (Lenton et al., 2022). This implies that communities and partners work together to build resilience through collaborative action, shared capacity building, and development of strong relationships constructed on mutual trust and respect. Hence community agency is an important factor in building energy resilience.

Returning to a previous normal in the sense of ‘bouncing back’ seems ill-advised where existing infrastructure and systems are not equipped to handle the realities of a rapidly changing climate. Instead, the concept of “bouncing forward” or “building back better” follows the idea to avoiding a return to the existing state, seeking to improve the system through broader inherent changes (SEI, 2020; World Bank, 2020). This could be through building back homes and energy infrastructure using more localised and sustainable energy solutions, enabling the realisation of a ‘new normal’.

The role of agency in community resilience can take several forms:

- Empowerment: Empowering individuals and communities to take ownership of their resilience-building efforts can increase their sense of agency and self-efficacy. This can lead to increased engagement and participation in resilience-building efforts.

- Decision-making: Giving individuals and communities a voice in decision-making processes related to resilience can increase their sense of agency and ownership over the outcomes. This can lead to more effective and sustainable resilience measures that reflect the needs and priorities of the community.

- Innovation: Agency can drive innovation and creativity in resilience-building efforts. Individuals and communities with a sense of agency are more likely to take risks and try new approaches to resilience-building that can lead to more effective and innovative solutions.

- Collaboration: Agency can facilitate collaboration and partnerships between individuals and organizations within a community. By empowering individuals and organisations to take ownership of their resilience-building efforts, they can work together more effectively and create a more coordinated and cohesive response to challenges.

There is a broad range of stakeholders that can take an active role in creating energy resilience in communities. Policy makers, citizens, and civil society may take purposeful action in finding innovative solutions to key development challenges, helping build community and place resilience. Local community members can tap into decentralised sources of knowledge and capability and utilise those in relation to threats.

## 5.2 Social capital, connectedness, and trust

Strong social networks and relationships within a community can help build trust, reciprocity, and cooperation, which are important components of resilience (Peters et al., 2010, p. 7601). These elements are often seen in communities with high levels of social capital. Such communities are more likely to work together and mutually address energy-related challenges, as well as support one another during times of crisis.

Social capital can be understood as an asset derived from both individual (ties of individuals to other individuals, groups, or institutions) and collective (linkages among various networks, organizations, and/or institutions and linkages between communities) levels (Pfefferbaum et al., 2017). Hence, social capital refers to how community members get involved and contribute to activities that benefit a community's goals before, during and after crisis event.

Social networks and collaboration are vital in cases of immediate power outages to support vulnerable community members and take collective action to address the challenges. In pre- and post-disaster situations, these assets also play a critical role. Social capital is considered the ‘‘core engine of recovery’’ post disaster, as communities with strong social networks have access to necessary information and support and recover faster than those without (Pfefferbaum et al., 2017).

Social capital, in the energy resilience context, can be attributed to the engagement of community members and their willingness and ability to address energy related questions, such as access and supply, through localised and bottom-up approaches.

The Venus Bay community has identified ‘community wealth building’ as a common principle of how to structure and operate local economies based on democratic participation and equitable prosperity. There are five key pillars that contribute to building ‘community wealth’: (i) enterprises – which enable and support community ownership, (ii) spending and supply chains – keeping value chains local, (iii) assets – social assets that accelerate the energy transition, (iv) the workforce – which includes funding options for volunteer-based and paid work, to support the community in crisis situations, and (v) finance – securing projects through a combination of external grants and investment from the community, with the priority to ensure benefits remain local (Venus Bay Community Centre, 2023c).

Another example for a community with strong social capital is the Hepburn Shire, 100km northwest of Melbourne, Victoria. The community addressed sustainability concerns with developing the Hepburn Wind Energy project. The project has created a foundation that is built on elements of social capital, trust, and the common good. In 2005, the Hepburn Wind energy project was proposed by Future Energy, a wind energy project developer. Initially, the community was highly divided about the project. Two years later, a cooperative (“co-op”) business and funding model was subsequently developed. Through extensive community consultation and active community participation, the project was able to build trust among the community through the concept of self-ownership. Hepburn Wind was the first energy co-op in Australia and by 2011 had 2,000 members. Now known as “Hepburn Energy”, it has contributed to the development of a progressive and timely governance approach as demonstrated by the overarching Hepburn Shire’s sustainability strategy.

The council’s sustainability strategy is unique in its holistic approach to building an energy and climate resilient community. The strategy consists of four core subjects: (1) large-scale renewable energy and battery storage; (2) valuing the natural environment and protecting biodiversity; (3) a circular economy approach to waste management and material recovery; (4) addressing climate resilience, including adaption measures related to infrastructure and critical resources such as water, community actions, and risk assessment.

The Hepburn (2022) Shire Council understands that these themes can only be achieved by breaking siloed thinking and accountabilities, supporting inclusivity, and working towards social justice. Examples include the strong acknowledgment of Aboriginal People’s and First Nation’s knowledge and experiences and their participation to support strategy objectives, general support of vulnerable community members (for example, through the solar savers project which provides rooftop solar to public and low-income housing), and the councils vision of ‘climate justice and [its responsibility to] make sure we look out for those who are less able to look after themselves’ (Hepburn, 2022, p. 21). Overall, the Hepburn Energy project has unleashed concepts guided by resilience building, with a focus on adaptive and anticipatory capacity. These ideas of caring for futures generations have also been adopted and standardised by a growing number of government agencies.

## 5.3 Social dynamics and communication

Communication is a crucial aspect of social dynamics as it helps build connections, exchange ideas, and shape collective decision-making processes. In the context of energy resilience, effective communication among stakeholders, such as utilities, policymakers, communities, and consumers, is vital for addressing challenges, coordinating responses to disruptions, and ensuring the smooth functioning of energy systems.

Effective communication is critical for building energy resilience. This includes both formal communication channels (such as government announcements or news updates) and informal communication channels (such as word of mouth within the community). Done well, it can help build trust, facilitate collaboration, and ensure that individuals and organizations have the information they need to make informed decisions about energy-related issues.

All community energy projects which have been introduced in Section 4 have been successful because of their clear communication strategies with the public. For example, the MyTown Microgrid project in Heyfield had an on-going communications campaign which was supported by webinars and workshops. This sought to include the entire community in discussions about the different steps and considerations related to finding the best local energy solution (microgrids, community batteries, home energy upgrades, or a community energy retailer) for the town. The Heyfield community was also informed and included in decisions about the technical and business model options, as well as what its choices were in terms of governance models. Access to up-to-date information, support through energy sector experts, and guidance by non-profit groups specialising in community energy, all contributed to building capacity for energy resilience.

The success of Hepburn Energy was also entirely founded on communication and proactive participation. As discussed in the previous section, the Hepburn community initially voiced it would not support the construction of the wind turbines. The initial community opposition was related to disappointment and not having a voice, a lack of inclusion in the decision-making process (Hepburn Energy Coop, 2023).

Communication channels were also particularly important in the Ngardara Solar Microgrid Project, which will install an off-grid microgrid for the Aboriginal community in Borroloola, a remote region 1000 km south-east of Darwin. The key communicators in this instance were Original Power and the First Nations Clean Energy Network, both well-established organisations with a strong track record working for and with Aboriginal communities. For such a project, it's extremely important for communication and trust that communication is undertaken in person and by being present on country.

These examples demonstrate that resilience building is a place-based construct and needs to be adjusted based on the needs of different communities.

Questions for fieldwork:

- What are the priorities in your community related to infrastructure and communications (buildings in the community, passing down information to vulnerable people, people with medical needs that require energy)?

(Corresponding research question: What (social) priorities do they see in building local energy resilience?)

- Have you had conversations with your neighbours or wider community about what you might do in a disaster? If yes, please list what you've done to prepare.
- Are there any barriers to communication and collaboration within your community?

(Corresponding research question: How do communities view their own role in energy resilience building?)

# 6. Energy resilience and lessons for and from communities

## 6.1 What do we learn from Guides and Handbooks?

In total, seventeen guides and handbooks that address resilience and disaster management have been reviewed as part of this desktop study (see Table 4 in Appendix). Most of the text documents are in English language and focus on different approaches to resilience building in the US and Australia. Only one of those reviewed was found to be a visual guide, which aims to educates children in Bangladesh about responding to floods and landslides (what to do and where to go). In the Australian context, guides and handbooks have been developed on a nation-wide user base, while others are state-specific, which reflects the size of and diversity within the Australian continent. The guides are listed by location rather than topic.

There are three types of guides and handbooks:

- Technical guides
    - that cover climate and energy resilience from an architectural perspective. The guides focus on retrofitting private and public buildings and secure the functioning of critical infrastructure. Measures include improving energy use, energy efficiency, energy storage and in general future-proofing the built environment for extreme weather events. The guides are targeted at town and city planners, governance bodies such as councils, engineers, building managers and experts in the energy sector including utilities.
    - that cover energy and network resilience from an operational perspective and focus on emergency response and recovery, distributed energy systems, and communication with emergency response organisations. The targeted audience includes energy utilities, network providers and other experts in the energy sector.
- Educational guides on energy resilience for communities (grassroots / top-down level)
    - that cover the planning and set up of community buildings that operate as evacuation centres in climate emergencies. The guide provides information on installing upgrades to ensure access to critical services including energy, financial strategies to cover upgrades, and community engagement (in terms of formal and informal responsibilities and roles). The guides are developed for regional communities and community organisations.
    - that cover communication approaches and collaboration among (i) Communities to develop leadership, collective action, and other skills to provide support before, during and after disasters happened; (ii) Local councils to meet the needs of disaster-prone communities; (iii) Emergency management and governance organisations to communicate and align strategies on resilience.
- Check-list type guides for individuals and households
    - that cover behaviours and advice on how to prepare, respond and recover from climate disasters, including communication with emergency agencies and post-disaster services, such as mental health services and financial assistance. The guides provide advice beyond homes and include visitors, vehicles, and pets.

While the guides focus on different aspects of resilience building in an energy security and climate disaster context, there is a common understanding of climate change acting as a key driver and that climate adaption measures are urgent. Another shared feature is that they endorse the need for transdisciplinary approaches linking physical features (homes, buildings, cities), public authorities, and institutions (involving diverse stakeholders). They all promote a common language and collaborative ways of working. Finally, all the guides acknowledged the temporal dimension of resilience building and the demand for developing short, medium, and long-term solutions.

There was found to be numerous handbooks and guides informing communities, public authorities, and the private sector on social, technical and governance aspects of building energy resilience. Although they were generally found to be highly comprehensive, it also made them quite complex and potentially challenging for all members of a community to access the content quickly and easily. Visualisation has been used to increase accessibility, as the example of the disaster guide targeted at children demonstrates.

## 6.2 What can we learn from other communities?

### Experiences in Australia

Regional and remote communities in Australia are facing challenges on multiple fronts when it comes to energy resilience. These challenges include:

- Reliance on imported fuel for electricity generation, which makes them vulnerable to cost fluctuations and supply disruptions.
- Distance from – or weak connection with – the main electricity grid.
- Exposure to unpredictable events, such as cyclones, bushfires, storms, and floods, which can damage power infrastructure and disrupt supply.
- The worsening impacts from climate change, which is increasing the frequency, intensity, and duration of these events.

These challenges are having a significant impact on the lives of people living in these locations. They can lead to power outages, which can disrupt essential services such as water and sanitation, healthcare, and education (Weir and Kumar, 2020). They can also damage homes and businesses, displacing people and hurting local economies.

To improve energy resilience for vulnerable communities, an important step is to shift to using more locally produced renewable energy. These forms of power generation can be more resilient compared with relying on the main grid. Solar PV has been reported to be able to withstand bushfires (TEC, 2020), and when appropriately mounted can withstand cyclones (Weir and Kumar, 2020). This can enable communities to recover energy supply much sooner. They are also more affordable, which can help to reduce the cost of energy for residents.

Another important step is to improve the resilience of electricity infrastructure. This can be achieved by designing and building power lines and substations that are less prone to damage by extreme weather events. It is also important to have backup power sources in place, such as batteries and generators, that can be used when the main power grid goes down. Improving energy systems for rural and remote locations is essential to build long-term community energy resilience.

**Bruny Island**

Bruny Island is one example of how a community can come together to transition to a more resilient energy system. Located off the south-western coast of Tasmania, it is connected to the mainland's electricity system via an undersea cable. As tourism has grown on the island along with peak demand, additional energy capacity was required to avoid power outages during peak tourism periods.

The island's residents were aware of the challenges they faced, and they were willing to work with the electricity network provider (TasNetworks) to find a solution (Lovell et al., 2018). The CONSORT project2 showed that

[2] The 3-year CONSORT (CONsumer energy systems providing cost-effective grid SuppORT) was funded by Australian Renewable Energy Agency (ARENA), 2016-2019.

household-level PV-batteries can be used to control grid supply[3], especially during peak demand. This is a promising approach for other islands and remote communities that are facing similar challenges.

The installation of home batteries on an island with poor telecommunication and internet connectivity was a welcome development for the community. The batteries provide a backup electricity supply in times of network failure, which was a major concern for islanders. However, the batteries also require communication with TasNetworks, which meant that the island's internet infrastructure needed to be upgraded. The upgrade of internet connectivity has benefited the island community in many ways, beyond simply allowing TasNetworks to communicate with the home batteries. Islanders now have better access to educational resources, healthcare services, and other essential services.

The project also highlighted the importance of community engagement. Island residents were strongly in favour of the project (Lovell et al., 2018) and they also advocated for a large-scale solution in the form of a community battery. While TasNetworks was committed to install individual household PV and battery storage systems, the community's desire to install a centralised battery raised the question for some participants regarding who should benefit most from the project (Watson et al., 2019).

The key message from the project was that communities must be engaged beyond the household level and should be involved as a community as such. This makes it more likely for them to support the energy system changes as utilities and network providers recognise the social and economic benefits emerging from community-based local energy solutions.

**Mallacoota**

The 2019/20 bushfires in Mallacoota had a significant impact on the community's energy supply. The town is located at the fringe of the grid and already experienced regular power outages. As the fires approached, the power supply was cut off earlier than expected which created challenges for communication, planning, and coordination of rescue efforts. The telecommunication infrastructure also failed so residents were no longer able to use their mobile phones to monitor the movement of the fires. Instead, they were forced to rely on personal and social connections, with face-to-face communication becoming the lifeline for many (The Insight Centre, 2021).

After the bushfire, the community was reliant on mobile generators fuelled by diesel to restore energy supply. The extent of damage to the central energy infrastructure meant that restoring it would be a slow process. Residents who could afford it purchased diesel generators as an indication of movement towards self-reliance (The Insight Centre, 2021).

The rebuild of energy infrastructure in Mallacoota was closely watched by the community who were disappointed to see the same infrastructure being rebuilt that had failed them. In Mallacoota, network upgrades included the replacement of wooden poles with concrete poles, but poles were not replaced in other fire-prone locations in East Gippsland (The Insight Centre, 2021).

The key learnings from Mallacoota are related to the rebuilding of energy infrastructure. The process should be clearly communicated to the community, feature fire-resilient upgrades, and most importantly proactively demonstrate a shift away from the centralised grid towards fire-resistant renewables and DER solutions. This is key for end-of-the-line communities with low energy security.

Here are some specific recommendations for how to improve energy security in bushfire-prone communities:

- Use disaster/fire-resistant materials for energy infrastructure, such as concrete poles and underground cables.
- Install distributed energy resources (DERs), such as rooftop solar and batteries, to provide backup power in the event of a grid outage.
- Promote energy efficiency measures to reduce demand on the grid.

[3] On average 10% of residents had rooftop solar installed, almost twice as much as on the Australian mainland.

- Develop community-based plans for energy resilience, such as mutual aid agreements and community microgrids.

By taking these steps, we can help to make bushfire-prone communities more resilient to climate impacts.

**Venus Bay**

The Venus Bay and Tarwin Lower Community Resilience and Reliable Energy Feasibility Study has been led by a strong desire for community energy resilience and this provides its core foundation. Venus Bay experienced frequent power outages in the past, but the impacts caused by the 2019/20 Black Summer Bushfires exposed serious vulnerabilities for reliable and resilient power supply. The fires in the surrounding area were more intense and longer lasting than experienced previously. As a result, the Venus Bay community acted to seek ways to address this vulnerability. The project had a clear focus on the supply and access of essential services, which they had defined as energy, water, and communications (telephone, mobile, internet, etc.). The choice and installation of distributed energy technologies were primarily considered a means to the provision of these services in times of crisis. The feasibility study found that needs during disaster situations differ from everyday ones, and that the community had a strong desire to not only ensure resilience of essential energy-related services, but also improve as a community overall (Skinner et al., 2022). The project has installed an additional solar array to the existing solar system and a community battery, enabling the system to function as a microgrid (Neighbourhood Houses Gippsland, 2022). The community is currently exploring ownership and financing models for community batteries and microgrids (Venus Bay Community Centre, 2023a, 2023b).

## 6.3 How do communities become energy resilient?

A worldwide community energy movement (see Box 3) has emerged as more people become driven to act due to their environmental concerns, as well as being motivated by social and economic drivers (Bauwens and Devine-Wright, 2018; Hicks and Ison, 2011; Hicks and Mey, 2016; Seyfang et al., 2013). The growing body of literature on the benefits of community-led and community-owned energy projects highlights the positive contributions of these projects, including to local energy resilience (Bomberg and McEwen, 2012).

Box 3: Community energy in Australia

The Coalition for Community Energy (C4CE, 2015b) defines community energy as "*the wide range of ways that communities can develop, deliver and benefit from sustainable energy. It can involve supply-side projects such as renewable energy installations and storage and demand-side projects such as community education, energy efficiency and demand management. Community energy can even include community-based approaches to selling or distributing energy*." Central is the notion of community of place, which is associated with local ownership, local project implementation, and equitably shared benefits.

Since Hepburn Wind (Australia's first community-owned renewable energy project) started generating in 2011, many projects have followed to create a thriving community energy sector. Today more than 130 groups initiate, own and maintain community energy projects across the country (CPA, 2023).

In 2015, a sector wide survey found that members of community energy groups are motivated by aspects of 'community self-sufficiency and resilience' (80%), associating these characteristics with a locally initiated and driven energy project (Hicks and Mey, 2016). This also reflects the international discourse, where community energy promises to bring autonomy and resilience (Bomberg and McEwen, 2012; Genus and Iskandarova, 2020).

Already in 2015, a sector-wide survey found that members of community energy groups are motivated by aspects of 'community self-sufficiency and resilience' (80%), associating these characteristics with a locally initiated and driven energy project (Hicks and Mey, 2016). This also reflects the international discourse, where community energy promises to bring autonomy and resilience (Bomberg and McEwen, 2012; Genus and Iskandarova, 2020).

Energy resilience varies among communities. Table *2* outlines the motivations, organisations behind the projects, technical systems, as well as public and corporate partnerships. This list is followed by communities which have explored and implemented renewable energy and distributed energy systems to build energy resilience.

Table 2: Examples of community solutions for energy resilience

| Project | Initial motivation | Community Group | Technologies applied/ considered | Partnerships | Measures of resilience building |
|---|---|---|---|---|---|
| Total Renewable Yackandandah<br>Indigo Shire, Victoria | 100% renewable energy and energy efficiency to become more self-reliant, reduce risks of energy system disruptions and reduce electricity costs | Total Renewable Yackandandah | Minigrids, solar, community battery, and Virtual Power Plant | AusNet Services, Mondo Power, Indigo Power<br>Local service providers including fire station and cemetery. | Rooftop solar in buildings and public places.<br>Batteries in public buildings and homes.<br>Community battery (behind the meter, community owned) integrated into multiple minigrids.<br>Alternative back-up power for critical service providers. |
| Venus Bay and Tarwin Lower<br>South Gippsland, Victoria | Experience of climate disasters | Venus Bay Community Centre | Microgrid, community batteries, solar | Neighbourhood Houses, Victorian Government | Draft action plan includes five focus areas: (i) an increase in household energy efficiency; (ii) installing renewables at community facilities, and (iii) at business sites; (iv) create power resilient clusters; and (v) balancing community energy needs with mid-scale renewables |
| MyTown Microgrid<br>Wellington Shire, Victoria | Make better use of locally generated renewables, while reducing costs and increasing resilience from climate disasters | Heyfield Community Resource Centre | Microgrid, community batteries (front of meter, behind the meter), town-scale smart home upgrades, local energy retailer | Wattwatchers Digital Energy, AusNet Services, Latrobe Valley Authority (LVA), Community Power Agency (CPA) | Interested in variations on the community battery that can provide emergency power to public facilities and local businesses to provide essential services, incl. cold storage for foods, shelter, communications, etc. |
| Borroloola Ngardara Solar Microgrid Project<br>Roper Gulf, Northern Territory | Shift to clean energy and lowering of electricity costs, reduce power outages, self determination | Borroloola Community | Off grid microgrid, solar, and battery | First nations-led energy project developer Original Power together with First Nations Clean Energy Network | First nations-led Energy retailers and job creation (training centre for knowledge and job skills) |
| Mallacoota - Community Microgrids and Sustainable Energy Program<br>East Gippsland, Victoria | Experience of climate disasters | Mallacoota Sustainable Energy Group | Microgrid with solar PV, batteries, and diesel generators.<br>Flexible control of residential water heaters | Victorian Government (DEECA), AusNet Services, and<br>Mondo | Focus on provision of essential services based on experience during 2019/2020 bushfires |
| Bruny Island Battery Trial - CONSORT<br>Kingborough, Tasmania | Developing a low-cost and alternative to upgrading undersea power cable and shift from diesel generation to renewable energy | None – individual households. | Solar PV and residential batteries to enable the state-owned power utility TasNetworks to control supply during peak times | ARENA, TasNetworks, ANU, Start-up Reposit, University of Tasmania, | Household batteries act as back-up power supply in case communities are temporarily being cut off from the grid.<br>Conflict related to trust: community's desired solution (central community battery) vs. the network's decision (home batteries), question about who benefits |

**Totally Renewable Yackandandah (TRY)**

The Yackandandah project consisting of three grid-connected minigrids, VPP, and community battery demonstrates a leading example of a community-led and community-owned renewable energy project which is consistently growing and evolving. The small town of Yackandandah, in northeast Victoria, has about 2,000 residents and is located at the edge of the grid. Connected via a single line to the main grid, the town experienced frequent power outages in the past. The journey to adopt renewable energy began in 2014, when the volunteer community group Totally Renewable Yackandandah (TRY) was formed. TRY developed a community energy project with the aim to improve energy efficiency, save on energy bills, achieve energy reliability and eventually reach 100% renewable energy (Totally Renewable Yackandandah, 2021).

In 2014, TRY secured a $100,000 government grant which funded a paid management position and allowed TRY to set up a business to operate as a community-owned energy retailer. TRY, initially built on the large number of existing rooftop solar systems in the town and focussed investments on home battery storage systems. In cooperation with the energy monitoring provider Mondo, a Virtual Power Plant was established which managed the town's electricity demand, supply and battery storage based on data collected through residential smart meters (Totally Renewable Yackandandah, 2021).

TRY's approach to energy resilience is characterised by its community-centric and localised vision of energy demand, its collaboration with local services and businesses, and its overarching aim of reaching 100% renewable energy. The group has ensured that critical infrastructures and public buildings, including local service providers (fire station, pubs, the sawmill, water treatment plant, post office and cemetery), are solar powered and self-sufficient in their electricity supply. TRY supported Yackandandah's Fire Brigade CFA in deploying rooftop solar and battery storage, in addition to diesel generator-based back-up power, in preparation of extended power outages (Totally Renewable Yackandandah, 2021). Overall, 40% of buildings on Yackandandah's main street are equipped with rooftop solar (Preiss, 2022). By late 2020, the Yack Valley reached rooftop solar density of 60% (Milbank, 2020). In 2019, TRY collaborated with Indigo Power to build a community battery. In 2021, the battery's capacity was updated to 274 kWh, which, combined with the 65-kW solar array installed on the sawmill, will enable the town to reach 100% renewable energy (Totally Renewable Yackandandah, 2021).

TRY has been active beyond the geographical boundaries of Yackandandah and joined the ARENA-funded "Project Edge" in 2021, which trials a virtual power plant for DER across the Hume region. The developments observed in the town of Yackandandah are particularly insightful in the context of resilience building, learning, and the continuous evolution of knowledge and level of engagement. Matt Charles-Jones, one of the leaders behind TRY, explains the key to Yackandandah's success has been cooperation and authenticity, "*we have been remaining humble about what it is we can do. We are not technical experts at all, but we are – collectively – experts in our own community*" (ABC, 2021). The case study of Yackandandah highlights the human dimension of the project, which is central for organisational and technical components to function, and for collaboration and knowledge-sharing to flourish.

**MyTown Microgrid**

The community in Heyfield explored, in a step-by-step process, different local energy options through a data-led feasibility project called MyTown Microgrid. The 3-year project (2020-2023) received $1.7 million grant funding from the Federal Government's Regional and Remote Communities Reliability Fund (and $100,000 from the Latrobe Valley Authority). The town was initially motivated by concepts of 100% renewable energy and achieving energy resilience. In the past, Heyfield has experienced threats from bushfires and floods (grass fires in 2011 and a flash flooding event in 2019), which strengthened the idea of becoming energy resilient.

University researchers, technical experts, consumer advocacy groups, and a community reference group, have been guiding the Heyfield community through the journey and introduced different technical, financial and ownership options during community consultation sessions. The project also funded a paid position (Community Liaison Officer) to engage with the community, local businesses, and institutions, including electricians and schools. This role has shown to be effective in raising energy literacy within the community (Heyfield Community Resource Centre, 2022). A practical output which has been developed as part of the feasibility project, is an online decision support tool. The web-based tool assists communities in their

consideration of different strategies, technology options and ownership models for local energy solutions based on their collective objectives.

While the project title implies the Heyfield community choose a microgrid as their energy solution, this option was ultimately considered unsuitable due to the town's proximity to the grid, the large number of existing residential solar rooftop systems and infrastructure costs associated with building an off-grid microgrid. However, the Heyfield feasibility study found community batteries, smart home energy upgrades, and a local energy retailer would be more suitable options based on the community's characteristics and requirements.

Other regional communities have been active in exploring suitable distributed energy options with grants from the Regional and Remote Communities Reliability Fund - Microgrids (RRCF). This saw more than two dozen projects funded under two rounds to undertake microgrid feasibilities for 110 communities. Overall, 50% of microgrid projects in Australia are in rural and remote areas. About 53% of microgrid projects include battery storage, while 25-30% of projects reported plans to install battery storage (Wright et al., 2022).

**Ngardara Solar Microgrid Project**

The Ngardara Solar Microgrid project is located in the Aboriginal community of Borroloola, 1000 km south-east of Darwin, the Northern Territory. The project also received funding under the RRCF grant program. The main motivation behind the project is to provide the remote community with renewable electricity, reduce energy costs, and increase thermal comfort (temperatures are extreme during summer and often exceed 40 degrees Celsius) (Original Power, 2022). Currently residents use prepaid cards to access electricity, so costs are high as the local energy network is diesel powered, which is also polluting and noisy. The risk of power outages and disconnections from the electricity network in Aboriginal communities increases during extreme temperature events (extremely hot or extremely cold weather) (Longden et al., 2021). Original Power (2022) estimates, the shift to renewable energy will reduce costs for residents and businesses by up to 70%. Energy resilience, in this context, primarily focuses on energy sovereignty. An off grid microgrid with battery storage offers the community a pathway towards self-determination. The project developer, Original Power, a First Nations'-led and community-focused organisation, is establishing training centres to ensure the community develops the required knowledge and job skills to build and operate the off grid microgrid. The formation of an Aboriginal-run energy retailer will ensure social and economic benefits remain within the community (Original Power, 2022).

# 7. Conclusion: Working definition of community energy resilience

This literature reviews provides a starting point for better understanding the various dimensions behind ‘energy resilience’ while specifically considering a community perspective. While ‘community energy resilience’ does not yet exist as a firmly defined concept, ‘resilience’ within the context of ‘energy’ and ‘community’ is regularly referenced and staunchly pursued.

The concept has been found to be highly relevant to communities in their pursuit of a variety of outcomes, such as greater diversity of energy sources, improvements in energy efficiency, further adoption of renewable energy technologies, more robust grid infrastructure, closer ties within the community, and better energy affordability. There is also a growing realisation that there are multiple additional benefits to be capitalised on from achieving a higher state of community energy resilience: the adoption of more sustainable practices, local socioeconomic benefits, improving health outcomes, enhancing existing critical services and energy infrastructure, and ultimately improve the overall resilience and well-being of the community.

It is crucial to recognise that energy resilience in communities is a relatively new concept that is part of an ongoing process involving learning, adapting, and transforming. This process exhibits distinct characteristics across technology and social dynamics. Human agency also plays a critical role enabling the community to ‘bounce forward’ or ‘build back better’. This avoids a return to the existing system, instead improving the community’s built environment, its infrastructure and more, through the adoption of localised sustainable energy solutions.

We suggest the following working (Table 3) definition for ‘community energy resilience’, sitting at the intersection of resilience, energy resilience and community resilience.

Table 3 Working definition of community energy resilience

| **‘Community energy resilience’** |
| --- |
| Community with the capacity and resources to adopt and utilise local appropriate energy solutions that help to learn and anticipate, withstand, and quickly recover from climate disasters. Key factors comprise:<br>• Technology and local energy infrastructure: small to medium scale, decentralised and adapted to local needs<br>• Social capacities: collaborative governance, high level of social capital, and inclusive communication<br>• Economic dimension: affordability and accessibility |

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# 9. Appendix

Table 4 Guides and handbooks on resilience, energy resilience and community energy resilience

| Author and title of the Guide | Location | Resource | Background and focus | Addressees | In the context of community energy resilience: | | |
|---|---|---|---|---|---|---|---|
| | | | | | What does the guide provide, what does it achieve? | What has not been provided or achieved by the guide? | Does it support our definition? |
| Energy Master Planning toward Net Zero Energy Resilient Public Communities Guide [link] | global | Alexander Zhivov (author) Book | The Guide is designed to provide a valuable information resource for stakeholders involved in community planning with a focus on buildings. | energy systems engineers, architects, project developers, energy managers, and building operators, public authorities | Technical information for town planning and retrofitting buildings to improve energy use and efficiency | No information on addressing diverse social and cultural backgrounds, financing models/ options for communities, developing agency and leadership | no |
| Guides to resilience community centres [link] | Australia | Community Power Agency (2022) | The guide informs setting up Resilient Energy Centres, equipped with a backup energy system to achieve energy independent operation in case the region will be cut off from the grid due to a climate related disaster. | Regional communities | Information about energy resilience centres (existing hubs, planning tools, funding options for new developments; stakeholder engagement and collaboration (roles and responsibilities) | No information on building communities and overcome cultural differences/ challenges, individual/ household measures, community leadership/ agency, communication | yes |
| Venus Bay Energy Study, Project updates [link] | Australia | Venus Bay Community Centre (2023) | Building energy resilience for the Venus Bay community including businesses and visitors | Tight-knit regional communities | The Milestone reports explores and test energy options to support community energy resilience and develop funding mechanisms to access suitable energy options | Resources document processes and findings from the community engagement (workshops, survey, milestones and progress timelines). The website does not provide specific facilitation or communication tools, although the methods used in the projects are outlined as part of the | yes |

| | | | | | | | |
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| | | | | | | reporting, which can inspire other communities to undergo such a development. | |
| Monash University Disaster Resilience Initiative *Compendium [link]* | Australia | Monash University | The creation of the *Compendium* was inspired by the recognition that there is a need to support communities to avoid duplication, preserve precious resources, and capture these learnings in a single collection. | communities, governments, organisations including education and research | Living document that collects and shares lived community experiences through case studies. It provides examples of activities that build community resilience and references other resources (Australian Institute for Disaster Resilience, state emergency management), including leadership building | Not a structured high-level guide, findings from case studies are not consolidated. No focus on user-friendly design or information layering.<br>case studies are location-specific (in Victoria). | To a large extent |
| *Community Resilience Planning Guide for Buildings and Infrastructure Systems*. [link] | United States | National Institute of Standards and Technology (2020). | Through a planning process the guide provides a structured and flexible way to set community-scale goals, aligns priorities and resources, identifies key stakeholders, and develops plans to recover community functions. It focuses on the built environment. | Public sector agencies, including emergency services, utilities, community engagement agents. Businesses, industry, service providers. NFP and volunteers. Technical experts and consultants | The guide links technical and social requirements to build resilient systems.<br>The guide acknowledges the key role of the community resilience leaders as part of a broader stakeholder engagement process. | The guide does not discuss the challenges related to cultural differences and inequities within the community.<br>Does not provide support tools for electing a leader or assist facilitating community engagement / participation. | No, the guide defines the community by geographical boundaries and governance structures, rather than socio-economic characteristics. |
| *Regional Resilience Toolkit: 5 Steps to build large scale resilience to natural disasters* [link] | United States | US Environmental Protection Agency EPA. (2019) | The Toolkit aims to help cities, regions, and other partners integrate hazard mitigation, sustainability climate adaptation and equity, into a single process to create an action plan. This helps to aligns goals and actions, and support | Coordination between (regional) government agencies, NGOs community groups. | The toolkit provides practical tools for storytelling and to well communicate information through different types of interactions, e.g. with community, emergency management, utilities, service providers and funding bodies. The toolkit | The toolkit does not cover the topic of energy in adequate detail and is limited to a high level, or the interdependencies between electricity, communication, water, transport and health. | Yes, however the definition provided by the toolkit largely draws on disaster resilience. |

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| | | | communities to obtain project funding. | | provides tested worksheets and engagement tools. It acknowledges diversity and inclusivity, and ensures values are met in planning. | | |
| *Oregon Guidebook for Local Energy Resilience* - For Small and Medium Electric Utilities [link] | United States | Oregon Department of Energy (2019) | The guidebook is intended to help Oregon's consumer-owned utilities staff identify incremental actions they can take today to improve business continuity planning; develop a framework to prioritize investments in distributed energy resources; and better understand the role of local utilities within the context of federal, state, and local emergency management planning. | Management and staff at small and medium energy utilities | Technical guide to educate the utility workforce about climate disasters and its impact on energy infrastructure. It recognises the interconnection between resilience, electricity, communication and transport in the context maintaining services and the need to plan, prepare, respond to emergency management services. It also explores alternative energy systems (DER). | While the guide provides definitions of resilience, energy resilience and community energy resilience, resilience is defined by ensuring utilities can maintain business operations during disasters. The role of communities is not discussed further and is restricted to end users. | No, as the guide does not establish a proactive role for communities in its definition of "community energy resilience". |
| Improve community Resilience [link]<br>Part of the Better Buildings Initiative | United States | Department of Energy (2019) | The guide has a technical and commercial focus and covers resilient architecture and building design, cooperation with utilities and network providers, finance models to improve resilience in town planning and the building sector. Energy efficiency focus | Urban planners, businesses and industry, stakeholders from the energy sector | Energy resilience is provided through services (heating, cooling, etc.) of the built environment, incl. grocery stores, universities, schools, hospitals, community hubs, workspaces, factories and residential homes, to enhance well-being. | The guide does not include socio-economic features of communities and does not feature proactive participation of communities to build community resilience. | No, resilience describes a system that resists being affected and returns to its functioning state, the community's role is limited to receiving services. |
| *Landslide Awareness Cartoon Booklet [link]* | Banglades h/ United Kingdom | University College London (UCL) Institute for Risk and Disaster | The cartoon booklet (in Bengali) was produced targeting primary school children to raise awareness of landslide disasters among vulnerable communities residing in the | Children under 10 years old in flood and landslide-prone regions of Asia | The visual guide provides information on disaster preparation and response to children. The main message is to listen to community members, choose elevated locations | The booklet does not cover electricity supply and energy resilience. | Partly, the booklet portrays townships and community as central for disaster risk reduction. |

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| | | Reduction (2022) | hilly regions of Bangladesh. The focus is the immediate disaster response. | | over slopes, cliff tops for buildings purposes, and monitor developments during heavy rain/monsoon season. | | |
| Get ready Queensland | Queensland, Australia | Queensland Government | Comprehensive website which guides individuals through various phases and steps of disaster preparation, response and recovery. | Households, citizens | The website targets old and new residents and visitors to plan for disasters, this includes homes, vehicles and pets. To communicate with emergency management agencies during disasters, assess financial and emotional assistance after the disaster. | Community cohesion and emotional support is key for disaster recovery, but not central to all phases. | No, community cohesion has not been applied to all phases. Energy is mentioned in the context of reporting damage energy infrastructure. |
| A Resilience Checklist – a guide for doing things differently and acting collectively [link] | Queensland, Australia | Commonwealth Scientific and Industrial Research Organisation (CSIRO) For the Queensland Reconstruction Authority | This check list has been developed to improve cooperation and alignment across government agencies on concepts and technical framing related to resilience and identify ways in which agencies can do things differently – adapt to change. | Individual agencies and organisation within the Queensland government | The check list provides a questionnaire which covers different levels at which concepts (e.g. resilience thinking) can be understood and approached (practical). | The check list does not include energy resilience or community resilience as concepts. | No, the absence of community and energy in the discussion of resilience makes this checklist unsuitable. |
| Building Resilience to Natural Disasters Collaboration Guide - Practical Guidance for Queenslanders [link] | Queensland, Australia | Queensland Reconstruction Authority (2020) | This document provides guidance on how to establish collaborative groups across stakeholders to advance resilience led by local groups. It reflects lived experiences and links activities to Queensland's disaster resilience policy framework. | community groups, industry bodies, NGO and ENGOs, all level governments, disaster management groups (local, district level), emergency management, professionals, experts on disasters, | The guide provides principles (theories) to build collaboration, leadership and governance structures, connect and develop new systems (innovate) that empower individuals and entire communities. followed by check lists for practical steps/ actions. | The guide does not include energy resilience or community resilience as concepts and is derived from the disaster resilience concept. | Although, the absence of community and energy in the resilience discussion makes this guide less useful, principles on collaboration and benefits are highly valuable. |

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| | | | | hazards and risk management | | | |
| Summary: Queensland Strategy for Disaster Resilience 2022–2027 [link] | Queensland, Australia | Queensland government (2022) | Through consultation with partner agencies, the Queensland Strategy for Disaster Resilience reflects strategic commitments, actions and lead agencies that will strengthen disaster resilience over the next five years in Queensland. | Queensland government agencies, businesses, individuals and communities | The document summarises government commitments, actions and the range of stakeholders involved in different phases of disaster management. It provides four objectives and clear descriptions of how these can be achieved, what success is. | The guiding document does not address energy-related impacts caused by disasters | No, but the clear messaging related to objectives and successes is a useful way of communicating processes and aims |
| Victoria's Critical Infrastructure All Sectors Resilience [link] | Victoria, Australia | Victorian Government (2023) | The report 2022 provides information on the resilience of critical infrastructure sectors, the key emergency risks, inter-dependencies and resilience improvement initiatives identified by industry and government. | Local council and local emergency management<br>(target audience has not been specified in the document) | The report discusses the climate impacts on critical services: electricity infrastructure, communication, transport, retail, banking, health, and water. | The document does not address the role and vulnerability of communities, their dependencies on electricity and other critical services as well as alternatives in case of disasters. | Resilience is not defined but is discussed in the context of processes or developments. |
| *Local Disaster Communication Planning Framework [link]* | Hunter Joint Organisation *2020* | NSW Government, Get ready for disasters | The Disaster Communication Planning Framework Planning aims to build “readiness” among communities to prepare for climate disasters. The framework focuses on effective disaster communication, including external and internal communication to ensure common understandings and consistency in messaging. | Councils | The framework provides material (e.g. templates) to develop a communication strategy for councils to meet the needs and requests of various groups, including communities, emergency management stakeholders and media channels. | Energy and sustainability are not covered in this framework, except for a mention regarding the (in)ability of charging a phone during a disaster. | The topic of resilience has not been defined or covered. |

Table 5 The key terms vulnerability, threat, hazard and risk explained

| Key terms | Definition | Source |
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| Vulnerability | Identifying vulnerabilities is akin to answering the question, “How could harm occur?” Sometimes, a vulnerability can exist simply from an asset’s implementation or deployment. | Washington university (2023) [link] |
| Threat | Who or what could cause harm? A threat is anything that could exploit a vulnerability and hinder the confidentiality, integrity, and availability of anything valuable. | |
| Hazard | A hazard is a source or a situation with the potential for harm in terms of human injury or ill-health, damage to property, damage to the environment, or a combination of these. | Government of Western Australia, Department of Mines, Industry Regulation and Safety |
| Disaster Risk | Disaster risk is expressed as the likelihood of loss of life, injury or destruction and damage from a disaster in a given period of time.<br><br>The level of risk reflects:<br><br>• the likelihood of the unwanted event<br>• the potential consequences of the unwanted event.<br><br>**Risk = Hazard + Exposure + Vulnerability** | UNDRR Global Assessment Report, 2015 [link] |

Table 6 Summary table of definitions related to ‘resilience’

| Source | Definitions of ‘resilience’ | Focus on |
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| Holling 1973 | “a measure of the persistence of systems and of their abilities to absorb change and disturbance and still maintain the same relationships between populations or state variables’’ | Persistence and relationships |
| Timmerman (1981) | Resilience is the measure of a systems or part of the system’s capacity to absorb and recover from occurrence of a hazardous event | Recovery of a system |
| Folke 2002 | Resilience in this context is the capacity of a social ecological systems (SES) to continually change and adapt yet remain within critical thresholds. Adaptability is part of resilience. It represents the capacity to adjust responses to changing external drivers and internal processes and thereby allow for development along the current trajectory (stability domain). Transformability is the capacity to cross thresholds into new development trajectories. Transformational change at smaller scales enables resilience at larger scales. | Ability to adapt and transform |
| Stockholm Resilience Centre | Resilience is the capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop. It is about how humans and nature can use shocks and disturbances like a financial crisis or climate change to spur renewal and innovative thinking | Ability to renew and innovate |
| IPCC 2007 | Resilience is defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt naturally to stress and change. | Maintain existing structure and functions |
| UNDRR (2017) | Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of such hazards in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management | Ability to transform and recover |
| Gatto & Drago (2020) | Resilience as the adaptive capacity of improving performance, as a result of learning and adaptation, informed by continuous change | sustainable development and bouncing forward/ progressive change |
| Masterson et al. (2014, p. 1) | Community resilience is the ability of a community or its constituent parts to bounce back from the harmful impacts of disasters. Recent years have seen a proliferation of work using the word resilience in conjunction with natural hazards and disasters. | Bounce back |
| UNISDR (2012) | The ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. | Ability to preserve and restore structures and functions |
| Reconstruction NSW (former Resilience NSW) | The ability to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard. | Ability to adapt, transform and recover |

| Source | Definitions of 'Energy Resilience' | |
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| US National Academy of Science (2012) | NAS identifies four basic resilience components: plan/prepare, absorb, recover, and adapt to anticipated and unanticipated conditions | prepare, absorb, recover, and adapt |
| US Department of Homeland Security (2013) | Having accurate information and analysis about risk is essential to achieving resilience. Resilient infrastructure assets, systems, and networks must also be robust, agile, and adaptable. Mitigation, response, and recovery activities contribute to strengthening critical infrastructure resilience. | Mitigation, response, and recovery |
| IEA | *Energy resilience* is the capacity of the energy system and its components to cope with a hazardous event or trend, to respond in ways that maintain its essential functions, identity and structure as well as its capacity for adaptation, learning and transformation. It encompasses the following concepts: robustness, resourcefulness, recovery. | Bounce back |
| AEMO & CIGRE | Energy resilience: The ability of a power system to limit the extent, severity, and duration of system degradation following an extreme event | Ability to limit the impact on energy infrastructure |
| NSW DNSPs | 1. The ability to anticipate, withstand, quickly recover and learn from disruptive events.<br>• Withstand means the ability to resist, absorb, accommodate and adapt<br>• Recover in this context refers to reconnecting as many customers as quickly and safely as possible to minimise customer time without power<br>• Disruptive events refers to events such as extreme weather events, cyber-attacks, or losses in power supply from fluctuations in intermittent energy sources<br>2. The ability to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard<br>• 'Recover' in this context refers to reconnecting as many customers as quickly and safely as possible to minimise customer time without power. | anticipate, withstand, recover and learn |
| **Source** | **Definitions of 'Network resilience'** | |
| AER (2022) | Network resilience as a performance characteristic of a network and its supporting systems (e.g. emergency response processes, etc.). It is the network's ability to continue to adequately provide network services and recover those services when subjected to disruptive events | Provide and recover services |
| NSW/ACT/TAS/NT Electricity Distributors (Ausgrid, Endeavour energy, Essential Energy, TasNetworks, EVO Energy, PowerWater) | Network resilience*: The ability to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard<br>What is the relationship between resilience, reliability and safety?<br>• Resist - Building our capability to withstand impacts or avoid network destruction<br>• Absorb/ Accommodate - Minimising disruptions to networks and customers and supporting communities during these events<br>• Adapt/ Transform Use learnings to identify opportunities or anticipate hazards to ensure the lived experience is acceptable to customers<br>• Recover Ensuring plans and processes provide energy supply restoration as quickly as possible | resist, absorb, accommodate, adapt to, transform and recover |

| Source | Definitions of ‘Disaster resilience’ | |
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| Royal Commission into National Natural Disaster Arrangements Australia | The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management | Adapt, transform and recover |
| International Federation of Red Cross and Red Crescent Societies (IFRC) | Disaster resilience is "the ability of individuals, communities, organisations, or countries exposed to disasters and crises and underlying vulnerabilities to: anticipate, reduce the impact of, cope with, and recover from the effects of adversity without compromising their long-term prospects." | Anticipate, reduce the impact, cope and recover |
| Keating et al. (2022) Transformative actions for community-led disaster resilience Fire to Flourish, Melbourne, Australia link | Disaster resilience: The ability to cope with short-term disruptions, adapt to long-term changes, and where necessary, transform the system so it can continue to function under future shocks and stresses. | cope, adapt, and transform to function under shock and stress |
| Mindaroo Foundation<br>We Rise Together. Lifting Australia to be the Global Leader in Fire & Flood Resilience by 2025 (2020) link | Community resilience in the context of Fire & Flood Resilience:<br>Highly resilient communities tend to have healthy social fabric, diverse and vibrant economies, and robust built environments. This sets them up with strong coping capacity to prepare for and bounce back from disasters. They also have the institutions and networks to learn and adapt over time.<br>"The capacity of individuals, communities, institutions, and systems exposed to hazards to survive, adapt, and thrive in ways that improve outcomes in the next disaster event and improve community well-being more broadly.” | survive, adapt, and thrive |
| Parsons and Morley (2017), The Australian Natural Disaster Resilience Index [link] | Disaster Resilience: the capacity of communities to prepare for, absorb and recover from natural hazard events, and the capacities of communities to learn, adapt and transform towards resilience. | prepare, absorb, recover and learn, adapt, transform |
| **Source** | **Climate resilience** | |
| ENA | Climate resilience is the ability of a system to absorb climate-related disturbances while retaining the same basic structure and ways of functioning. With respect to network assets this refers to the ability of assets to absorb climate related impacts but still retain adequate, reliable and safe functioning. | Ability of systems to absorb and retain functions |
| Federal Energy Regulatory Commission (US) | The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event. | Ability to reduce impacts, adapt and recover |
| Bushfire and Natural hazards CRC (for the Australian Natural Disaster Resilience Index) | The capacity of communities to prepare for, absorb and recover from natural hazard events and to learn, adapt and transform in ways that enhance these capacities in the face of future events. | Ability to prepare, absorb and transform to improve the future response |

**We are not technical experts at all, but we are – collectively – experts in our own community" (Matt Charles-Jones, one of the leaders behind Totally Renewable Yackandandah in an interview with the ABC, 2021)**

UTS Institute for Sustainable Futures